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OF

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Designed by J. L. Morton

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GEOLOGY

OF

NEW-YORK.

PART IV.

COMPRISING THE

SURVEY OF THE FOURTH GEOLOGICAL DISTRICT.

BY JAMES HALL.

ALBANY:
CARROLL AND COOK, PRINTERS TO THE ASSEMBLY.
1843.

TO HIS EXCELLENCY

WILLIAM C. BOUCK,

GOVERNOR OF THE STATE OF NEW-YORK.

SIR,

I herewith submit a Report on the Geology of the Fourth District, comprising the counties of Wayne, Monroe, Orleans, Niagara, Seneca, Ontario, Yates, Livingston, Genesee, Erie, the western part of Tompkins, Chemung, Steuben, Allegany, Cattaraugus, and Chautauque.

I have the honor to be,
With great respect,
Your obedient servant,
JAMES HALL.

PREFACE.

HAVING been appointed by the late Governor, the Hon. WILLIAM L. MARCY, to investigate the Geology of the Fourth District, which embraces the counties just specified, my duties in that region commenced in the spring of 1837. The subjects of the successive Annual Reports since that time, are embodied, as far as possible, in the following work. A multitude of minor details are necessarily omitted, but it is believed that everything of economical importance has found a place in this Report.

I have conceived it my duty to record my own observations, rather than to compile from the labors of others; yet it has been far from my intention to neglect any sources of information within my reach; and at the end of the Report will be found a list of those persons, so far as I know, who have written upon the Geology of Western New-York.

In the commencement of the work, it was intended to confine the details chiefly to physical geology, and to present only a few of the most prominent and characteristic fossils of each rock; but, as there appeared some doubt whether the work on Palæontology would be completed, more attention was devoted to this subject, and a large number of figures prepared for the work. Too little time, however, remained for its proper investigation, and the descriptions have been mostly written and the names given while the work was passing through the press, and it would be presumptuous to suppose that what is done can claim perfection. In preparing this part of the work, I have consulted all the authorities within my reach; it was undertaken both for my own benefit and for those who wish to know something of the fossils of the New-York rocks, and who have not access to foreign authors on the subject. I feel, therefore, that those who are the best qualified to judge of it, and to detect the errors, will appreciate the motive, as well as the difficulties encountered, and deal leniently with the faults.

The drawings for illustrating the organic remains, have been chiefly made on wood by Mrs. HALL; and although I may be regarded as a partial judge, it is but justice to say that they are executed with fidelity and precision, and the figures will enable any person to identify the fossils of Western New-York.

During the first year of the survey, I was assisted in the field labor by the late Dr. G. W. BOYD, and subsequently by Prof. E. N. HORSFORD of Albany, and Prof. E. S. CARR of Castleton Medical College. To the industry and fidelity of these gentlemen it gives me pleasure to bear testimony; and to the first, who is now gone from among us, I may be permitted to offer, in honor of his memory, a tribute to his zeal, perseverance and accuracy. My acknowledgments are also due to Mr. JOHN PATTERSON, of the Assembly Printing Office, for the careful supervision of the sheets of this work as it has passed through the press, and I have often had occasion to avail myself of his literary and scientific acquirements.

TO THE INHABITANTS OF THE FOURTH DISTRICT, from whom I have received the most liberal aid and encouragement, and to whose hospitality I have been often indebted, I have many acknowledgments to make. It has been my first endeavour to elucidate the geology and the economical resources of that portion of the State; and if much time has been occupied in investigating the lithological variations, the points of junction of successive strata, and especially in obtaining great numbers of their characteristic fossils, it has been with a view to carry out the plan of the survey in the spirit in which it was conceived. The subject has been pursued throughout with a feeling that though utility was one grand object, yet science was not to be subordinate; that in the Geological Survey of New-York, knowledge was to be acquired and disseminated among the people, not only to aid them in understanding phenomena immediately connected with their pecuniary interest, but to direct them in gratifying the wants of a higher nature, and appreciating the wisdom and beneficence, and the harmony of design, in all the creations that have preceded, as well as in all that now surround them. I cannot but believe that the organic remains presented in this report, and which are so widely distributed, and so abundant in nearly all the rocks, will be found an interesting subject of observation. To all young persons, and to pupils of schools and academies, they will become a fascinating study, and at the same time induce recreation and exercise, promoting health and happiness.

Many points where I had promised myself a further time for investigation, I have reluctantly been compelled to abandon. To have been able to review many portions of the district would have given me pleasure, but the close of every season has found me leaving the field only after the snows of winter admonished me that I could no longer labor to advantage.

The enlightened spirit in which this survey was directed, and the munificence with which it has been sustained, have afforded every means required for its completion. The State of New-York, which has heretofore established her claim to the dignity of the Empire State, has now added another wreath to her laurels, in becoming the first in the patronage of science, and in the benefits thereby bestowed on her citizens, as she is first in resources, in commerce, and public improvements.

Under such circumstances I offer these results with diffidence, conscious that neither limitation of time, nor of expense, can be urged for the imperfections, and none can feel more than myself the deficiency of the present report as an illustration and description of the grand physical and geological features and phenomena of Western New-York. But the field widens as we advance; as in every department of nature, examination leads to more extended discoveries, so the geology, and more especially the palæozoic geology of every country a progressive study, offering to the student treasures ever new and in exhaustless variety.

JAMES HALL.

TABLE OF CONTENTS.

CHAPTER V.

NEW-YORK SYSTEM.

CHAPTER VI.

OLD RED SANDSTONE.

CHAPTER VII.

CARBONIFEROUS SYSTEM.

CHAPTER VIII.

CHAPTER IX.

CHAPTER X.

CHAPTER XI.

CHAPTER XII.

CHAPTER XIII.

CHAPTER XIV.

CHAPTER XV.

LAKE RIDGES.

CHAPTER XVI.

CHAPTER XVII.

CHAPTER XVIII.

CHAPTER XIX.

CHAPTER XX.

CHAPTER XXI.

LAKES.

CHAPTER XXII.

CHAPTER XXIII.

CHAPTER XXIV.

CHAPTER XXV.

CONCLUSION.

LIST OF ILLUSTRATIONS.

LITHOGRAPHIC PLATES.

TABLES OF FOSSILS USED IN THE DESCRIPTIVE PART OF THIS WORK,

Numbered at the bottom from 1 to 66.

LITHOGRAPHIC PLATES AT THE END OF THE WORK.

GEOLOGICAL MAP OF NEW-YORK.

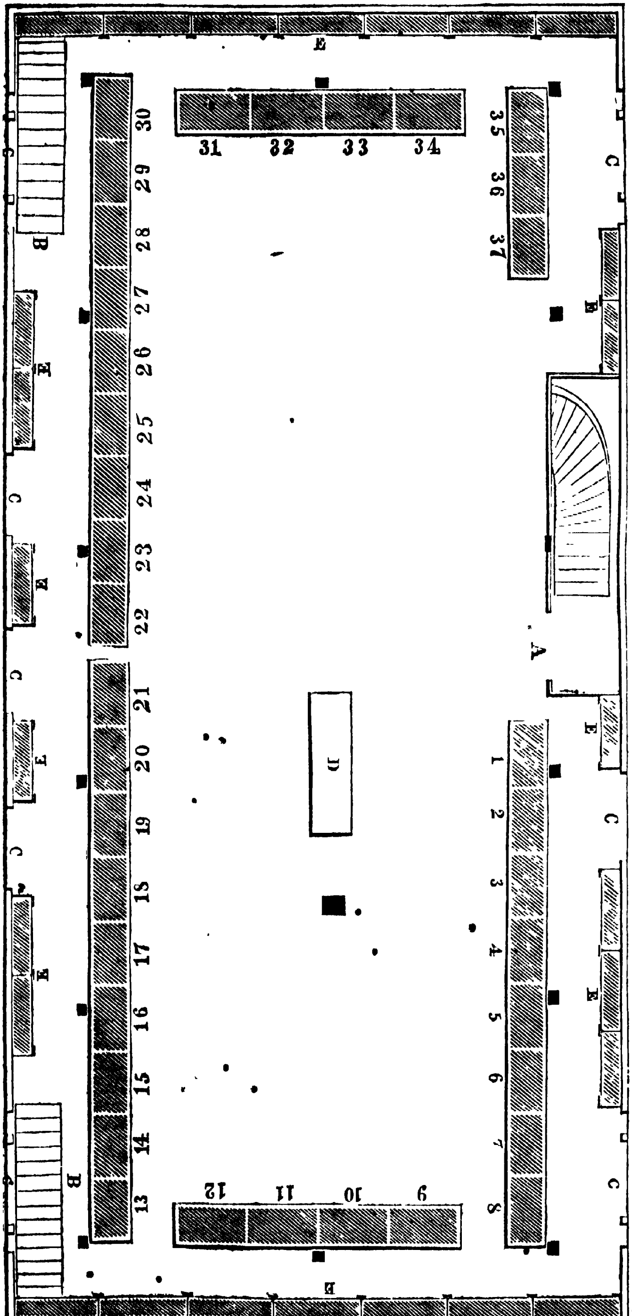
The accompanying Geological Map of the State is intended to present a clear idea of the general geological divisions which have been enumerated in the reports. In a few cases it has been found impracticable, from the small scale of the map, to indicate all the subdivisions. Thus the lower limestones (Birdseye and Trenton) are blended in one color. The same course has been adopted in relation to the Helderberg division, where the small extent of surface occupied by each member would preclude the indication by separate colors. There is no difference in color to indicate the line of demarkation between the Portage and Chemung groups, and in truth there is no distinct line of separation in lithological characters between the two. All cases of decided change in lithological character are indicated by color. That part of the map appertaining to the Fourth district presents a series of almost parallel lines of color, showing the limits and the undisturbed range of each formation, rising one above the other on the south in a series of steps or terraces.

The tabular arrangement of colors in the margin, will indicate the formation marked by any particular color upon the map. The transverse sections at the bottom of the map, colored in the same manner, illustrate very satisfactorily the order in which the strata naturally overlie each other. From these alone, the map will be understood without consulting any other explanations, except in cases where there is disturbance or derangement of the strata.

The Carboniferous strata within the State are only in isolated patches, consisting of the conglomerate and associated sandstone. In some of the maps, a portion of the State of Pennsylvania has been colored under the direction of Prof. H. D. ROGERS, and this illustrates more clearly the connexion between the rocks of New-York and the coal-bearing strata of Pennsylvania.

The coloring is continued beyond the Niagara river, showing the undisturbed continuation of the rocks of the Fourth district into Canada.

EXPLANATION OF THE DIAGRAM.



A. Entrance to the room.

B. B. Stairs to gallery.

CCCCCCCC. Windows.

D. Table.

EEEEEEEEE. Vertical cases standing against the side of the room.

The figures indicate the Tabular cases, with the contents, as follows:

1. Primary system.
2. Taconic (Tighconick) system.

NEW-YORK SYSTEM.

3-1.* Potsdam sandstone.
4-2. Calciferous sandrock.
5-3. Black-river and Birdseye limestone.
6-4. Trenton limestone.
7-5. Utica slate.
8-6. Hudson-river group.
9-7. Grey sandstone.
10-8. Oneida conglomerate.
11-9. Medina sandstone.
12-10. Clinton group.
13-11. Niagara group.
14-12. Onondaga-salt group.
15-13. Waterlime group.
16-14. Pentamerus limestone.
17-15. Delthyris shaly limestone.†
18-16. Oriskany sandstone.
19-17. Cauda-galli grit.
20-18. Schoharie grit.
21-19. Onondaga limestone.
22-20. Corniferous limestone.
23-21. Marcellus shale.
24-22. Hamilton group.
25-22. Hamilton group.‡
26-23. Tully limestone.
27-24. Genesee slate.
28-25. Portage group.
29-26. Ithaca group.
30-27. Chemung group.
31-28. Catskill group or Old Redsandstone.

CARBONIFEROUS SYSTEM.

32. Conglomerate.
33. Coal and coal plants from Pennsylvania.§
34. Red sandstone and associated trap rocks of Southern New-York.
35. Boulders.
36. Sands and clays.
37. Marl and modern tertiary fossils.

* The second series of numbers are those attached to the cases in the room, showing the succession among the rocks of the New-York system.

† The Encrinal and Upper Pentamerus limestone, are not separated in the arrangement.

‡ Two cases are occupied by the Hamilton group.

§ The New-York series ends with the Conglomerate, and these specimens from the coal fields of Pennsylvania are introduced for the purpose of showing the relative situation of those rocks.

PLAN OF ARRANGEMENT

IN THE

STATE GEOLOGICAL COLLECTION.

The plan of arrangement adopted in the State Collection has been, as far as possible, in the order of nature. The object to be attained, being the dissemination of information among a large number of persons who have given little attention to the science of Geology, the simplest mode of presenting the subject would of course be most satisfactory. The room appropriated for the purpose is about seventy feet long and thirty-four feet wide. Around the outside of this room is a series of vertical cases, and about four feet within this area is a series of tabular cases; thus presenting a double series of specimens. A single case is devoted to the productions of a rock or group, and nothing foreign to it is allowed to enter. Each tablular case, being 3½ feet long by 2½ wide, contains from 50 to 70 typical specimens of rocks and fossils of the group, giving the observer at a glance a comprehensive view of the most prominent and important features of each. In the vertical cases a more numerous collection is arranged, and the more rare or less characteristic productions of the rock or group here find a place.

The accompanying diagram will render this description more intelligible. On entering at the door, the visitor turns to the left, bringing himself in front of the range of vertical and tabular cases, (reference at present being had to the latter only.) The first case presents him with the most characteristic and important varieties of granite, gneiss and associated rocks and minerals. The second presents a series of magnesian slates, crystalline limestones, etc. being a metamorphosed group known as the Taconic (Taghkonic) system. The third case presents the products of the lowest known sedimentary rock containing organic remains — the Potsdam sandstone. From this point every successive case at the right hand presents the observer with the next rock in the ascending order of the series; and by passing on in this direction around the room, the whole series is examined in their natural order of superposition.

By the aid of sections this is made intelligible even to the least initiated, and has proved a very satisfactory mode of arrangement. The series terminates in New-York with the conglomerate of the Carboniferous system, and the next case is devoted to a collection of coal and coal plants from Pennsylvania, showing the full development of the group. Succeeding this we have the red sandstone of the southern part of New-York, being the New red, or of a formation intermediate between it and the coal. The three remaining cases are devoted to surface products, as boulders, sands and clays, marl, peat, and modern tertiary fossils.

The collection of fossils, not yet completed, is to be arranged in drawers beneath these cases. In the gallery of this room there is a geographical collection of specimens, presenting the productions of each county separately arranged.

REPORT

OF THE

SURVEY OF THE FOURTH GEOLOGICAL DISTRICT

CHAPTER I.

PRELIMINARY CONSIDERATIONS.

The Fourth District comprises fifteen and a half counties, as previously enumerated; and embraces all that part of the State lying west of the parallel of Cayuga lake, and included between the Pennsylvania line on the south and Lake Ontario on the north.

The succession of strata, occupying the different portions of this district, have been made known from time to time, in the several Annual Reports presented to the Legislature. It now remains to give a connected view of these, with their striking features and fossil contents; the object of the work being to aid those who wish to obtain a knowledge of our rocks, and also to show as far as possible, by an exhibition of their distinctive features, the reasons on which the subdivisions have been founded. With this design, some wood-cut illustrations are given of characteristic scenery, when the rocky strata are exhibited. The principal illustrations, however, are those on which the geologist depends when making his explorations in the field — the organic contents of the rock. Wood-cuts of the most important and characteristic fossils of each rock and group are inserted in the text, under the proper heads. Thus each rock will be represented in its most characteristic fossils, which will greatly aid the student who has not the advantage of an arranged collection for reference, and enable him to decide from a few specimens the situation of the mass he is examining. This mode was adopted, believing it would be impossible to present a satisfactory report without such illustrations.

The great object of the survey, as originally contemplated, was to lay before the people of the State as much practical or available information as possible, in regard to the rocks, minerals and soils. These, then, were the prominent points to be kept in view. In attempting to do this, the manner and matter are not always such as would have been chosen, had the report been a communication to a body of scientific men. On the other hand, it is impossible to avoid the use of terms, some of which are strictly technical, and others not familiar to every reader. Still many of these terms are being introduced into our English dictionaries, and will soon be considered a part of the language. Those which are not thus used, are readily found and clearly defined in the Glossary; and as every term employed is more expressive or significant of the idea, than words of ordinary language, it is presumed that the knowledge of such, and their application, will fully repay every one the trouble of adding them to his vocabulary.

Were it possible to use the familiar language of conversation so as to give names to all the objects, and to describe all the phenomena of nature, it would perhaps be desirable to do so; but as our knowledge of nature increases, our vocabulary becomes deficient, and we are compelled to resort to other languages for terms expressive of the object or idea. These at length, and by frequent repetition, become a part of our own tongue; and in time, by familiar use, their origin is forgotten. Thus has it been with all words and phrases introduced from other languages.

Now inasmuch as Natural History, in all its departments, must become a popular study, it is evident, either that these terms must be acquired, or others substituted; and it will require far more labor to find familiar terms expressing the same thing, than to learn those already applied. There is also a necessity for a universal language; for nature is universal, and every where the same. Whatever mode, therefore, will render a knowledge of nature of more easy acquisition to the greater number, it is the duty, as it should be the pleasure, of every lover of nature to adopt.

In all cases, in this report, where the name of a fossil is rendered more familiar by being translated, it will be done; but in many instances, the name thus translated would be inapplicable or inconvenient. Such instances sometimes occur where fossils have been named from theoretical considerations, which have afterwards been overturned by the acquisition of new facts. An example may be cited in the name *primigeneus* or *first-created*, which we cannot with propriety affirm of any fossil at the present time; as it may happen that one of the same genus will be found in an older rock. Names expressing any quality in a superlative degree are likewise objectionable, as has often been found; for so long as any remain unknown, we cannot with propriety use the superlative signification, as it may be superseded by the same quality in a greater degree in another individual.

Numerous objections, in popular regard, may doubtless be made to our present nomenclature, but it is far easier to make objections than to propose a more acceptable substitute, and a report like the present is not the place for reformations in science. Reform should be made by those best acquainted with the subject; and in these pursuits, such men are usually too much occupied, and interested with their discoveries, to attempt innovations in the nomenclature. On the other hand, those who have but partial acquaintance with the philosophy of the subject, the facts, are the first to propose a reformation in the vocabulary, and from the want of this essential knowledge, fail in attaining the object, and leave it in a worse condition than before.

No one who is aware that our present system of nomenclature had a beginning, and that it is an improvement upon all that preceded it, but believes likewise that another and better system will hereafter take its place.

The arrangment by classes, orders, genera and species, is the only one which will enable man to systematize his discoveries or results, whether in individual objects or in philosophic truths; and the more nearly he can adopt this mode, the more nearly has he arrived at the order of nature; and in the same proportion, the more accurate become the details, and consequently the general results. What is here true of individuals or facts, is true in like manner of masses; and the application of this principle in Geology is that which is bringing the subject more strictly within the limits of the exact sciences, or the more exact of the natural sciences.

In geological formations, the relative place of species, genera, orders, etc., with their subordinates, has not yet been determined. Thus we find a single rock, and a group of rocks, occupying the same place in the scale, or the same column in the tabular view. This at present is matter of necessity; for there has not been time in all cases to make the minute examinations which are required, in order to pronounce where the limit of a genus or species should terminate; and therefore groups, which may be either orders or genera, hold the same place as individual rocks which are species.

In rocks, as in other classes of natural objects, it is often very easy to discover the generic limit, clearly and undoubtedly, as in Botany the oaks; while in other cases, as in the grasses and flowerless plants, the most minute examination is requisite to separate genera and species. Subdivisions will one day be made in what are now termed groups of rocks, as have been in some of the obscure families of animals and plants; and it is well to bear in mind, that a group is composed of an assemblage of individuals, which, for want of more accurate knowledge, are left thus, rather than hazard a division at present. A group, then, consists of an assemblage of individuals. A rock constitutes both the species and genus, there being no allied one with which it could be united to form a genus of more than one species.

From these remarks, it is not to be understood that Geology is so much more obscure or doubtful than other sciences; for subdivisions of genera and orders of plants and animals are constantly made, for the reasons that the individuals in question differ in essential particulars from the descriptive characters of their former associates. The same thing has yet to be done for Geology; what now constitute groups, will be identified as consisting of several individuals, and separated accordingly.

In this way only, man progresses in systematic knowledge; at his first investigations, throwing together those things which bear some obvious resemblance; and in his subsequent examinations, with increased knowledge, making more accurate and natural subdivisions.

In our own geology, the first step towards this degree of perfection has been made in the groupings adopted in the Reports. This was all that could be accomplished for the present, when the whole subject was to be reduced from its former chaotic state, and while so much remained to be done in its other departments. The arrangement of the whole system in classes, orders and genera, will follow naturally, from what has been done, all the elements being prepared.

The first object in the prosecution of this survey, has been to ascertain the existence and extent of the different rocky masses, their lithological characters, their mineral and fossil contents and other associations, and their order of succession, or the manner and order in which one rock is preceded or followed by another. Facts of this kind were collected throughout each mass from one extreme to the other, in many cases extending across the whole State. In this way only could the materials be obtained for forming a System, or presenting in their proper order and association the collections made in different parts of the State. Thus our rocks have been arranged, and each one holding its appropriate place in the series, its extent and its mineral productions are easily pointed out. The relation of any one mass to others of importance is thus readily seen, and also the relative position of the whole as regards the great Coal formation or Carboniferous system.

Among the most important facts demonstrated in the progress of this survey, is that of the non-existence of the great Coal formation within the limits of New-York, except its lower member in a few detached points or outliers. This knowledge, though negative, is nevertheless of great value; having forever set at rest a vain expectation, which has cost an immense expenditure in time and money. When facts of this kind are fully understood and appreciated, the importance of the survey will be seen in the abandonment of all schemes of mining for coal and the precious metals, and the consequent quiet and satisfaction ever attendant on rightly directed enterprise.

It is thus negatively, as well as by direct and positive discoveries, that science ameliorates the condition of mankind; turning attention from useless and visionary pursuits, and directing it to that which yields a ready and satisfactory result for the expenditure of labor and time. And although the promulgation of scientific truths may restrain the vagaries of minds which delight to build the splendid air castles of suddenly acquired wealth, it will nevertheless direct man's energies to sources where perseverance is sure to be crowned with rewards which a morbid fancy would crave at the commencement of the enterprise. From science alone will man learn his true interests, as regards his well-being in this world.

In a report like the present, being the result of investigations commenced after much was already done, and where it is not always convenient to refer to the author, time and place, a short notice of what had been previously accomplished, and what was the condition of geological knowledge when the survey began, will show the manner in which our rocks have been studied heretofore, and afford an explanation of the comparatively little progress that had been made towards a correct classification of the same.

Thirty-three years have elapsed since Mr. Maclure published his "Observations on the Geology of the United States." To him we are indebted for the first sketch of a system, and a geographical distribution of the rocks of this country. At that period, it was impossible to give the connected and systematic information which years of experience have enabled us to acquire; and no attempt was made, farther than to identify our strata with those of the eastern continent.

It would be useless to follow, in chronological succession, those who have labored at the same task, viz. not to develop the system of rocks as they are, but to identify them with the known formations of Europe. This undertaking, as we have learned from experience, was at that period a hopeless task; for only very recently have we obtained any thing like a correct classification of the older deposits in England, while on the continent much yet remains to be done. Under such circumstances, it is not surprising that many errors were committed, and our progress in the science consequently retarded.

The name of the late STEPHEN VAN RENSSELAER will always be remembered with reverence by the American student of geology, and perhaps scarcely less so in other branches of natural science. Through his munificence, Professor EATON was enabled to make a very extended and systematic survey of the rocks of New-York; and if, in his report, some things are not perfectly in accordance with recent discoveries, we must remember that at that period he was almost entirely without a guide in these older formations; that he was in fact describing rocks which at that time were not understood in Europe, and which no geologist had yet attempted to classify. Had he evinced still more independence of European classifications — as is now recommended from high authority on the other side of the Atlantic — pursued the investigations of the subject to a more thorough detail; published sections illustrating the order of superposition from the older to the newer rocks, with their fossils so numerous and so characteristic, he would have left an undying fame to himself and his noble patron. We can only regret that this was not done in the most extended and perfect manner, since it is evident* that on the part of Mr. Eaton every desire existed to do so, while the means furnished by Mr. Van Rensselaer were unlimited for illustrations of every kind; yet so trammelled was the former by European authorities, that no more was produced than the imperfect sketch then presented to the public.

In that work (Survey of the Canal Rocks), which was published in 1824, it is evident that the author was fully aware of the great extent of our undisturbed strata as compared with those of Europe. He remarks, that "Our secondary rocks along the canal line are several "hundred miles in extent, and remarkably uniform in their leading characters."

"After examining our rocks with as much care and accuracy as I am capable of doing, I "venture to say, that we have at least five distinct and continuous strata, neither of which "can with propriety take any name hitherto given and defined in any European treatise which "has reached this country. The late work of Philips and Conybeare describes many of the "beds, and some of the varieties found among the rocks referred to; but the nomenclature "of these very able geologists cannot be adopted in our district, without mangling and distorting the unprecedented simplicity of our rock strata."†

* Canal Rocks, pages 8 and 9. † Ib. page 7.

I quote this, to show that Mr. Eaton was aware that the names and arrangement adopted in the systems of European authors did not apply to the rocks of New-York; and yet, most fatally, he attempted to apply that arrangement as far as possible, all the time supposing himself to be investigating rocks of the same age, while in truth they were much older than any described by the authors quoted. This attempt to identify the rocks of New-York with the Secondary system of Europe, probably arose from the general belief that the older or Transition strata were in a highly disturbed and altered condition, having undergone mutations by which nearly all the organic forms were obliterated. Thus when so great a range of undisturbed strata, abounding with organic remains, was presented, as along the line of the Erie canal, it was quite natural to refer them to the secondary deposits; indeed it required knowledge, at that time not possessed in our country, to decide the true age and position of these rocks.

In that work, nearly all the rocks of western New-York are enumerated in the order of succession; and, with some exceptions and omissions, the order is correct, and the subdivisions will always hold good in the science. It is a remarkable fact, that at this early period, Mr. Eaton should have recognized the sandstone of the Catskill mountains as the Old Red of Europe; which, now that we have identified its characteristic fossils, is proved to be true. Had he seized this grand idea, and confined himself to the elucidation of the strata below the Catskills, he would have brought to light the most interesting series of rocks yet known in any part of the globe. But in his examinations westward, the attempt to identify the Oneida conglomerate with the Coal conglomerate, and the sandstone bordering Lake Ontario with the New Red sandstone, gave rise to that distortion of the geology which has prevailed regarding the whole western portion of the State. The great source of error throughout seems to have been the prevailing desire to identify, within the limits of New-York, all the rocks and systems published in Europe from the Tertiary downwards.

We cannot otherwise than regard it as a great misfortune that European systems were ever made a standard for our rocks, which should have been studied and described as they are, and as they always must remain the grandest development in the world, of the older fossiliferous formations.

Prof. Eaton had previously published his "Index to the Geology of the Northern States," in which he attempted to give a systematic classification of American rocks. He subsequently published two editions of a geological text-book, with many modifications regarding arrangement, with which more recent observations do not concur. How far the rocks of the State were developed, and their relative position shown by his labors, will be seen when describing individual masses; and in all cases, the names by which he designated them will be given among the synonymes, or adopted when applicable.

Prof. Eaton, in connexion with Dr. T. R. Beck, afterwards made an agricultural survey of Albany county, in which all its mineral productions are described; and with Dr. L. C. Beck, a similar survey of Rensselaer county. These labors led to the establishment of the Rensselaer School, under the patronage of Mr. Van Rensselaer; the objects of the Institution being to disseminate a knowledge of the natural sciences, with their application to agriculture and the arts of life.

Besides the publications of Prof. Eaton, few have appeared in a separate form upon the geology of the State. The other records of observation consist mostly of notices and communications made to scientific journals and learned societies, and published in their transactions. In these are preserved a very numerous collection of facts relating to the mineralogy and geology of the State.*

Having been a pupil of Prof. Eaton in the Rensselaer Institute, and receiving there my first instruction in Geology, it was natural to speak of him and his labors, as a tribute of respect as well to himself as to Mr. Van Rensselaer, than whom no man more desired the amelioration of human evils and the extension of knowledge.

To speak of all whose labors deserve the grateful remembrance of the student of nature, would carry me beyond the proper limits of my subject; but two names which preëminently claim a notice, are those of Dr. MITCHILL, the father of natural history in this State, and to whom we owe the first collection of minerals brought to this country from Europe; and DE WITT CLINTON, who, to every other distinction of greatness and excellence, added the most enlarged views for the advancement of scientific knowledge.

We now come to the condition of the subject in New-York, previous to the commencement of the survey in 1836.

Very little detailed knowledge of the strata was possessed; a general idea of the order among the principal rocks, with a more particular description of some places, being all that was taught. The intimate relations and connexions of our series with the great Coal formation was not understood, and doubt and anxiety prevailed regarding the probability of finding coal within the State.

The attempt at subdivisions among the strata had not been attended with entire success. The slates and sandstones of the Hudson river group had been considered as the lowest rocks of the Transition system; while the calciferous sandrock, and the limestones of the Champlain and Mohawk valleys were supposed to lie above. This error arose from the influence of the disturbing force, which has operated so extensively along the eastern border of the State; dislocating, overturning and altering the strata to a great extent, and so disguising the lowest stratified masses as to render it, at that time, extremely difficult or impossible to identify them with the undisturbed and highly fossiliferous strata of the same group farther west. At that time few observers had attempted to elucidate the order of superposition, and thus the subject of their actual relations remained involved in doubt and obscurity.

The origin of the brine springs of the central and western part of the State was unexplained; and the search after stronger water, or fossil salt, was conducted at hazard, regardless of the conditions or situation of the materials giving rise to the springs. The position of the salife-

* A very complete list of these may be found in the Report on the Geological Survey, made by the Hon. J. A. DIX to the Legislature in 1836.

rous rocks had not been clearly pointed out; and it was the general belief that these masses, continuing westward from Salina, bordered Lake Ontario. In this manner two very distinct formations were confounded with each other, and the mistake gave rise to much difficulty and disappointment; for as the sandstone of Lake Ontario every where contained salt springs, it was inferred, that by boring to a sufficient depth, water could be found of the quality of that at Salina. Numerous attempts of this kind were made, and always resulted in failure, for the reason that the former seems less abundant in saline matter than the latter, and also that there is no situation along its range to act as a reservoir, like the great depression of the Onondaga valley.

The difficulty of identifying strata at different and distant points, gave rise to many errors. As an instance of this, the limestone of Black-Rock was always supposed to rest upon, and constitute a part of the Niagara limestone, while the whole Salt group which intervenes had been overlooked. This arose from the preconceived opinion that the Salt group was north of the terrace at Lewiston, and consequently the two limestones in question could be separated by no known rock.

In this state of things, it is not surprising that mining, and borings for salt water, should have been made in all situations and in every rock. Having no guide in geological indications, any situation presenting some remote analogies, or the existence of some peculiar substance, was sufficient inducement to undertake extensive explorations; and had it not been that the purse usually failed sooner than the zeal of the individuals, we might have had some fine artificial exhibitions of our strata.

As an example of the slight grounds upon which explorations are undertaken, it may be mentioned, that almost every rock containing carbonaceous matter, or possessing bituminous odor, has been bored or excavated for coal; and the presence of bitumen in any rock, is by many considered an unerring indication of the existence of this mineral. Not less futile or ill founded are the explorations induced by the presence of iron pyrites, or a few glimmering scales of mica, which have given origin to mining operations on a small scale in innumerable places. These illusions, however, are fast vanishing before the diffusion of more accurate information, and a few years will see every one in possession of the requisite knowledge to direct his inquiries aright.

In all attempts to reconcile the rocks of America with the geological arrangements of Europe, the difficulties arose from certain remarkable differences between the formations of the two countries; such as the existence of successive and extensive limestone deposits in the eastern portion of the United States, with—as we have now learned—the absence of the carboniferous limestone of Europe, the most important limestone there known as existing below the coal. These limestones agreed with none at that time described, and as they possessed some general characters (containing corals and encrinites) in common with the carboniferous limestone, they were referred to the same period.

A glance at the treatises on geology which have appeared in England during the last thirty years, will give the history of progress in this part of the subject there, where so many observers, with so great facilities, have been constantly at work. It must be recollected also that these comparisons between the rocks of the two countries were made before the application of organic remains to the identification of the age of rocks had become general, or even known here at all. Mineral or lithological characters were at that time the principal means of deciding this question, and it is well known how liable to error we become by depending upon this character, for the rocks even of different parts of this State; how much more so, then, when attempting to identify those of distant continents.

Again, while in Europe the older strata are much broken up and inclining at a high angle, those of the same age in New-York are very little disturbed, and throughout more than a thousand miles in extent westward, are nearly horizontal. Thus while seeking for these characters in our rocks, we neglected much more important evidence; and it has sometimes happened that the same formation, in one place, from its horizontality referred to more recent deposits, has in other places, where disturbed and upheaved, been referred to older ones.

This character of undisturbed horizontality over a great extent, in Europe and particularly in England, always considered as indicating deposits of a newer age, naturally led to the same conclusion here regarding our strata. At the present time, with all our guides, and which have only been afforded within a few years, we can scarcely conceive the condition of the subject during the earlier periods of observation in this country. From these facts, we learn that no condition of rocks, in regard to greater or less degrees of disturbance, can be considered an indication of their age. We find in our country the oldest sedimentary rocks in their natural or horizontal position, unaltered and undisturbed; while in Europe, deposits much newer than the coal are so altered, that till recently they have been referred to the primary or hypogene.

At the time our strata began to be studied, the doctrine of total destructions and renovations was generally admitted; the termination of every geological period was supposed to be marked by the annihilation of every living thing, and the commencement of the next one as distinctly by a new and entirely different creation. Further observation has tended to the abandonment of this doctrine; and so far as our knowledge now goes, there seems to have been a gradual change from the first period of living things to the present time. Except in comparatively limited districts, no sudden destructions or violent catastrophes have occurred; the loss of species appears to be due to their gradually dying out, as the climate and condition of the ocean became unfit for them; and the appearance of new ones seems, in like manner, to be induced by changes causing a condition favorable to their existence.

Of the extinction of species, we have an example on our own coast at the present time, and others might be enumerated. An extensive bed of the dead shells of the *Pholas costata* has recently been found at New-Bedford, while it is unknown as a living shell on the shores of the eastern or middle States.* It is thus evident that this shell at one time existed in great numbers in a situation where, by some change unfavorable to its continuation, it has become extinct.

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* Dr. Gould's Report on the Invertebrata of Massachusetts, p. 27.

At one time fishes were supposed to date the commencement of their existence subsequent to the Coal period; nevertheless, their remains have been traced downwards through the Carboniferous system, the Old redsandstone, and into the middle of that vast fossiliferous series of the older periods known as Transition or Silurian. In New-York, the remains of fishes have been found in the Oriskany sandstone and succeeding limestones of the Helderberg series, holding a central place in the New-York system. From the facts now known, it appears that trilobites were the first created animals possessing highly developed locomotive powers; they being the "lords of the earth" till the appearance of higher organizations, as in the fishes. Still, subsequent facts may reveal to us the astonishing truth that fishes were among the earliest inhabitants of the globe, and thus that vertebrated forms held place among the first creations.

Scarcely less erroneous was the opinion promulgated that the fossil remains of the older strata consisted of a few singular crustaceans with brachiopodous shells, or such as possessed an opening under the beak for the protrusion of a peduncle by which to attach themselves, as in Delthyris and Orthis; together with some singular forms of chambered shells, as Orthoceræ, and others; and that the whole assemblage was so unlike the Fauna of the present ocean, that there was nothing existing with which to compare them. On the contrary, though the greater number as regards species and individuals are of types quite distinct from the most of those inhabiting the present ocean, yet we now know that several of the fossil genera of the older rocks are still living in our seas, having existed through every geological era. A species of the genus Lingula appears in the oldest known fossiliferous rock; and this shell, with Orbicula, were among the earliest inhabitants of these ancient waters. In rocks of the same period, we find shells closely allied to, if not identical with, Trochus, Turbo, Buccinum, Nucula, Avicula, and numerous other genera; while among the living crustaceans of the southern hemisphere, are forms closely allied to the trilobites of this period. In fact it would appear that in these earlier deposits are an assemblage of fossils, as much like the Fauna of the present seas as in some of the subsequent geological periods.

The doctrine of violent catastrophes, and of sudden changes in the inhabitants of the ocean, was based upon the examination of limited districts, where the entire series of deposits had never existed, or had been subsequently obliterated. And gradual and tranquil as the changes now seem to us, they may appear infinitely more so when a perfect sequence among the strata of the whole globe shall become known—when a *complete* succession shall be established from the oldest to the newest rock. From what we now know, compared with the knowledge existing a few years since, we can readily infer that some distant places, or even nearer localities, may furnish links now wanting in the chain.

In learning to regard nature as always the same, and her laws unchanging, we have made a grand step towards the explication of phenomena before unexplained, except through a suspension of the natural laws, or a miraculous interposition of creative power. Nature is always perfect and unvarying, but man's knowledge is progressive; consequently in every advance he arrives nearer to the truth, and yet as far from knowing all nature and her laws as he is from Infinity.

The knowledge of mankind, therefore, at one age seems but as folly or ignorance in a succeeding one; and it is the same regarding our own knowledge at different periods. Still there are certain principles which never fail, and which man through his whole life, and mankind throughout all ages, have acknowledged as fixed and unalterable. It is not the facts of observation that change, but the inferences which we draw from them, as our knowledge becomes more extended, and facts before unknown are added to the stock.

Exact knowledge, therefore, consists in those things which can be seen or demonstrated; while in all knowledge of inference, there is progression. Opinions which are often the result of imperfect knowledge are liable to change, and the human mind is never advanced by adopting the opinions of others; for by that means, man is never made a thinking being, but rests upon authority.

Viewing nature and the mind of man in this light, we are not to look at the imperfections in the works of those who preceded us, but to be satisfied to add a few more facts to the great store of exact knowledge. We are to consider always that theories and systems are merely an exposition of the present amount of knowledge on the subject; and that *science* is the term used by philosophers to designate the conclusions drawn from a systematic arrangement of facts, verified by other facts, relating to any portion of nature's works; not in the least signifying that man's knowledge is perfect in any department of nature, or that science is less susceptible of improvement by the addition of new discoveries.

In all sciences, the acquisition of new truths exhibits in new light the beautiful operation of the laws of nature; and in none more than in geology does it show them operating in a uniform and unvarying manner through successive periods, as proved by the organic contents of the strata of every geological era. In no science have facts accumulated more rapidly; but it is within a comparatively recent period that these have been rightly interpreted, or have led to the simple and satisfying, and at the same time stupenduous conclusion, that nature has been operating through incalculable periods of time, with the same harmony and unity of design as we behold in her present creations.

The history of geology in our own country, even for a few years past, and within the memory of almost every one, shows how rapidly the subject has advanced, till from a word scarce comprehended, the application of its principles are of daily adoption among us, and the results of its investigations known to all.

CHAPTER II.

General Features of the Strata, Topography, etc.

In describing the rocks of the Fourth Geological District, according to their physical or lithological characters, and the effects of these in modifying the contour of the surface, we shall find the whole area occupied by several successive parallel groups or associations of strata, each possessing characters which distinguish them from others above and below. The general line of their bearing or strike is nearly east and west, with some slight variations owing to denudations, but never to uplifting or derangement. This will be clearly seen on reference to the colored geological map. Throughout the whole distance, there are no disturbances of much importance; and the greatest effects produced in any case, are slight dislocations extending for a few yards; or sometimes gentle undulations of the strata, which may affect them for several miles. To this character of the country we owe its great simplicity of structure, the order of succession being scarcely any where obscured except by superficial detritus. This in many places, and for considerable extent, covers the nearly horizontal strata, and in some instances renders the local succession obscure. Still the numerous river channels and ravines, the deep excavations of the north and south lakes, all aid in developing in the most satisfactory manner the whole series from the highest to the lowest rock. And although we have not to describe the great changes and important modifications wrought upon the strata by plutonic agency, yet we have exhibited in the most perfect manner the natural arrangement of the deposits, the situation and condition in which they were left by the agents of their production; and we can recognize, unchanged by subsequent influences, the nature of deposits at remote points from each other. We trace a rock through all its grades of coarser materials to finer and finer, until at last we find it composed of comminuted matter which slowly sank to the bottom in the deeper parts of the ocean.

The analogy to recent formations is thus more fully seen; for we have precisely the same materials, differing only in degree of induration. We have the unaltered monuments of a wide spread ocean teeming with life, and we find recorded its changes through vast periods of time. We now learn what were the conditions of its bed at these successive periods, and also what different characters it presented at distant points. The varying forms of its inhabitants are as well marked and as perfectly preserved, as the recent species amid the mud and sand and pebbly bottoms of our present seas. The geographical limits of certain genera and species are as well defined in that primeval ocean, as in the present; and as now, upon the same bottom, we find in some places great accumulations of organic forms, while in others they are rare or wanting. Like our present ocean also, we know that this ancient one was agitated by winds and moved by tides; the drifted shells and comminuted corals tell us plainly of waves and currents, while in other places the fine sediment and equally distributed organic remains speak either of a quiet sea or deep water, where they were placed beyond the tumult that might have raged nearer the surface.

It is scarcely possible that the organisms of successive epochs could have been preserved in greater integrity than throughout the series, not only in our limited district, but over the whole State, and far westward to the Mississippi river; upon whose banks, and those of its tributaries, we find such an abundance of forms, as perfect almost as the living Naiades of these streams, which derive the material of their habitations from the destruction of these ancient deposits.

In its great topographical features, this district presents the following view: Bordering Lake Ontario on the north, is a low plateau, gradually rising to the south for a distance varying from four to eight or nine miles, where we abruptly ascend a terrace, which at its western extremity attains a height of two hundred feet, but which slopes gently down almost to the general level farther east. From the top of this terrace, we pass over a broad plateau of nearly level country, slightly depressed towards the centre, but rising gently again to the south till we come to the base of a second terrace, having a general height of sixty feet or more above the country on the north. These two terraces correspond with the outcrop of the two great limestone formations, the southern one extending throughout the State, forming a prominent feature from the Hudson to the Niagara river. Beyond the terrace last mentioned, the country is level and generally even for several miles, when we commence a gradual ascent to higher ground. Here, however, there is no definite line bounding the northern extension, as in the case of the two terraces; but the outline is irregular, projecting in one part and receding in another. We find ourselves upon the margin of a country composed of hills and valleys, having no general direction other than that given by the water courses. Although the country to the south of this is hilly, and in some parts rising to an elevation of twenty-five hundred feet above the ocean, yet it must be remembered that there are no ranges of mountains; the whole surface is equally and alike covered with elevated plateaux, without the possibility of limiting any of them as to course or direction. The deepest valleys being north and south, give this apparent bearing in some places to the neighboring hills.

Having no indications of disturbances or upliftings, we are therefore to look to another cause for the production of these hills. We must fancy this whole southern border of the State as having once been a high and broad plateau, with the underlying rocks extending much farther to the north, uniform in outline and even in surface as the limestone terraces just described; and that from denudation, the breaking up of the strata in some places, together with the action of waves and currents, has resulted this irregular and uneven surface. As proof of this, if we examine the strata on the two sides of a ravine, we shall find that if continued they would meet in the same plane; and pursuing the same course in regard to near or distant hills, or across broad valleys, we find invariably the same rule to hold good. These features are produced only by the removal of the mass which once filled the space, precisely in the same manner as those made by the excavation of roads through ridges of sand and gravel; the power in this case being that of nature over a great extent of surface, and in the other that of man over a very small one. All these hills are termed in geology *outliers*, or continuations of the same strata, where some intervening portions have been removed.

The larger streams flow in the deepest valleys, while the intermediate portion of country is less excavated, and presents eminences less abrupt. Much of the higher ground, indeed, exhibits a surface with gentle eminences and broad valleys, bounded by low hills equally extensive. This character is more extreme toward the southern limit of the State; and on going northward, gradually diminishes, the undulations becoming more gentle, until finally we come upon an almost unbroken level.

Further examination will show that each change in the topographical features is due to a change in the underlying rocks, and that the same rock does not give rise to any two of the main features described. The place and limit of certain formations are thus indicated upon the surface, and afford a general guide to the observer; though he will find less important changes in the strata not affecting the external form or character of the country. The thickness or extent of a rock, also, has great effect in modifying the external exhibition; while thin masses of different kinds may exist interstratified with thicker ones, and the whole surface carry the character of the predominating rock.

On investigating the lithological character of the strata of this district, we shall find that their varied composition and texture has given rise to the great features of its surface; and that hence is due not only those pleasing and beneficial inequalities, but also the origin of the streams and water falls which beautify and enliven the scenery, while they offer encouragement to enterprise and industry, which in a country less diversified would never be called into action. We find the first plateau, or that bordering Lake Ontario, underlaid by a soft friable or shaly sandstone, having nowhere, except in its higher members, sufficient firmness to resist the universal denuding action which has formerly prevailed far beyond the limits of this district. Accordingly it is evenly worn down, and presents few varied features, except in the river channels. Through Wayne and a part of Monroe counties, a portion of this gentle slope toward the lake is underlaid by some thin beds of limestone with alternating and succeeding shales, giving no different aspect to the surface. Through this part of the country, also, the terrace bounding the plateau is scarcely defined, forming merely a slight elevation above the country on the north. Westward from Rochester, it becomes a prominent feature; and the shales just alluded to form its abrupt northern slope, increasing in height as we go westward. The platform of this terrace is a thick mass of limestone, which has resisted the influences that levelled the shale and friable sandstone on the north; and it now presents its line of strike in bold relief, extending from Rochester to the Niagara river at Lewiston, and far beyond into Canada.

Again, this limestone is succeeded by soft marls and shales which have been levelled by the denuding agents, and present the second broad plateau. This is again limited on the south by a mass of limestone, sufficient to resist the power that wore down the others. Succeeding this limestone, are in turn soft shales, forming for some miles a level country, and the next ascent is produced by the interstratification of harder layers of sandstone. These strata of sandstone being thin, prevented the entire levelling of the shale, but did not produce the well defined outline presented by the limestone; consequently we have the gently swelling hills, gradually receding, and the contour softened in the undulating curves which mark the windings of the streams.

Such are the principal features of a portion of country, the rocks of which we are about to describe.

Connected with, and dependent upon this character of the surface, are other circumstances to be noticed. The form of the country, determining the direction of the present water courses, is a matter of great importance. The highest portion of this district is occupied by the counties of Chemung, Steuben, Allegany, Cattaraugus and Chautauque, the mean elevation of which is about two thousand feet above tide water. The northern portion of this range forms the dividing ridge of the principal streams flowing in opposite directions, which mingle their waters with the ocean at distant points. Those on the north find their way into the Atlantic by Lake Ontario and the St. Lawrence river; while on the south, some flow into the ocean by the Susquehannah, and others passing into the Allegany, find their way to the Gulf of Mexico by the Ohio and Mississippi. The Genesee is an exception to the general rule — a river which takes its rise beyond the borders of the State, and flows northerly through all these counties, and discharges its waters into Lake Ontario. A river of this magnitude passing through a great succession of strata, and descending in all its course nearly two thousand feet, has produced some grand exhibitions of the rocky strata.

Valleys similar to that of the Genesee, cross the district in a north and south direction; the principal of these are occupied in part by lakes, as Cayuga, Seneca and Canandaigua; the valleys in all cases continuing to the north and south of the extremities of these lakes, but the direction of the water courses being opposite from the highest part of the valley which is south of the lakes. These ancient water courses, with the great lakes and the river discharging all the western waters through its narrow gorge, while they modify the topography, form some of the most striking features of the district, and are subjects of the highest interest both to the man of science and the utilitarian.

To the same cause, to which we owe these prominent features and the hills of the southern counties, is also due the deep fertile soil prevailing throughout the greater part of the district. The materials excavated from these valleys in the form of fragments and masses have been transported and reduced to the condition of sand, clay and pebbles, which is distributed over the surface. By the same operation, also, the materials of the northern calcareous strata are mingled with the comminuted rocks of the south, and form the soil of unsurpassed fertility which supports the heavy forests, and produces the abundant harvests which render western New-York the garden of the State.

The high hills and deep valleys indicate the absence of an immense quantity of matter, which, during the same period, was transported in the direction of the great outlets into the present ocean, there to lay the foundation of future continents in strata like those occupying our district, filled with the organic remains of successive ages, and exhibiting throughout their extent all the varying characters that we now find in the rocky strata of our continent.

CHAPTER III.

Tabular view of the rocks and groups described in the Geological Reports of New-York; their extent, and agreement with those of Europe.

Geographical or local names having been employed in the annual reports for designating the different sedimentary deposits, the extension of this idea led to the adoption of the term NEW-YORK SYSTEM, including all those masses so well developed in the State, defined below by a well known line of demarcation, and terminating above with an equally well ascertained limit, viz. The Old Red Sandstone. In all this series, there are no limits by which subdivisions could be indicated, of sufficient importance to entitle them to the name of systems. The term thus becomes purely geographical, leading to no theoretical considerations whatever, being no favorite of individuals, but a consequence of the superior development of the strata included in that System, as brought forth by the geological survey of the State. The names which designate formations of the same age in other countries, are found inapplicable to our rocks; and by adopting the term New-York System, all ambiguity respecting its signification is avoided.

Below is a tabular view of the systems and groups adopted by general consent for the rocks of the State, and followed in all the Reports with no important variations. The names have, with few exceptions, been derived from well known places, where the rock is best developed, indicating in all cases an important point for the investigation of observers. In most instances where names had been previously applied, and concerning which there was no ambiguity, they have been retained.

I. PRIMARY OR HYPOGENE SYSTEM.

Including granite, gneiss, hornblende rocks, etc.

II. TACONIC SYSTEM.

Represented by the Taconic range of mountains in the eastern part of New-York.

III. NEW-YORK SYSTEM.

This includes all the products between the Taconic and the Old Red Systems, commencing with the lowest known sedimentary rock, and terminating at the base of the latter.

Under the New-York System are included the following rocks and groups, in their order of succession :

	Geographical subdivisions.	*Systematic subdivisions, founded upon the fossil and lithological characters.*	
NEW-YORK SYSTEM.	CHAMPLAIN DIVISION.	1. Potsdam sandstone.	
		2. Calciferous sandrock.	
		3. Black-river limestone group, embracing the Chazy and Birdseye.	
		4. Trenton limestone.	
		5. Utica slate.	
		6. Hudson-river group.	
		7. Grey sandstone.	
		8. Oneida or Shawangunk conglomerate.	
	ONTARIO DIVISION,	9. Medina sandstone.	
		10. Clinton group.	
		11. Niagara group, including shale and limestone.	
	HELDERBERG SERIES.	12. Onondaga-salt group.	
		13. Water-lime group.	
		14. Pentamerus limestone.	
		15. Delthyris shaly limestone.	
		16. Encrinal limestone.	
		17. Upper Pentamerus limestone.	
		18. Oriskany sandstone.	
		19. Cauda-galli grit.	
		20. Schoharie grit.	
		21. Onondaga limestone.	
		22. Corniferous limestone.	
	ERIE DIVISION,	23. Marcellus slate.	
		24. Hamilton group.	Moscow shales. Encrinal limestone. Ludlowville shales.
		25. Tully limestone.	
		26. Genesee slate.	
		27. Portage or Nunda group.	Portage sandstone. Gardeau flagstones. Cashaqua shale.
		28. Chemung group.	

IV. OLD RED SYSTEM, OR OLD RED SANDSTONE.

This division includes those rocks forming the greater part of the Catskill mountains; and extending westward, they disappear near the Genesee river.* The remains which mark this division, so far as yet known, are principally those of fossil fishes; two species only of shells having been found. Fucoids and fragments of land vegetables are abundant.

V. CARBONIFEROUS SYSTEM.

Of this System, but a single member, the lowest of the series, occurs in the State; unless it may be in the counties o Delaware and Sullivan.† This member, the conglomerate, forms numerous outliers in the Fourth district, always, however, isolated, and of small extent; no rock in the series above being visible.

VI. NEW RED SANDSTONE.

This formation extends within the State, occupying a portion of Rockland county, and being a continuation of the same rock more extensively developed in New-Jersey.

VII. TERTIARY.

Including the blue and yellowish clays, and their fossils, of the Champlain and St. Lawrence valleys.

VII. QUATERNARY SYSTEM.

This system includes all the superficial deposits of the State, except the Tertiary, and may be arranged under the following heads:

1. Transported materials,	Including gravel, sand, clay, etc.; being all that class of deposits which are usually known by the names diluvial, alluvial, drift, etc.
2. Local deposits,	Peat, muck, lake marl, tufa, bog ores, and soil formed from the decomposition of rocks in place; fossil bones of mastodon, etc.

* Since the numerous investigations in Europe have proved the Old Red Sandstone a system distinct from the lower rocks, it seems premature, in our present state of knowledge of that rock in this country, to merge it in the New-York System; particularly since those points which have served to identify the rock with the Old Red of Europe, certainly contain a very distinct assemblage of organic remains from the groups below. The rocks occupying the Catskill mountains, though evidently of the same age as the sandstone yielding remains of fishes farther west, have as yet produced no organisms of this kind; and further examinations must settle the question regarding the propriety of their union with the New York System.

† It must be remembered that we have no limestone within the limits of the State, equivalent to the carboniferous limestone of Europe; and therefore the lowest member of the System spoken of, is the lowest member as the series is known to us in New-York. Farther west, however, there is a limestone, holding the place of the carboniferous of Europe, which passes beneath the conglomerate; both of these are well exposed on the Ohio river, and in many places in Indiana and Kentucky. If this limestone be regarded as a part of the Carboniferous System, the conglomerate, which in western New-York and some parts of Ohio rests upon the Chemurg group, must be considered the second member in the ascending order.

The New-York System includes rocks, which, in Great Britain, have received three distinctive appellations: 1, The *Cambrian System* of Prof. Sedgwick; which, judging from specimens, includes rocks lower than the Utica slate, and apparently similar to the disturbed strata along the Hudson river, though probably not reaching so low as the Potsdam sandstone. 2, The *Silurian System* of Mr. Murchison; which embraces the rocks and groups from the Utica slate to the Hamilton group, and so ably and beautifully illustrated by that author. 3, The *Devonian System* of Prof. Phillips; which appears, from the numerous illustrations of its fossils, to correspond to the Chemung and Portage groups, and also to include a portion of the Hamilton.*

The Devonian System, as usually understood in this country, is supposed to include the Old Red Sandstone of Europe; but in central New-York, there is a well defined line of demarkation between the Chemung group and the Old Red, which contains remains of the Holoptychus, &c. Many of the fossils figured by Mr. Phillips are identical, and others very similar to those of our Chemung and Hamilton groups, while they differ widely from those of the Catskill, or Old Red Sandstone.

From the absence of all extensive disturbances of the strata, we are enabled to trace an uninterrupted series from the Potsdam sandstone to the Old Red. No where is there known to exist so complete a series of the older fossiliferous rocks, as those embraced within the limits of the State; and terminating at a point of great and important change in the condition of the surface, and included between this and the rocks of metamorphic origin, we have here offered one of the most decided and best characterized systems known in the whole world.

The New-York System thus becomes equivalent to what was embraced in the *Transition* by Werner, which term in modern times has been found too objectionable to retain. It likewise includes the three systems of English authors just mentioned, leaving the Old Red Sandstone and Coal to a subsequent period. And this for the reason, that in New-York, where the means of investigation are best afforded, and where the whole series is undisturbed, there is manifested the most complete and continuous succession; showing but one geological era for the deposition of the whole. In that era, the earth first witnessed the dawn of animal life, and ages of its greatest fecundity in marine organisms; and the approach of the period when it became fitted to support a vegetation so luxuriant and universal, of which no modern era affords a parallel.

Hitherto great confusion had prevailed regarding the rocks here enumerated as occurring between the Carboniferous and Primary series; and it was not until the publication of the result of Mr. Murchison's labors, that we had any definite knowledge of the sequence, in other places, of these extensive groups, which over thousands of miles in area are the most impor-

* Since writing the above, I have received Mr. Murchison's Address before the Geological Society of London, (1842,) and he there distinctly states that the Devonian System constitutes a portion of the Silurian, and is inseparable from it. This view accords perfectly with the facts here stated. In the same Address, the Cambrian System, as distinct from the Silurian, is no longer sustained; and the reasons are given which led to its adoption, as well as those for its abandonment. The views which have been long entertained here in New-York are thus unexpectedly corroborated, and the results will doubtless prove auspicious to the science.

tant rocks of our country. Heretofore they had all been termed *Transition* or *Greywacke*, and no successful attempt at subdivision had been made by any European geologists; while in this country, as before mentioned, all efforts had been to identify them with the published systems of Europe. Mr. Murchison's work therefore shed a flood of light upon what had previously been a region of darkness, and gave confidence to those whose examinations were directed towards the subject of elucidating these deposits.

In the Annual Report of 1840, I expressed the following opinion of the value of that work to the American student in lower geology:

"Since the publication of Mr. Murchison's work, we have been enabled to establish with "great certainty, the analogy of our rocks with those of the Silurian System, as developed "in England and Wales. In this country, however, the greater undisturbed range, and ap- "parently better development of particular members, with more numerous species of organic "remains, enables us to limit our subdivisions within narrower bounds, and thus offer greater "facility for the study of particular groups." — "It forms an era, and an important one in "the development of the older fossiliferous rocks, which have been so long enveloped in "obscurity. It offers inducements to the study of the same, which have never before been "presented; since, particularly in this part of our country, the rocks of the Silurian System "are better developed than any others; while the means of studying them with guides have "been entirely wanting. Thus the student, after weary months of labor, abandons the sub- "ject in despair, being unable to identify the rocks or fossils with any system heretofore "published; and having made too little progress to systematize the whole, distrusts what he "does know, because it seems inapplicable to what he supposes the same rocks or their "equivalents in another county." Mr. Murchison has done for the older deposits what Mr. Lyell has done for the more recent; and we have now in each system standard groups of reference, which, so far as examinations have progressed, hold true over extensive districts of country.

Mr. Murchison, in company with M. de Verneuil, has since been investigating the same formations in Russia; and he mentions, in a letter, the occurrence of rocks in Siberia, charged with Pentamerus Knightii, a fossil abundant in a particular position in England. Formations of the same age have long been known in Sweden and Norway, Canada and various parts of North America, extending far westward; and during the past year, I have traced the groups as developed in New-York, throughout the country intervening this State and the Mississippi river, and thence into the territory of Iowa. The occurrence of fossils typical of the lower part of this great series, shows its extension over an extremely wide area. Fossils from Lake Huron, Lake Winipeg, and several points of the far northwest, all indicate the existence of rocks equivalent to the Lower Silurian of England, or the Champlain division of New-York. Mr. Stokes, in a paper "On some species of Orthocerata," published in the Geological Transactions, speaking of the localities, and the circumstances under which they were collected, remarks: "It will be observed that these American localities are "widely separated from each other, and are not parts of a continuous deposit; but the agree- "ment in character of the limestone rock, and of the fossils, shows that they are of the "same geological age." From examinations made in the eastern part of Maine, New-Brunswick, Nova-Scotia and Canada, by Messrs. Jackson and Alger, Capt. Bayfield, Dr. Emmons and others; and from the examinations of Bigsby on Lake Huron, of Houghton in the northern and southern peninsulas of Michigan, and of Owen upon the Mississippi river; together with facts collected from others, and having also passed over much of this ground myself, as well as of some intermediate points, it appears that there is an almost continuous deposit of the lower rocks of this great system entirely across the continent, from the Atlantic to the Pacific oceans. Thus over an extent of more than half the circumference of the globe, the existence of these older fossiliferous rocks has been proved; and from being a neglected and unarranged mass, they seem likely to assume the first rank in importance among geologists of the present day.

Notwithstanding the remarkably persistent character of the lower formations of this great System, I am able to state from personal observation that the higher groups thin out rapidly in a western direction from New-York. The rocks above the Helderberg series, known in New-York as Marcellus slates, Hamilton, Portage and Chemung groups, and some minor subdivisions, altogether forming a mass of more than three thousand feet in thickness, have diminished to less than as many hundreds before reaching the Mississippi river. At the same time, the rocks forming the principal part of the Catskills, and being in part or the whole equivalent to the Old Red Sandstone of Europe, together with several members of the Helderberg series, have disappeared in a western direction within the limits of the State of New-York. The wide spread and generally uniform character of the one, proves a similarity of circumstances throughout; while the great difference in thickness, and the absence of fossils in parts of the other, proves a great difference in the conditions under which they were deposited at different points. We shall probably find that the remark heretofore made, that "the older deposits are the more universal," will hold true, not only as regards the great systems or classes, but also the minor subdivisions. It exhibits in the commencement of the organic period, a uniformity in depth and temperature of the ocean, or other circumstances favorable to the development of the same forms over vast areas, which in subsequent periods have constantly diminished.

While the investigations have been going on which have resulted in the development of the rocks of New-York, as exhibited in the tabular arrangement, we have had fellow laborers in other parts of this great field. Other States have pursued the same course; and from the numerous and efficient observers, we have accumulated a great amount of knowledge regarding the geological structure of the whole Union.

In Maine, the Primary and lower fossiliferous rocks have been investigated by Dr. Jackson, and also the Primary and Coal measures of Rhode Island, and the Primary of New Hampshire.

In Massachusetts, after the publication of the report of the first survey, a resurvey was ordered; and Prof. Hitchcock has just completed two quarto volumes, giving the results of his researches in the Primary, some isolated tracts of the Carboniferous, New Red Sandstone of the Connecticut valley, and Tertiary upon the coast.

In Connecticut, Dr. Percival with Prof. C. U. Shepard have investigated the geology and mineralogy of the State, which includes the Primary, New Red Sandstone and Trap.

In New-Jersey and Pennsylvania, Prof. H. D. Rogers, and in Virginia, Prof. W. B. Rogers, have been occupied in exploring the formations from the Primary, through all the older fossiliferous rocks, the Carboniferous period, New Red, Oolite, Greensand and Tertiary.

In Maryland, a geological and topographical survey of the State has been in progress for several years, by Prof. Ducatel and J. H. Alexander, Esq., and the work is now nearly completed: a local survey of the coal region of Alleghany county has been made during the past summer, by Prof. Aikin.

Prof. W. C. Booth has made a geological survey of Delaware, giving a complete account of all its formations and mineral productions.

In the Ohio survey, under the direction of Mr. Mather, the reports of Dr. Locke, Messrs. Whittlesey, Briggs and Foster, have elucidated in a great measure the geology of the State. Dr. Hildreth had previously done much towards illustrating this subject, and his valuable papers in the American Journal of Science are fully appreciated by those who have any knowledge of these formations in the west.

In Michigan, Dr. Houghton has been actively and zealously engaged in prosecuting to its completion, a very thorough survey.

In Indiana, Dr. Owen, under the direction of the authorities, and partly upon private enterprise, has developed the great geological features of that State; and, with Dr. Locke, has more recently been engaged in the lead region of Illinois, Wisconsin and Iowa.

In Tennessee, Dr. Troost has been for several years engaged in a geological survey of the State, which has developed an interesting series from the Primary upwards.

Mr. Nicollet has recently been investigating the formations west of the Mississippi, and his discoveries in that region have proved highly satisfactory and important.

In Georgia, Dr. Cotting has completed a survey of the State, and published a report upon its mineral productions.

North and South Carolina had been previously investigated by Professor Olmsted and Mr. Vanuxem.

It will thus be seen that much the greater part of the territory east of the Mississippi river has been partially or entirely explored under the direction of the respective State governments. The remainder will doubtless soon be investigated, either under the same auspices, or by private enterprise. Much yet remains to be done in the way of harmonizing views, and bringing the nomenclature to some general standard. For as these surveys have mostly been pursued quite independently of each other, it has led to the adoption of terms, which, however applicable, cannot all be well retained without overburdening the science with synonyms. The comparative development of the rocks and groups in different parts of the Union, will probably be the test of nomenclature; since local or geographical names have been generally adopted, and at the present time meet with most favor.

The results of all these investigations have proved the existence of the rocks of the New-

York System over the greater portion of the country between the grand Primary chain on the east and the Mississippi river. And it further appears that throughout all this extensive area, these formations are overlaid by no rocks more modern than the Coal formation, except in a few limited districts where the newer Secondary rocks or those of the Cretaceous group succeed the latter. Such wide development and generally undisturbed condition will certainly afford the means of bringing to light many important facts regarding the formations, which could never have been known from the examination of limited districts, however perfect the sequence. As before remarked, the territory of New-York, from possessing the most complete series, and abundance of fossils, together with the undisturbed position of the strata, offers the most interesting field of investigation and reference, and will be found the best point of departure for the geologist who is making more extended researches.

The geographical divisions in this table, though convenient for reference, nevertheless do not indicate any great natural divisions of the system as founded upon fossil characters. Such a mode of subdivision will follow only a perfect knowledge of the fossils, both in this State and elsewhere. From the commencement of the fossiliferous rocks, to the termination of the Hudson-river group, there seems to have been a uniformity of condition and a continuation of species which cease with this period, and cannot be found in any subsequent one. The two lower masses, it is true, so far as examined, contain few fossils, and those of species not known to extend upwards; but these rocks must be considered as having been produced at the dawn of that era, and are emphatically the "protozoic rocks;" while, after living forms had become abundant, many of the same continued throughout the whole period undestroyed.

Mr. Conrad is disposed to include in this period the Medina sandstone and Clinton group. The former possesses many analogies, though none of the fossils of the lower rocks; while, on the other hand, none of the fossils of the Medina sandstone are continued into the rocks above, and the apparent continuation of the Grey sandstone into the base of the Medina would argue in favor of placing the latter in the lower division. But in regard to the Clinton group, its great contrast with the Medina sandstone, both in lithological and fossil characters, seems an insurmountable obstacle in the way of uniting this with the lower division; particularly as in many points that group, or its fossils, pass into the next above, while we have not a solitary example of the passage of any fossil from the lower group into this. The termination of the Medina sandstone, therefore, as far as regards the State of New-York, must be considered the termination of the lower division of the system.

Throughout a part of New-York, and more particularly in Pennsylvania and Virginia, as we learn from Professors H. D. and W. B. Rogers, the Oriskany sandstone forms a marked line of separation, and might perhaps well be considered the limit of the Second great division. Nevertheless, the absence of this rock in western New-York, in Canada, and, so far as I know, in Michigan, Ohio and Indiana, would still render it an obscure point of reference. The "Cliff limestone" of Ohio, which is there known as a single formation or group, includes rocks both above and below the Oriskany sandstone. This shows such a close analogy in the strata, that together with the absence of the rock on which the division is to be founded, it seems more natural to bring all the limestones into the second great division. Throughout the region noticed, the upper limestone of the Helderberg series, the Corniferous, would form a much more obvious termination of the second division. This is every where recognizable, and thence upward to the Carboniferous, the rocks are marked by an entirely different assemblage of organic remains. In the Helderberg series, where well developed, the line of division, if dependent upon fossils, can be made at one point as well as another; few of the forms rising above the group of which they are typical.

This arrangement would leave all the shales and thin-bedded sandstones of the succeeding groups to form the Third and last division of the System; being a natural lithological assemblage, and also palæontological, if specific characters are considered.

Another advantage to be derived from this arrangement is, that the great dissimilarity of the products of the different divisions would lead to no confusion, as might result if some of the limestones are left to be grouped with the shales; the latter being very meagerly fossiliferous in the west, while the limestones are highly so.

The middle division would embrace groups exhibiting a considerable diversity of fossil characters, yet all possessing forms bearing a generic identity. The different groups, as exhibited in the tabular view, with their fossils, to be enumerated in another place, will show the character of this division of the system. These three divisions would be easily recognized from the great change in lithological character, as well as extinction of fossil species, at the termination of each one.

CHAPTER IV.

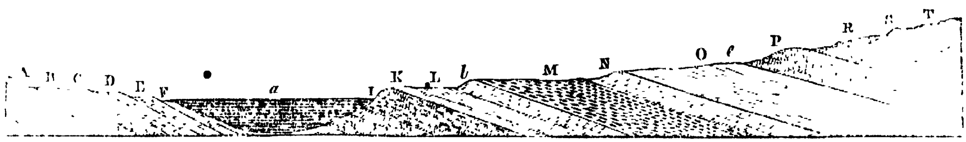
Enumeration of the rocks and groups below those of the Fourth Geological District, in the order of succession.

The rocks occupying the Fourth District commence at about the termination of the lower great division of the System; a point above which, few or none of the previously existing organic forms are continued. The rocks and fossils of the lower division are described in the reports of the First and Third districts; and they are merely enumerated here in the order of succession, for the purpose of showing their connexion with those of the Fourth district, which terminate above with the conglomerate of the carboniferous period. The report will thereby be rendered more complete and satisfactory in itself, affording means of reference to the relative situation of the lower rocks, and of comparing the genera and species of their fossils with those above.

The want of some previously acknowledged base line, from which to make the starting point, has been felt during the whole of the survey; and to supply in some degree this deficiency, I have examined the lower rocks upon the north side of Lake Ontario. These show a continuation of the lower groups as developed in the eastern part of the State, with the exception of that portion occupied by the basin of the lake. This, between the Fourth district and the Canada shore, has been excavated partially from four of these groups, viz. the Utica slate, Hudson-river group, and Grey sandstone, as well also as a large portion from the Medina sandstone, which forms the southern border of the lake from Oswego to its western extremity, and its northern margin for many miles near the western termination.

From these facts, it will appear that a section extending across the Fourth district, and embracing the rocks upon the north side of the lake as far as the Primary range, will give a connected view of all the rock formations presented farther east.

The following woodcut will illustrate these remarks. It shows the relative position of all the rocks of the Fourth district, as well as their relations to the lower ones, in a section extending from the Primary of Canada, across the lake, and thence across the State of New-York from the mouth of Genesee river to the Pennsylvania line.



A. Primary.
B. Potsdam sandstone.
C. Calciferous sandrock.
D. Black-river limestone.
E. Trenton limestone.
F. Utica slate.
G. Hudson-river group.
H. Grey sandstone and Oneida conglomerate.
I. Medina sandstone.
K. Clinton group.
L. *l.* Niagara group.
M. Onondaga-salt group.
N. Helderberg series.
O. Hamilton group, including Marcellus slate and Moscow shale.
e. Tully limestone.
P. Portage group and Genesee slate.
R. Chemung group.
S. Old Red system.
T. Conglomerate of the Carboniferous system.
a. Lake Ontario.

The distance upon the north side of the lake has been much shortened in proportion, in order to give more room for the rocks upon the south side.

The same order of succession as here exhibited in the lower rocks and groups, may be seen upon the northern shore of the lake between Gananoqui on the St. Lawrence, where the Primary and Potsdam sandstone are in juxtaposition, and Toronto, where the Hudson-river group forms the only rock of the neighborhood. The Calciferous sandrock, Black-river and Trenton limestones, are seen at intermediate points, covering extensive tracts in the neighborhood of Kingston, Bay of Quinta, and other places. From the point where these rocks leave the northern shore of the lake, they trend northwesterly; appearing upon the north side of Lake Huron, and thence extending westward to the Mississippi river.

1. Potsdam Sandstone.

The Potsdam sandstone is the lowest known sedimentary fossiliferous rock; it appears in the Second district as a mass of great importance, and flanks the great Primary range or nucleus on the east, north and west, and rests directly upon the hard crystalline strata, as may be seen by reference to the Geological map. It is usually of a pure quartzose character, generally grey, though often striped, and sometimes partially or entirely red. From its proximity to rocks of igneous origin, it frequently assumes a slaty or gneissoid structure; and it is not improbable that sometimes, in favorable situations, it becomes so completely disguised as to be mistaken for a gneissoid or granular quartz rock. In places it appears as a conglomerate, but in all the localities examined on the north of Lake Ontario, the enclosed masses are angular, showing them to be near their origin. This is an extensive rock, known as before stated in New-York, Canada, and, from Dr. Houghton's researches, on Lake Superior; and from position it is probably the same which appears on the Mississippi river, and mentioned by Dr. Owen in his Report on the lead region of the northwest.

This rock is No. 1 of the Pennsylvania Survey, being common to that State, New-Jersey and Virginia. It is an interesting rock, as exhibiting to us the dawn of animal life ; and the first living thing entombed and preserved through unnumbered ages, its delicate structure uneffaced to the present moment, is a species of Lingula, which is its only known fossil. This fact affords a remarkable example of the tenacity of life in this family of shells, for we find them in every successive group in the system ; they have existed in every geological era, and are living in the present ocean.

2. Calciferous Sandrock.

The Calciferous sandrock, a mass for the most part intermediate between sandstone and limestone, being an intermixture of both, forms the next rock in succession, and appears equally extensive. Indeed, in some places, it is more persistent than the former. It is a very important rock in the First, Second and Third districts, both in extent and thickness. It is likewise interesting from being the lowest position in which anthracite coal is known to exist, being found in this rock associated with the quartz crystals. It yields the finest quartz crystals known, and they are more or less abundant in all situations where the rock occurs.

Organic Remains. — In nearly all the situations where this rock appears, fossils are rare or entirely wanting, and but few individuals have ever been found. Those at present known are the following: Lingula acuminata, Ophileta levata, O. complanata, Pleurotomaria, Orthoceras primigenius, and plates of Crinoidea.

In the upper layers of this rock at Chazy, Dr. Emmons has obtained the following fossils: Scalites angulatus, Maclurea labiatus, M. striatus, Bellerophon sulcatinus, Orthis and Orbicula.

There is also a layer characterized by the presence of fucoids, which is very persistent; and probably from these marine plants is derived the carbonaceous matter which forms the anthracite.

3. Black-river Limestone Group.

This group consisting of the Birdseye and Chazy limestone, is a remarkably persistent mass, being known together with the succeeding one, almost or perhaps the entire width of the continent. The rocks of this group appear in the northwestern part of New-York ; they extend thence into Canada, and they are seen on Lake Huron, upon the Mississipppi river, at Frankfort in Kentucky, and are well known in Pennsylvania and Virginia.

Organic Remains. — The Birdseye limestone of Prof. Eaton forms a part of this group, being every where known by the presence of its peculiar fossil, the so called *Fucoides demissus*, (since ascertained to be a coral,) which is typical of this rock in all situations. Besides this fossil, it contains a species of trilobite, Orthoceras multicameratus, Ellipsolites ? Strophomena lævis. Few others are known, and it usually appears destitute of such remains.

The Chazy limestone, which is considered by Dr. Emmons a distinct rock, contains a few fossils peculiar to itself. These are the Maclurea, a fossil closely allied or identical to Euomphalus ; Columnaria sulcata, with a few others.

4. Trenton Limestone.

This rock usually consists of a dark-colored limestone, intermixed and interlaminated with black shaly matter of a character similar to the succeeding rock. It accompanies the Birdseye in New-York, generally resting upon it in situations where both appear. In lithological characters and fossils, they differ essentially; the latter more particularly distinguish them. It appears to be equally extensive with the mass below; the true distinction between them, however, not being always observed.

Organic Remains.—This is geologically the lowest rock that yields an abundant harvest to the palæontologist. The following are already figured and described: Isotelus gigas, I. planus, Bumastis trentonensis, Calymene senaria, Calymene ——? Illænus trentonensis, Ceraurus pleurexanthemus, Trinucleus tessellatus, Trocholites ammonius, Inachus undatus, Pleurotomaria lenticularis* and three other undescribed species, Subulites elongata, Cyrtoceras filosum, Cameroceras trentonensis, Orthoceras multilineatus, O. trentonensis and three other undescribed species, Bellerophon punctifrons, B. bilobatus, B. profundus, Nucula inflata, N. faba, Pterinea undata, P. orbicularis, Strophomena alternata, S. deltoidea, S. sericea, Orthis striatula, O. pectinella, O. leptænoides, Delthyris expansus, Delthyris ——? Atrypa extans, A. bisulcata, Favosites lycoperdon.

5. Utica Slate.

The Trenton limestone is succeeded by a dark or black carbonaceous slate. Where extensive disturbances have prevailed, this mass is not every where distinguished from the group which succeeds, though it merits a distinct place, from its general characters as well as from its peculiar fossils. Within the State, it is every where black, and usually soft and fissile; but from contained fossils, it would appear that its color has changed to green in Ohio and other places at the west. Thin beds of impure limestone are associated with it in many places. From a comparison of specimens from this rock when in the vicinity of hypogene or altered masses, it corresponds very closely with the Llandeilo flags of Mr. Murchison; and I have detected in specimens of the latter a small Lingula, which is very similar if not identical with one which occurs in the Utica slate. In its lithological characters, it does not differ from the shale interlaminated with the Trenton limestone.

Organic Remains.—Triarthrus Beckii, Trocholites, Avicula insueta, Nucula poststriata, N. scitula, Cypricardia sinuata, Graptolites dentatus, G. scalaris. The following are common to this rock and the Trenton limestone, according to Mr. Vanuxem: Orthis striatula, Strophomena alternata, Lingula ovalis, Favosites lycoperdon, Isotelus gigas, Calymene senaria.†

* The *Trochus lenticularis* of the "Silurian System."

† See Report of Third District.

6. Hudson-river Group.

Where the strata are undisturbed, a well marked line of division usually separates this group from the Utica slate; but along the Hudson river, and in other places where disturbance has prevailed, the two are not easily separable. Indeed from the fact that several fossils of the Trenton rocks are continued through the Utica slate, and appear in this group, we might almost be inclined to consider it as a continuation of the same; beginning with a shaly limestone, and passing through shale and shaly sandstone to the termination of the series. The group consists of shales and shaly sandstones, with thin courses of limestone, and in many places its upper portions abound in fossils.

Organic Remains.—The following are those enumerated and described: † Calymene senaria? Triarthrus Beckii, Trinucleus caractaci, Avicula demissa, Pterinea carinata, Cypricardia modiolaris, C. angustifrons, C. ovata, Nucula, Strophomena nasuta, † S. sericea, Strophomena ——? † Orthis striatula, O. Actoniæ, O. testudinaria? O. crispata, Orthoceras æqualis, Pleurotomaria, stems of Crinoidea, Graptolites serratus, G. scalaris, &c. It will be seen that several species (†) are common to this group and the Trenton limestone.

This group appears to be equally extensive with any of the lower masses, but its lithological characters change essentially at distant localities. Upon the Hudson river, and in most other places in New-York, it is exhibited in the form of slates and thin-bedded shaly sandstones, forming what has been known as argillite and greywacke. Pursuing this group westward, it is found in Ohio represented by limestone and shale or marl, forming the "Blue limestone" of the Geological Reports of that State. It presents the same character in Kentucky, Indiana and Wisconsin. At the same time, however, it retains many of its characteristic fossils, with the addition of many new ones, or species which do not exist in any group in New-York. This group thus exhibits an example where lithological character has ceased to be of any great importance in identifying strata. The fossils at the same time are found to be much more constant, though the greater number of individuals of different species renders the eastern types less prominent than otherwise.

This group not only extends into Canada on the north and east, but far west and southwest; appearing, if we may judge from specimens, in Tennessee, and near the Hot springs in Arkansas. It is likewise an important rock in Pennsylvania and Virginia. This mass becomes interesting from the fact that it appears to be equivalent to the second great group in the Silurian system of England, representing in its undisturbed and fossiliferous condition the Caradoc sandstone. This would appear from the comparison of numerous specimens, brought out by Mr. Lyell from well known localities in England, and which are now in the Collection of the Lowell Institute at Boston. These leave no doubt of the perfect identity in fossil and lithological characters. The same group, when disturbed and upheaved, as it is on the Hudson river, doubtless represent the Cambrian system; this portion having generally been considered as a much older series than the same farther west. But the facts correspond to those observed in England, viz. an identity in the contained fossils; the only difference being produced by disturbance, and sometimes a partial alteration of the products.

The change in organic remains at the termination of this group is very great, scarcely one of the same species being known to exist in the higher rocks. It thus becomes an important point, and well entitled to be considered as the line of division between the lower and higher portions of this great system.

7 & 8. Oneida Conglomerate, and Grey Sandstone.

In the eastern part of the State, the Hudson-river group is succeeded by a quartzose conglomerate; while in the western part, a grey sandstone occupies the same place. The conglomerate forms the Shawangunk mountain, and the mass in Oneida county and in Pennsylvania attains a much greater thickness. It is not seen in place west of Oneida, though it appears in boulders* scattered upon the surface. The Grey sandstone succeeds the Hudson-river group in Oswego county, there being a gradual passage from the one to the other. It is in character a grey quartzose sandstone, fine grained and compact, entirely destitute of fossils except a few fucoids, thus forming a contrast with the mass below.

Passing upward, the Grey sandstone intermingles with the Medina sandstone, which in its lower part differs from that, chiefly in color, but its upper part contains peculiar fossils. The red color of the Medina sandstone seems in some places to be partially communicated to the grey below, which is often striped and spotted with red. There is lithologically no very strong line of demarkation between the two rocks; thus offering a gradual passage from the Hudson-river group to the Medina sandstone, which might perhaps with propriety be included in the lower division. The chief difference is in color, and the occurrence of a few fossils not found below.

The latter rock forms the lowest mass of the Fourth district, and its connexion with those below has been briefly explained; the short notices being intended merely for reference as to order of succession, characters of strata and fossils; while for the details of each mass, the other reports will be consulted.

The section shows the absence of three members: the "Grey sandstone," the Hudson-river group, and Utica slate. The whole width of the lake from the Genesee river northward, is excavated in the lower part of the Medina sandstone, and the whole of the three groups enumerated. Farther west along the southern shore of the lake, pebbles and worn fragments of the rocks of the Hudson-river group, containing the common fossils, occur in great numbers.

To the south of the lake, the section exhibits the rocks of the New-York System, from the Medina sandstone upwards, in their order of succession, and also their connexion with the next higher masses. In this order, the different rocks and groups will follow in the succeeding chapters.

* See Report of Third District: Oneida conglomerate.

CHAPTER V.

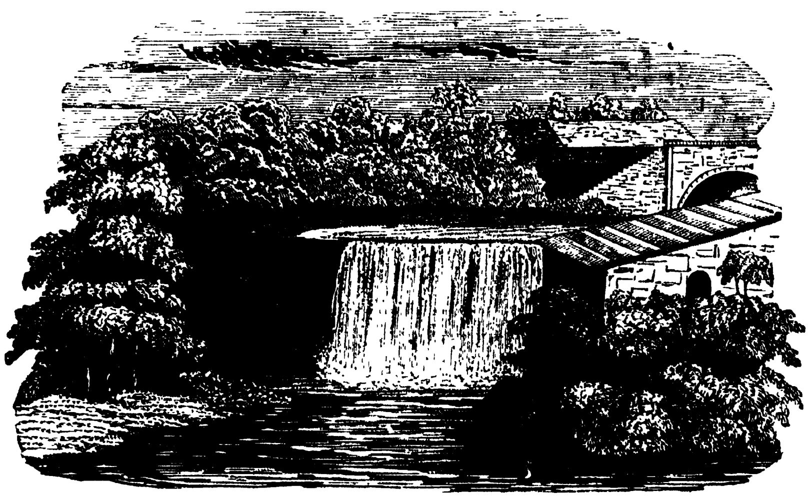
Description of the rocks and groups of the New-York System embraced within the Fourth Geological District.

The previous chapter contains an enumeration of the deposits forming that part of the New-York System between the Primary and the Medina sandstone, or No. 9 in the order of succession, and the lowest rock of the district. The rocks of the Fourth district consist principally of series of limestones, shales and sandstones, each passing into the other by insensible gradations in some points, while in others the line of separation is distinctly marked. Each formation or stratum is limited on the north by its outcrop, and on the south by the superposition of the next successive deposit, under which it disappears. These are for the most part continuations of those which commence farther east. In some instances they have thinned partially, and some members of the Helderberg series are wanting; in others, as the Medina sandstone, and Niagara group, the greatest development appears within the limits of this district, and diminishes to the east.

Investigations throughout the whole State have proved that there is some one point or limited area where each rock, or the members of each group, are better developed than in any other, and this one is adopted for the name. The advantage of names from localities over those from descriptive characters, is decidedly great. In the latter case, the description or character may not convey to the reader precisely the same ideas as those possessed by the writer; and again, distinctions in character cannot be so accurately described, but that another rock may possess the same in a sufficient degree to be mistaken for the true one. The characters of a rock rarely remain uniform over a great extent of country; and hence a descriptive name, applicable in one place, may not be so in another. On the other hand, when a name is given from the locality, the description of the rock follows; and although it may vary at distant points, or another rock be found possessing the same character, still the type remains; and whatever of doubt or obscurity may ever arise, the examination of the original locality would decide all difficulties. Since rocks are identified more by their fossil contents than by their lithological character, a name descriptive of the latter is of less consequence than formerly, when fossils were the subordinate characters of a mass.

Notwithstanding, however, that palæontological characters have taken precedence over all others in distinguishing sedimentary strata, still the lithological character must not be overlooked; for in some cases it will be found an unerring guide, if properly understood, over hundreds of miles in extent. Changes in the lithological features of a rock, also, which may render observations unsatisfactory or doubtful, are usually accompanied by greater or less change in the nature of the fossils. In no case, therefore, are to be overlooked either of the three important facts and characters, viz. *Lithological character*, *order of superposition*, and the *nature of the contained fossils.* A more extended knowledge of the development of the *great groups of the older sedimentary deposits, which with some exceptions or interruptions extend almost across the continent, will enable us to appreciate more fully the comparative* importance of the distinctive characters by which they are identified.

2.



View of Medina Falls, from a Sketch by MRS. HALL.

9. MEDINA SANDSTONE.

Saliferous rock, of EATON; *Niagara sandstone, Red sandstone of Oswego, Variegated sandstone*, and *Red marl and sandstone*, of the Annual Reports.

(No. 5, OF PENNSYLVANIA SURVEY.)

This mass is usually a red or slightly variegated sandstone, solid and coherent in the eastern extremity of the district, becoming friable and marly in its western extension, and admitting an intercalated mass of grey quartzose sandstone which contains marine shells; while in the red portions, are rarely found other than marine vegetables or fucoids. This rock gives origin to brine springs throughout its whole range. It extends westward beyond the limits of the district into Canada, but is not known in the southwest, in Ohio and Indiana. Both in Pennsylvania and Virginia, it is found possessing the same essential characters as in New-York.

The locality which gives the name, exhibits the rock best developed, and with its characteristic fossils. The rock is the lowest of the district, and the ninth of the New-York System in the ascending order.

By reference to the Geological map of the State, it will be seen that this rock extends throughout the district from east to west, bordering Lake Ontario. It forms but a narrow band in Wayne county, but expands to the westward, and seems to attain its greatest thickness near the Niagara river; as is indicated by the breadth of surface occupied by the mass, and also from the fact that it appears on the north side of the lake to the west of Toronto. It continues beyond the Niagara river, having been traced as far as the head of Lake Ontario, and it is believed to extend much farther westward.

In Wayne county, it is usually a firm siliceous rock, approaching to a conglomerate in some places near the lake level. On going westward, the sand in part gives place to argillaceous matter; and before reaching the Genesee, the greater part of the mass, visible above the lake, has become a marly sandstone; the upper part, only, being firm, and withstanding the effects of weathering. Its enduring character in the eastern part of the district is well exhibited by the great number of pebbles and boulders scattered over the surface of Wayne county, and some parts of Monroe, and which diminish westward. Pebbles of this rock, however, form a large portion of the drift far to the south, and may be found intermingled with the products of more southern ranges, in all the valleys as far as the Pennsylvania line. In some places in the northern range of counties of the district, the surface is literally covered with pebbles of this rock, almost wholly unmixed with any other.

From its shaly or marly character upon the Genesee river and in the country west, this rock was originally mistaken for the red shale of the Salt group, which it closely resembles. The latter appears in Onondaga county on the canal; and by following the same line westward, no other rock appears until within a short distance of Rochester. The marly sandstone appearing here was naturally taken for a continuation of the rock seen in the vicinity of Syracuse, and the occurrence of salt springs likewise aided to complete the deception. This opinion prevailed until the Geological survey had made some progress, when it was found that the Clinton and Niagara groups both intervened between the Medina sandstone and the continuation of the Onondaga-salt group.

The scenery exhibited along the line of outcrop of this rock is in some places interesting in the highest degree. In Wayne county, from its rising but little above the lake, it forms only some inconsiderable falls in the streams; always strongly contrasting, by its deep reddish brown color, with the rocks above. In Monroe county, it forms the lower falls of the Genesee, one hundred and ten feet in height; one of the most picturesque spots in the district, exhibiting not only this rock, but above it, in the cliff, the Clinton group and shale of the Niagara. It also forms the banks of the river below, extending nearly to the lake. In Orleans county, at Albion, there is a low fall on Sandy creek over the same sandstone; and by following that stream farther up, its connection with the higher rocks can be readily observed. At Medina, on Oak-orchard creek, this rock forms the beautiful little cascade represented in the woodcut.

The deep gorge and the high cliffs on either side of the Niagara at Lewiston, are more than half excavated in this rock; and the partial obstruction of the water at the whirlpool is caused by a part of the same mass. Its alternations of harder and softer masses produce cliffs or cascades along its whole extent.

This rock, where best developed, admits of a fourfold division, as it appears throughout the greater part of the Fourth district. Including the "Grey band," which here forms an integral part of the mass, it may be represented as follows:

1. Red marl, and marly or shaly sandstone, sometimes banded and spotted with green; the bands horizontal, or parallel to the strata, and vertical.
2. Grey quartzose sandstone, entirely distinct from the mass below.
3. The lower part is merely a repetition of No. 1; gradually passing into a more sandy form in the western portion of the district, while in the eastern portion the whole of this division is more siliceous, the central mass (No. 2) not appearing.
4. The grey or greenish grey terminal portion of the mass, which in the Third district is considered a distinct rock, forming the Oneida or Shawangunk conglomerate. In the Fourth district, it always appears more or less as a part of the Medina sandstone, possessing the same lithological features.

1. Red Marly or Shaly Sandstone.

Throughout the counties of Niagara, Orleans and Monroe, the lower part of this rock is a soft red shale or marl, with but a small admixture of siliceous matter. It coheres but slightly where weathered, and readily decomposes to a loamy clay. When exposed in the banks of ravines and streams, it presents a cracked and crumbling appearance; the surface crossed in every direction by seams, separating the whole into small angular fragments, which are constantly softened and detached by the weather, exposing a fresh surface which in turn undergoes the like changes. The first appearance, after being broken down in this manner, is that of cubical or angular fragments, which are easily crushed in the hand, mixed with a smaller proportion of soft clay. The process of disintegration goes on till the whole is reduced to a clayey soil of a brick-red or brownish color. These changes may be witnessed on the banks of the Niagara at Lewiston, the banks of the Genesee below Rochester landing, and in nearly all the small streams crossing the Ridge road between the Genesee and Niagara rivers.

In Wayne county, the lower division of this rock can scarcely be said to exist, though that portion near the level of the lake possesses in a considerable degree the same characters. The color of the decomposing rock has been communicated, often in a high degree, to the soil above. This is more particularly seen where the covering of transported materials is light, as throughout all that portion of the country between the Ridge road and Lake Ontario. The same color prevails in a less degree much farther south, where the materials derived from the destruction of this rock form a large proportion of the drift or transported matter, producing the soil of the district. This brownish color of the soil will not be confounded with the deep red color produced by the destruction of the red shale of the Onondaga-salt group, which is seen to a great extent farther east, but which has had little influence in the Fourth district.

The uniform texture of this part of the rock, is the cause of the very even surface of the country bordering Lake Ontario between the Genesee and Niagara rivers. The same character is presented in some degree east of the Genesee, except where interrupted by hills of drift. When penetrated to some distance, it appears compact, and is readily quarried into large blocks, but it does not withstand the effects of weathering. This has been tested by the experience of many years; and the quarries in this division of the rock are now, I believe, generally abandoned.

This is one of the most uniform masses in the whole district, the only change in its whole extent being the gradual increase of argillaceous matter in a westerly direction. Its uniform reddish brown color is but slightly relieved by the occasional spots and bands of green, and the absence of fossils renders it a very uninteresting rock to the geological observer.

2. Grey Quartzose Sandstone.

In the western part of the district, the lower division is succeeded by a grey quartzose sandstone, exhibiting a sudden contrast in the material and coloring matter. This mass, which is twenty-five feet thick on the Niagara river, extends through Niagara and Orleans counties, but is not seen in Monroe or Wayne, either from having thinned out, or from passing beneath the lake; the former is more probable, as there is no evidence of the latter. From Medina westward it exhibits a prominent line, rising abruptly from the softer rocks below, and jutting out beyond those above, forming a terrace, which runs a little to the north of the great limestone terrace or mountain ridge. It appears as a projecting band in the banks of the Niagara river, extending from Lewiston as far as the Whirlpool, where it disappears beneath the level of the water.

The mass is mostly composed of thin layers, from the thickness of one-eighth of an inch to six inches. Near the Niagara river the layers are generally thicker, the deposition apparently having been more rapid. At a quarry one mile north of Lockport, the layers are often exceedingly thin, not more than one-eighth to one-fourth of an inch, and perfectly separable from each other, the planes in many instances presenting a partial coating of the oxide of manganese. The surfaces are exceedingly smooth, as if washed by water before the deposition of the succeeding layers; in other cases they are covered with the separated valves of Lingula, and marked with numerous wave-lines.

This mass, which is light grey or nearly white on the Niagara river, becomes slightly tinged with red on going eastward, and at Medina some thin layers are strongly colored; it, however, maintains its general uniformity, the grey color and quartzose character every where predominating. East of Medina it is seen in but few places, and in these not well developed.

In lithological character, this mass bears a very close analogy to the sandstone forming the terminal member of the Clinton group in Herkimer county, as it appears on the south side of the Mohawk in several places. The peculiar fossils are wanting, however, and the association is entirely unlike.

The range of the grey sandstone from Lewiston eastward is, for several miles along the base of the escarpment, formed by the Niagara limestone; afterwards it extends a little farther northward, and becomes from thence a distinct elevation from half a mile to one mile north of the principal terrace, and nearly parallel with it. The descent over its outcropping edge is a rapid slope, covered with fragments of the sandstone broken up and mingled with the soil. After passing a few miles to the east of Lockport, the elevation produced by this rock merges in the general level of the country; and thence eastward, exhibits upon the surface no evidence of its existence.

This rock is extensively quarried for flagging stones a mile north of Lockport, where slabs of the finest quality, and of any dimensions, are obtained. The surfaces are almost entirely smooth, interrupted only by the slight wave-lines; they can be obtained of any desirable thickness, and from their uniform quartzose character, are extremely durable, and wear evenly. These quarries are owned by Whitmore & Co.

Some quarries in this rock have more recently been opened near Medina, where stone of similar character is obtained; and when a sufficient demand for the article shall be created, the whole distance from Medina to Lockport, along the outcrop, can be converted to an open quarry. At Lewiston, where the rock has been excavated, it does not furnish so good flagging stones, the layers being thicker, and better suited for building. Other localities in the neighborhood may, however, prove of a different character.

3. Red Shale and Sandstone.

The grey quartzose sandstone is succeeded by a red shaly or marly mass, similar to that below, which soon alternates with thin courses of red argillaceous or quartzose sandstone. The shaly matter diminishes, and the sandstone increases in the same ratio as we ascend, and towards the top becomes mingled with grey or greenish grey in large proportion. The whole is finally terminated by a grey or ash-colored siliceous, or, in some places, argillaceous sandstone, differing but slightly from that below.

This division of the rock is mottled or variegated with spots and lines of grey and green; these are often circular, presenting the same structure and composition as the mass around. The difference of color is owing to a change in the oxidation of the iron, which is the coloring principle of the rock, and has been produced by some carbonaceous or bituminous substance lodged at a point now the centre of the green spot. Bands of green, parallel to the stratification, have been produced in the same manner, the carbonaceous matter spreading over a considerable surface. Lines of green perpendicular to the stratification, which frequently occur, are not so readily explained upon any supposition of this kind, and I am inclined to believe that they have been produced by the infiltration of water charged with carbonaceous matter from the soil above. That water may produce such discoloration, I have observed many facts to corroborate; and if the change in color can be produced by a small quantity of bituminous or carbonaceous matter, for some distance around it, I see no reason why the same change may not be produced by water flowing through peaty soils, and passing into a seam or joint in the rock. I have seen pebbles of the same red rock of the more sandy variety, which had lain in the bed of a muck swamp, with the color completely discharged from the outer part. The color is likewise lost by continued heat, as is proved in stones used in the furnace at Wolcott. The presence of carbon, in this instance, may have aided to produce the change.

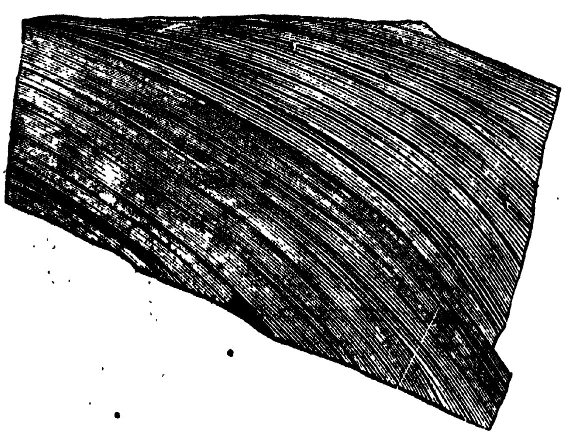
4. Greenish Grey Argillaceous or Siliceous Sandstone. *Grey Band* of Eaton.

Towards the upper part of the Third division, the coloring matter becomes less universally diffused, or the deoxidizing process has been more efficient, and spots and lines of grey increase until the greater part becomes of that color. At this stage there is sometimes an increase of argillaceous, at others of siliceous matter, and a gradual passage into the upper division of the rock. At Lockport, and in some parts of Wayne county, this part of the rock is a green marl with spots of bright green shale intermixed. It is generally argillaceous in character, though at Lewiston some portions are highly siliceous. The variation from the mass below is chiefly in color, and it forms a marked line, contrasting strongly with the dark brick-red of the Third division. The intimate connexion of this portion with that below precludes the idea of considering it a distinct rock, as color is the chief difference; and this change, though often abrupt, is usually gradual. It sometimes contains small black pebbles, which appear at first view like organic bodies, but they are never in sufficient proportion to give it the appearance of a conglomerate. These may be seen at Medina, and at Lewiston, sparingly scattered through the rock, differing entirely in character from the surrounding mass. This division of the rock is very variable in thickness, and in some places scarcely recognizable. In the eastern part of Wayne county it is about three feet thick, at another locality but a few inches; on the Genesee river it is nearly five feet, at Medina about four feet, at Lockport less than two feet, and on the Niagara river it is ten feet thick.

The intercalation of the grey siliceous mass (No. 2), differing in color and lithological characters, and the repetition above of precisely the same products as below, reveals a fact of great interest, showing that important changes occurred in the condition of the deposits during what we regard as a single period. After a long continued deposition of the mud formation highly colored by oxide of iron, there was an entire cessation so far as to allow the deposition of uncolored or grey and purely quartzose sandstone; after which, the former red deposit was resumed precisely as below. All the circumstances connected with this quartzose deposit are interesting, it being the only part of the rock where animal organic remains are found. Here we find Lingula, Cytherina and Pleurotomaria in great numbers, besides Bellerophon, Cypricardia and Orthoceras in less profusion. The condition of all these fossils, however, indicates disturbance in the waters from which the mass was deposited, or rather near the close of its deposition. The Lingulæ, so far as ascertained, are all of broken or single valves, and usually crowded together in great confusion; the other fossils present the same appearance of having been drifted into their present situation. At Medina, these fossils are near the upper part of the grey mass, and are not found above; they are here more abundant than in any other place, few being seen west of Lockport. The cause of this agglomeration and destruction may perhaps be explained by changes which took place in the condition of the mass during its deposition, as indicated by appearances near Lockport and elsewhere. These conditions seem to have been either the frequent oscillation of the surface; or that the mass in which they are imbedded formed at that time a sandy beach, over which the tide sometimes quietly ebbed and flowed, and where again the stormy waves dashed with fury, destroying and overwhelming all within their reach.

If we might be allowed to hazard a conjecture as to the changes and their causes going on at the time of the deposition of these different divisions, we would incline to the belief, that the lower shaly deposit was the product of a mud volcano, rapidly ejected and spread over the surface, rendering the sea turbid and discolored to such a degree as to prevent the existence of any organic forms.* Afterwards a cessation of the volcanic action allowed the deposition of the grey quartzose mass; the materials having, perhaps, the same origin as the grey sandstone which was formed previous to the commencement of the Medina. Although during this period there was no matter ejected from the volcano, still it may have produced oscillations of the surface, causing alternate deep and shallow water, or deep water in some places and shallow in others. Subsequently, towards the close of the grey deposit, the volcano broke forth again, with renewed energy, destroying all the organic forms which had come into existence during this comparatively quiescent period, and overwhelming the whole with another deposit of red mud like that below. Again after a time, the subterranean action appears to have become more quiet, gradually subsiding, and allowing an increase of sandy matter from some other source. Lastly, toward the termination of the deposit of mud, and when the sand had increased considerably, we find an abundance of the vegetable forms given in the woodcut and plate, and the whole series terminating with the grey division, marked by that singular fossil the Dictuolites.

Diagonal lamination. — The sandy strata at Rochester, Medina and elsewhere, exhibit diagonal lines of deposition; and in some places these lines are more strongly marked than those of the stratification, and the rock presents the appearance of being inclined.



* The fragments of fucoids found may have been drifted from some distant locality.

The above woodcut will give an idea of this appearance; in other instances the lines are more curved, though generally when seen on a large scale, they are nearly straight. From the interlamination of shaly matter, the strata to which this structure is confined often appear in wedge-form layers of greater or less extent, enclosed between parallel lines. In most instances this structure is clearly produced by deposition alone; but where the lines of lamination, as indicated by color, are strongly curved as in the woodcut No. 4, it seems impossible that it could have been produced by deposition. As this rock is everywhere free from disturbances or upliftings, there could have been no lateral movement, except on a small scale, to have produced this effect. The infiltration of finer particles, with a greater proportion of coloring matter, may perhaps explain the appearance without having recourse to any extraneous agency. This structure is seen in the more siliceous strata on the Genesee below the lower falls, and at Medina.

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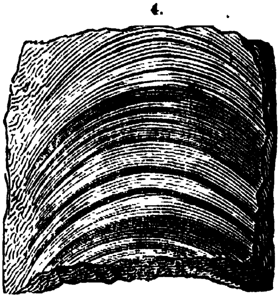

In many places where this diagonal lamination is exhibited, there is a tendency to the production of conglomerate in the associated strata. Thin layers of pebbles and angular fragments are of frequent occurrence at Rochester, Medina and other places, and associated with them and the more sandy portions of the rock, are frequently found fragments of what appear to be shells of Lingula. The latter may be seen in loose specimens somewhat weathered, below the lower falls of the Genesee, at Rochester.

In specimens which I have more recently collected, the fragments of shells appear as if drifted by waves and spread evenly over the surface, precisely in the same manner as comminuted shells upon the shore of the ocean. In instances of this kind, after walking for a mile upon a sandy beach, without seeing anything other than a stranded Fucus, I have suddenly come upon a space several feet in extent, which, apparently from a slight eddy, or inequality in the surface, was covered with comminuted shells and fragments of coral. The analogy to some of our sandstones where organic remains are rare, is thus most strikingly exhibited.

Accretions.—In the Second division of this rock, at Lewiston, and other places, we notice upon the surface small points and blotches of fine black sand, scarcely cohering, and which crumbles on the touch. These in many places are larger; and at Lockport, in the thin-bedded sandstone, they are frequently several inches in diameter. All have the same incoherent structure, appearing like a mass of black or dark colored sand, around which the strata have been deposited. From the manner of their occurrence, and from the stratum frequently being a little elevated just around them, it is evident that they were formed during the deposition of the mass. Their limits are well defined, and they separate from the stratum, frequently leaving a circular hole in the quarried slab. A specimen of this kind may be seen in the State Collection. In a few instances I have observed these masses of black sand surrounded by a firm coating or shell of sandstone an inch thick, like the ordinary rock, but separating from the stratum, and presenting a smooth spheroid. This peculiar form of accretion I have seen only in this rock; the structure is quite unlike the bodies of this kind usually met with, and seems due to the decomposition of iron pyrites, or some other substance where the force was directed outwards, rather than toward the centre.

The sandy portions of the Third division often contain oblong or rounded accretions or pebbles of shale, which on weathering are dissolved out, and leave corresponding cavities. These appear much like worn fragments of the red shaly part of the rock, and are distinctly laminated; still from the manner of their being imbedded, and uniform size, they are probably referable to the first named cause. They are always of a deep reddish brown, while the mass which contains them is frequently much lighter in color. This, if they were contemporaneous, only shows the superior attraction of the argillaceous mud, for the coloring matter, over the sandy portions of the rock. The flattened oblong form of many, renders it a matter of doubt whether they are accretions or pebbles.

Localities.—This rock appears as a conglomerate in a ravine near the level of the lake, about two miles northeast of Wolcott furnace. This was the farthest eastern point at which it could be detected in the district. An examination was made for this rock from the Wolcott ore bed towards the lake, but without success, the low marshy ground preventing its appearance. The same is true at Wolcott furnace, and also on the west side of Little Sodus bay.

The sandstone is quarried on Beard's creek and Little Red creek in the town of Wolcott, and used in the construction of furnaces. It is again well exposed near the forge on Salmon creek, and contains its characteristic fossil, the Fucoides Harlani. It also appears in the town of Williamson, near the lake shore.

In Monroe county, in the town of Penfield, this sandstone appears on the lake shore, presenting a few feet of the strata below the clay and gravel. On the eastern side of Irondequoit bay, it has been quarried for the piers at the mouth of the Genesee. It appears again near the head of the bay.

The lower falls of the Genesee are caused by this rock, more than one hundred feet being exposed at that place. From the falls it forms both banks of the river, extending nearly to the lake. This is one of the best localities in the district. It is again seen a little north of Adams's basin, about twelve miles west of Rochester. In passing through Sweden, about twenty miles west of Rochester, the bed of the canal was excavated in this rock.

West of the Genesee the sandstone does not appear on the lake shore in Monroe county, but by tracing up the small streams it may always be found; it is of little interest, however, from its uniform character and the absence of fossils. A short distance northwest of Adams's basin, the rock with Fucoides Harlani appears in the bed of a small stream. In the neighborhood of Clarkson corners, it approaches the surface, giving its characteristic color to the soil. The upper part of the mass, abounding in the Fucoides Harlani, is quarried near the village of Brockport; and also in the northern part of Clarendon, Orleans county, forming a good and durable building and flagging stone. The softer portions are well developed in the banks of Sandy creek, particularly at the crossing of the Ridge road, and also nearer to the lake.

The rock again appears near Holley, and at numerous places on the Eric canal westward. It is well exposed in the small stream on the south side of the canal near Albion, and is seen more or less between this place and Medina.

At Medina, on the Oak-orchard creek, we have the best exposure of the mass, which exists in the State, and hence its name. The thickness here exposed is not greater than on the Genesee river, nor so great as on the Niagara at Lewiston, but it exhibits all its fossil types in the greatest perfection.

A little northwest of the village, it is quarried for flagging stones. From Medina westward it is almost constantly to be observed either in the canal, or in the terrace formed by the outcropping edge of the middle division as far as Lockport. At this place it is well exposed about a mile below the village, on Eighteen-mile creek, exhibiting likewise its fossil shells, though in less profusion than at Medina. The Fucoides Harlani, however, is rare, and not well preserved here. In the quarries, and the brow of the hill further north, the central portion of the mass is well exposed.

From Lockport westward, the Third and Fourth divisions form part of the slope of the terrace, contributing to the height of the same above the country on the north. The central hard portion being less destructible, has protected the base of the terrace, and projects beyond the higher part in a step or table.

In the banks of the Niagara, it is very finely exposed. At Lewiston, it exhibits about two hundred feet in thickness, and gradually declining, passes beneath the water before reaching the falls. The grey quartzose sandstone, like that at Lockport and Medina, is seen at the Whirlpool, projecting into the river on either side, and forming a barrier which has at one period obstructed the waters in their passage to the lake. Below Lewiston it is seen in the banks of the river, extending nearly to the lake shore, where it slopes down, and becomes covered by the superincumbent clay.

On the Welland canal, at St. Catharines, at Hamilton, and numerous other places along the slope of the terrace, this rock may be seen, showing its continuation beyond New-York, and in the same line of direction.

Thickness. — From the circumstance that the base of this rock is nowhere to be seen in the Fourth district, its entire thickness cannot be ascertained. Its greatest width is on the Niagara river; but here a large portion of it is excavated on the north, leaving probably less than half its original extent within the State. From the width here exposed, the thickness actually measured, and the rate of dip to the southward, there is about three hundred and fifty feet of the rock between the mouth of Niagara river and the termination of the rock above Lewiston. By reference to the Geological map, it will be seen that this rock thins out entirely in an easterly direction in Oneida county; showing from that point westerly as far as Lake Ontario, a gradual increase in thickness. Examinations farther westward are required before the point of its greatest development can be ascertained.

Mineral Contents of the Rock.

Copper and iron pyrites, with oxide of manganese and iron, and carbonate of copper, are the only metallic substances I have met with in this rock, and these only in minute quantities. At Lewiston the upper part of the mass contains numerous small spiculæ of pyritous copper, and the fissures and joints are often lined with a thin coating of green carbonate of copper; and on subsequent examination, I find that at this locality it is very generally diffused, though the quantity is small.

The hydrated peroxide of iron is seen lining small cavities in the grey quartzose sandstone at Lewiston and elsewhere; and the black oxide of manganese is commonly seen in the joints and between the laminæ, though never in large quantities.

A reddish colored sulphate of baryta in small spherical masses, or filling small cavities in the rock, occurs at Rochester and a few other places.

Carburetted hydrogen gas rises from this rock in considerable abundance in some places along the Erie canal east of Lockport. The principal point is Gasport, where it is collected and passed through a tube, supplying a quantity sufficient to illuminate a large room constantly. The light is less brilliant than that of artificial gas, being more yellow, and, from the manner in which it is consumed, giving rise to much smoke. I have seen no places which emit sufficient quantity to induce the erection of apparatus for collecting it, except as a matter of curiosity. The evidence of bituminous matter is here fully established, even if the green threads and spots were not considered sufficient; but the origin of this is still left in obscurity. The amount of organic matter, both animal and vegetable, known in this rock, is so exceedingly small, that it could scarcely be supposed to give rise to the constant emission of this gas. The impervious nature of the lower part of the mass, and the absence of fossils in the next rock below, would preclude the idea of its origin in that direction, as there are no disturbances known in the district.

Springs.—Along the outcropping edges of the siliceous portions of the mass the soil is thin, and water readily percolates through the fissures, offering no springs. The more even surfaces, particularly of the lower division, are sufficiently moist, and in level situations or depressions too much so, for fertility. Springs are of frequent occurrence at the junction of the Second division with the more impervious mass below.

Saline springs are everywhere to be found in this rock throughout its whole extent, from the eastern part of Wayne county, and even as far as Oswego, to the Niagara river; and beyond this, in Canada, deep borings have been made and much salt water obtained. In some places salt had been manufactured for a long time previous to opening the Erie canal; but the greater facilities and better quality of the brine at Salina, with that means of transportation, soon superseded the manufacture of salt from any of the springs in this rock. It appears in all cases where I have been able to obtain any knowledge upon the subject, that there is a large admixture of impurity in the brine, and the salt has a " sharp bitter taste " and brown color: the taste owing probably to muriate of lime, and the color to iron. This objection could probably have been obviated, had the strength and quantity of the brine been sufficient to warrant the undertaking.

There were never, so far as I have learned, very extensive operations carried on at these brine springs. The borings have rarely been made to any great depth, and the quantity of water being small, the fixtures have been temporary, and, from disuse, nearly every spring visited had become filled with fresh water. In a few cases the destruction of vegetation around, and the saline taste of the earth, fully indicate the presence of salt.

I have not been able to satisfy myself that deeper boring was always attended with an increase in the strength of the brine, though in a few cases this has been recorded as the fact. At St. Catharines, U. C., where a boring of five hundred feet was made in this rock, I was informed that the strength of brine increased with the depth; but here, as well as elsewhere, the work has been abandoned.*

From the situation of numerous springs of this kind which I visited, and which are upon level ground, or in depressions having little or no outlet, I am disposed to believe that a depression in the rock, with the exposure of much surface, concentrating its saline matter in one point, is required for their production. In the greater number known to me, the discovery was made by the saline water rising to the surface, but in many instances it was found by excavating or boring into the rock in places where no salt spring was previously known; and in almost all cases where excavations have been made in the lower division of this mass, the water is more or less brackish. From these facts we have almost conclusive evidence that this deposit, throughout its whole extent, is impregnated by saline matter.

A fact of this kind has lately come to my knowledge, through Judge Allen of Saratoga. During the extreme drought of the summer of 1841, the wells situated upon this rock in many towns in Orleans county became dry, and they were in consequence excavated or bored to a greater depth; and in nearly all cases the water proved to be in some degree saline, and in one case so much so as to warrant the erection of fixtures for the manufacture of salt. Most of these wells were in situations where salt water had never before been known to exist, and furnish another fact in evidence of the wide distribution of the saline ingredients.

Agricultural characters.—The soil overlying this rock, from the varying nature of the mass below, is of the same character. In the eastern part of the district it is a sandy loam, or in numerous instances sandy; the argillaceous nature of the rock increasing in a westerly direction has given rise, generally, to sandy loam. Limited tracts are sandy, and other portions are again of a clayey nature. Whenever the rock approaches the surface, the soil is a heavy mixture of clayey loam and fragmentary matter; proper cultivation, however, mollifies this nature, and it is considered among the most fertile soils of the district. From the fact that

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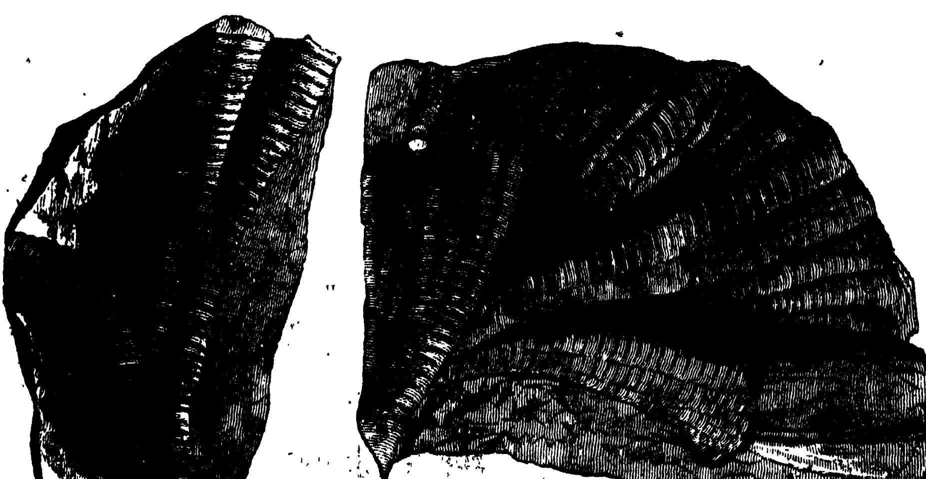
* I find the following record in my notes, made at St. Catharines. Depth of boring 500 feet. Water at 300 feet 27°; at 429 feet 29°, but this increase in specific gravity was not constant, and it is not certain that the water increased in strength on descending.

Lake Ontario has recently occupied all that part of the district north of the Ridge road, the soil is not as evenly distributed or as uniform in character as it otherwise would have been. Slight elevations of sand, or sandbars, have accumulated in many places, and argillaceous materials at intervening points. The surface, therefore, presents all varieties from a light sand to a heavy clay loam, or gravelly loam. The drifted materials which occupy a considerable portion of the surface in Wayne county, are mostly of loose gravel and sand.

Organic Remains of the Medina Sandstone.

In this rock, like all others colored by the red oxide of iron, fossils are rare, and throughout the greater part of the first and third divisions, the only fossil remains are Fucoides. In the lower division few of these have been found; mostly in fragments, and in such a condition as would indicate their partial destruction before being imbedded, or their subsequent absorption by the matter of the rock. The green threads and spots, probably due to some organic nucleus, disclose nothing by which its nature can be ascertained, and we are left to conjecture as to what may have been their origin.

In the third division of the rock two species of Fucoides abound in great perfection, the F. Harlani and the F. auriformis. These are always attached to the under surfaces of the layers, and rest upon a bed of shale, as if they had grown upon the clayey bottom, and been buried by the first succeeding deposition of sand. The first named species is very abundant, often covering with its beautiful articulated branches the surface for many feet in extent. The other species is also abundant in many places.



Figs. 1 and 2. Fucoides Harlani.

The Fucoides Harlani is everywhere typical of the Medina sandstone, continuing throughout its whole extent so far as known. It occurs in the Third district, at Fulton, Oswego county, and in the Fourth district in Wayne county, at Rochester, Medina, and on the Niagara river. In Canada, it is found along the Welland canal, besides numerous intermediate places. According to Mr. Vanuxem, it occurs in Pennsylvania and Virginia, having the same association. It thus becomes the most characteristic indication of the rock, and is considered as one of its essential organic forms, occurring in no other rock, and being an example of a peculiar type which commenced and terminated its existence with this rock. The second figure in the woodcut represents that part of the fossil near the base, from which the branches diverge. Fig. 1 is a more common form, and the most abundant is that of single, elongated, straight or curved branches, crossing each other in various directions upon the surface of the stone. Their annular ridges or apparent articulations are always visible, except when much weathered, and from these it was formerly supposed to be the stem of a crinoid. The substance of this fossil is frequently replaced by pebbles and small angular fragments, and in such cases the beautiful annulated structure is less distinctly visible. The Fucoides auriformis (Pl. I. fig. 2) is equally common in the Fourth district, it being abundant at Rochester, Medina, and other places, holding the same position as the first. It appears slightly elevated above the surface of the stone in the form represented in the figure, like a collection of small auriform appendages, whence it receives its name.

The Fucoides heterophyllus (Pl. I. fig. 3) is allied to the preceding, and abounds at Rochester. This figure will be readily recognized by any one who has explored the river banks below the lower falls. The representation is of its more common form, but there are many other varieties which may be referred to this species. Its great uniformity in general appearance and manner of occurrence, indicates that it is organic; and for the present all forms of marine vegetation, which have no characters sufficiently marked to place them in other families, are referred provisionally to the Fucoides.* Some other forms appear in the rock, apparently referable to marine vegetation.

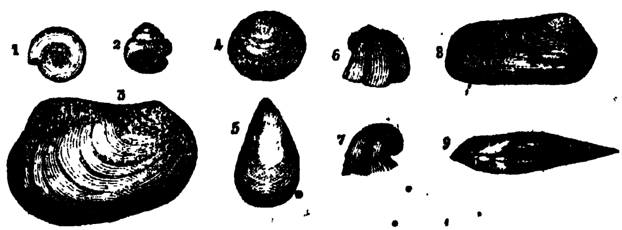
Throughout all the red portions of the rock, no animal remains have been found, with the exception of fragments of Lingula. Whether the deposition of mud charged with ferruginous matter was unfavorable to their existence, or whether subsequent causes have obliterated their remains, it is perhaps not easy to decide. In the Old Red Sandstone, which is equally charged with the oxide of iron and often very highly colored, the remains of fishes are perfectly preserved; the scales and fins, their teeth and all their solid parts are still in a state of perfect preservation, and but slightly tinged with the coloring matter. At the present time, we have no similar deposits in progress extensively enough to determine whether organic forms flourish under such circumstances. The water flowing from chalybeate springs, and the ferruginous deposit originating from the same, do not apparently prove obnoxious to the frogs and fishes that inhabit the pools and streams.

* A species of Fucoid consisting of long slender stems, vertical as to the strata, is found in the town of Penfield, Monroe county.

From many circumstances, it would appear that the lower part at least of this deposit was thrown down rapidly. The quantity and uniform nature of the mass show but one source for the material for a considerable period of time, there being no alternation or intermixture of different substances. If we consider the condition of the water rendered turbid by such a quantity of mud, and highly colored by the iron, it is not surprising if organic forms did not exist.

In the grey sandstone (second division), animal organic remains are abundant in some places, though the forms are not numerous. At Medina, in the upper part of this mass, shells of Lingula, Pleurotomaria and Cytherina occur in great profusion. These likewise occur at other places, but less abundantly. At that place, in the bed of the stream above the falls, the Pleurotomaria are crowded together in such numbers as to constitute almost entirely a distinct stratum several inches thick. The Lingulæ and Cytherinæ are scarcely less abundant, forming the greater part of the stratum. In other places these all disappear, except the Lingula, which preserves its place much longer than the others. Some portions of the rock where these fossils occur is tinged with red, and on decomposing becomes brown, but never of the deep color of the mass above or below.

The following are the more common forms found in this rock, at Medina and Lockport:



1 & 2. Pleurotomaria perretusta, (a cast.)
3. Cypricardia alata.
4. Orbicula parmulata.
5. Lingula cuneata.
6 & 7. Bellerophon trilobatus, (a cast.)
8 & 9. Cypricardia orthonota, (a cast.)

Besides the fossils figured, the Cytherina is abundant; there is also a small shell resembling the Nucula? lævis of Murchison, and an undescribed Avicula, with one or two other shells, and, rarely, fragments of Orthoceræ. Those figured in the woodcut, with the exception of the Orbicula, are associated at Medina, and we find the same at Lockport. The individuals like Nos. 3 and 8 are more abundant at Lockport than elsewhere.

In the upper division, the only fossil known is the Dictuolites Beckii of Conrad (Plate I. fig. 1). This is one of the most interesting fossils found in the rock, often covering large surfaces with its strong rigid branches and beautiful interlaced rootlets. A remarkable peculiarity of this fossil is the angular or reticulated structure presented by the branches, so unlike vegetable forms generally. The spaces produced in this manner are various in form and unequal in size, as will be seen in the figure, which is a faithful representation of a specimen from Medina, now in the State Collection. The surfaces of the stratum where this fossil occurs often present beautifully defined ripple marks. Mr. Conrad thus describes these appearances : " Upon this surface there is a beautiful fossil, which consists of stems or branches joined in a reticulated manner, and having undulated lateral root-like fibres. This fossil is spread over a considerable space, and I noticed that in some instances it followed the undulations of the ripple marks : it was therefore pliable, and moored by its root-like fibres to a sandy bed, over which a current of water ran, producing such impressions as we see caused by tidal currents on a sandbar."*

Ripple Marks.

These evidences of shallow water do not appear in the lower division of this rock, at any locality which I have visited ; and their absence fully accords with the other facts implying a rapid deposition in comparatively deep water. Only when we come into the Second division of the mass, do we find some imperfect markings of this kind, nor do they occur in any degree of perfection except in the higher strata, and in few localities. At about the termination of the quartzose deposit, and in all the higher portions of the rock, they are of frequent occurrence, and often in great perfection. The specimen from which the accompanying il-

Ripple-marked Sandstone. Medina Falls.

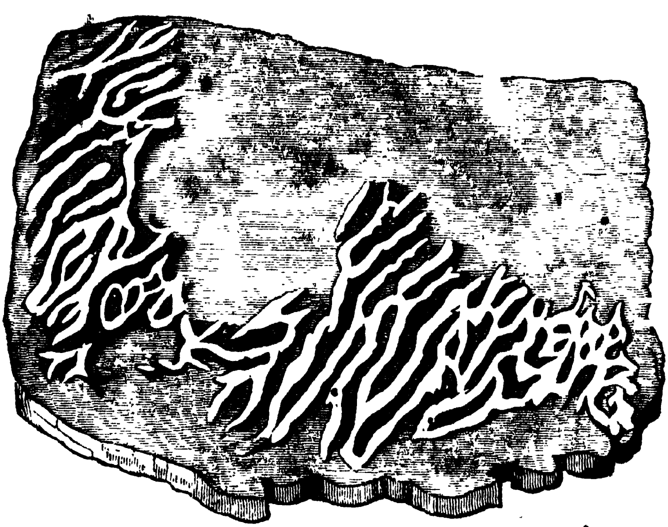
* Geological Report for 1837.

lustration is taken, was from Medina, a few feet above the position of the Lingula, Cytherina, &c.; the rock, a variegated quartzose sandstone, showing a slight admixture of the marly deposit which immediately succeeds.

In the terminal grey mass at Medina these markings are very beautifully preserved, in connexion with the Dictuolites. Here the longitudinal direction is north-northeast and south-southwest; and those which the figure represents vary from this but a few degrees, though the difference was not accurately determined.

These facts indicate a shallow sea during the whole time of the deposition of the upper part of this rock; and the diagonal lamination is equally a proof of currents in the ocean during the same period.

In a few instances, I have met with another kind of surface marking, of which I have seen no explanation. It is more common in some of the higher groups than in the Medina sandstone. The illustration No. 8, is from a specimen of this kind.



The surface of the stone presents undulating ridges, frequently meeting and forming a kind of irregular network. An appearance somewhat similar is seen where two plane surfaces with wet clay, or other adhesive substance between, are forcibly separated — the clay is thus raised in irregular ridges. I have usually referred this appearance to the effect of water evaporating from a partially indurated stratum, where the mass below contracts more than the thin film upon the surface. From the numerous similar facts, together with more pressing and important details, these have been left without sufficient investigation to form a satisfactory conclusion. On the surface of sandstones, alternating with shales in the Portage and Chemung groups, this kind of marking is very common, often extending over large spaces.

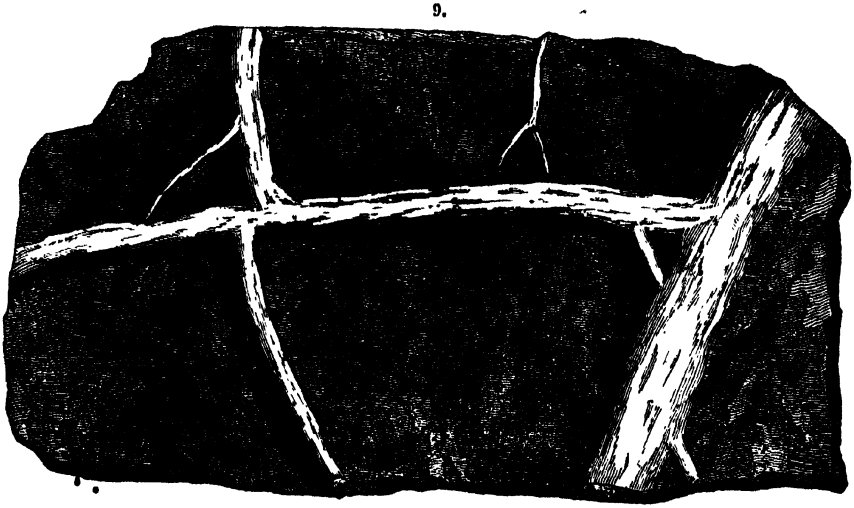
Sometimes the ridges are much larger than here represented, at others the marking is very fine, and barely raised above the general level. The same appearance occurs in the Clinton group, often presenting beautiful specimens, like the tracings of a sculptor's chisel.

Shrinkage Cracks.

These marks, as recent productions, have probably fallen under the observation of every one, appearing in the clayey beds of shallow pools which have rapidly dried in the sun, when the mud shrinks and cracks in various directions. Such marks could never be produced beneath water, and consequently their occurrence in rocky strata affords a clear inference that the surface in question has been once elevated above the water, and subjected to atmospheric influence, or perhaps to the sun's rays. As these are usually produced in soft shaly beds, it requires, for their preservation, that the next deposit be of different material, and thus casts of the cracks are preserved. Sometimes, however, the cracks themselves are preserved in the stone.

Although I have met with no examples of this kind in the neighborhood of Lockport or Medina, where the ripple marks are so well preserved, yet farther east we find them in great perfection. The mass in which they occur is a soft red shale, and is succeeded by a sandy deposit. The sand has filled these cracks, and the whole becoming consolidated, the sandy layer above separates from the shale below, presenting casts of the cracks in strong relief; as seen in the accompanying illustration.

9.



Markings of this kind are not of uncommon occurrence in many of the succeeding deposits, and particularly toward the close of the Onondaga-salt group.

Sandy Beach and Stranded Shells.

Among the interesting phenomena attending the deposition of the grey sandstone of the Second division, are the evidences of a sandy beach which was alternately washed by the advancing and retiring waves, and again left dry and above their reach. The proofs of this condition we find in the situation of the shells of Lingula, spread upon the surface, and the wave-lines, which mark the successive layers.

In the open quarries at Lockport where extensive surfaces of the smooth layers are exposed, an observer will notice the shells of Lingula cuneata, curiously distributed, each with a little ridge of stony matter extending from the beak, narrowing and sloping down to the general level of the stone.

The analogy of this little sloping ridge of stone to what we see formed in shallow currents, or where waves are washing a beach, and meet some obstruction, as a pebble, is too obvious to be mistaken; and the observer at once feels that he has discovered unerring marks of the course of the current, at the period when this rock was deposited. The beaks of the Lingula are all directed to the N.N.W. or varying from this to N. by W. half W. This perfect parallelism, where hundreds may be seen on the surface of a single slab, is very striking.

At first these shells appear as if they might have been living, and anchored to the sandy bottom by their peduncles ; but further examination has proved that they are all single valves, and must have been floated into their present situation, and strewed, by the waves or the current, evenly over the sandy surface. They all present the outer or convex side of the shell upwards, and this is the position they would naturally take under the circumstances. After being thus left, and adhering firmly to the sand, the current or advancing tide swept over them again without the power of removing them from their position. The consequence would then be the production of a little ridge of sand, extending from the beak of the shell in the direction of the current.

10.

The figure No. 10 is a representation of a small specimen with three shells of the Lingula cuneata, each with the little ridge of stony matter as described, extending from its beak. It will be recollected, also, that it is not to the surface of a single layer or stratum that these shells are confined. They appear upon successive strata for many feet in thickness, and they are sometimes separated from each other by a deposit of less than half an inch. These circumstances prove the operation of similar causes during a long period of time. Each succeeding layer retains the impressions in a very beautiful manner, and thus we often obtain specimens with shells upon the upper side, and casts upon the side below. Several large slabs of this kind may be seen in the State collection.

The evidence from these drifted shells, with their ridges of stony matter, corroborates the inference drawn from the condition of the fossils at Medina. It will be noticed, also, that the position of the fossils at the latter place is east a little south from the quarries near Lockport, of which we have been speaking. The direction of the current as there indicated would have a tendency to drift all the shells in a south and easterly direction. Since this mass has once extended much farther north than at present, as is evident from its abrupt outcrop, and the great excavation of the lake valley, it is quite probable that Medina was brought within the range of the current from the N.N.W., and that from the proximity of land or very shallow water, the fossils accumulated as there described.

The Lingulæ are not alone in the production of these appearances upon the surface; in some instances we find small fragments or pebbles of a greenish shaly sandstone, precisely like some parts of the lower mass, which seem to have been stranded in like manner as the shells. This is seen in the specimen of which Plate II. is a representation. In this instance three of the largest obstacles are fragments of green shaly sandstone, and the others shells of the Lingula.

It might appear from what is here stated, that there is a discrepancy in the direction of the water as indicated by the Lingulæ, the little ridge of sand pointing northwardly, while the fossils are accumulated in a southeasterly direction. The explanation seems to me to be this, though some other view may be adopted: The surface on which the shells were stranded, was a long low beach or sandbar washed by the waves of the ocean, as will be seen by further illustration. The shells were carried forward by the waves, which advanced high up the beach; with the retiring wave, all these would be moved backward a short distance, but would soon be left attached to the sand, the water of the still retiring wave scooping out the depression in front and at the side, and piling up the little ridge beyond the beak. In this manner, the direction apparently indicated is opposite the real direction of the force which transported the specimens. That such is the process by which shells and pebbles are stranded on the present beaches, any one will be convinced by observation. By the retiring of the wave, also, any single valve of a bivalve shell, which may remain with the outer side downwards, will surely be overturned, and at last usually remain in the reverse position, as is the case with all the shells of the Lingula on the sandstone. After being once fixed in this manner, they are not easily removed by succeeding waves.

The surfaces of these slabs upon which the shells are found have often a beautiful clouded appearance, which is caused by the sand of different colors and specific gravities being strewed unequally over the surface. The whole perfectly represents a modern sea beach washed by the advancing and retiring waves, where the sand of different colors is arranged in clouds and undulating stripes by the force of the water and the different degrees of resistance.

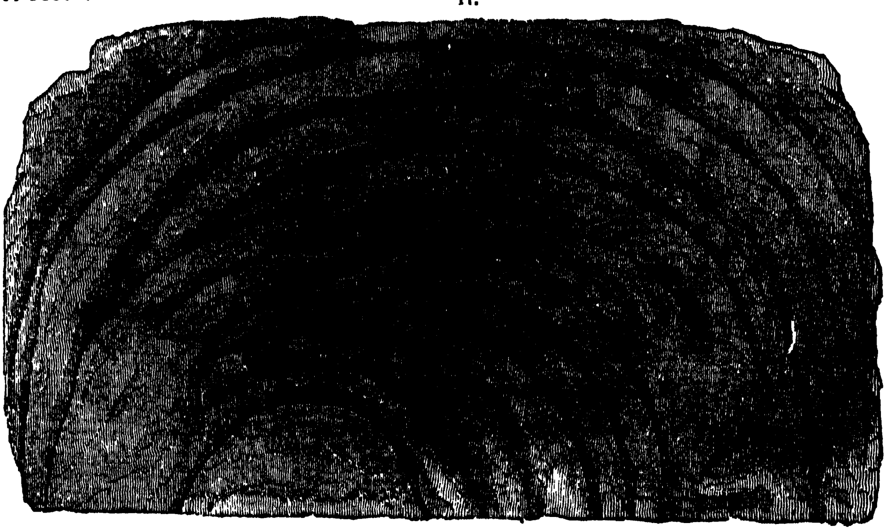
The analogy is here so perfect that it cannot for a moment be mistaken. The surface of the stone represented in Plate II. exhibits this character in a good degree, though not in so great perfection as many others. This one was chosen as showing the occurrence of fragments of sandstone with the shells, and also a slightly varying direction in the current. An infinite variety of beautiful appearances are produced by the combination of all these different influences; and one can scarcely resist the desire to transport a large portion of the quarry to his own cabinet, every fresh specimen disclosing beauties, and effects, not before noticed. A drawing can give but a faint idea of these exhibitions, but the large slabs in the State Collection convey a more satisfactory impression, while a visit to the quarry is indeed enchanting.

Wave Lines.

As if all the other circumstances noticed were not sufficient to convince one of the condition of the ocean and its shores at the period of the deposition of this grey sandstone, the advancing waves have left their impression upon this ancient beach, which has now become a solid rock.

The surfaces of nearly all the strata in the quarries near Lockport are marked by numerous slight ridges, often in parallel curves, and again varying and interrupted. If upon the upper side of the stratum, they are crossed from within the curve outwards, there is a slight descent: the under side of the layers in like manner present the cast or reverse of this. These lines are always curved, and usually limited at either extremity by another series meeting the ends of the former, and extending their curve beyond. The lines appear upon successive strata frequently accompanying the Lingula, and likewise often upon layers where these shells do not occur.

11.

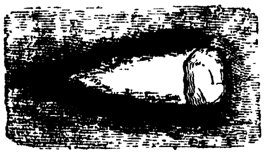


The woodcut No. 11 is an illustration of these lines as they appear upon a slab about five feet in length. The course varies but little in the numerous instances which I have examined. A line perpendicular to the curve generally gives a direction differing but little from N.N.W. and S.S.E.; which shows that the direction of the wind varied between north-west and north, and that the line of beach must have been nearly at right angles with this direction, which corresponds very generally with the present line of outcrop of this rock.

Existing phenomena of the character here described may be witnessed every day upon the shores of the ocean, or of the larger lakes. Any one who has passed along a sandy beach during the ebbing of the tide, or when toward evening the fresh breeze of the day is lulling, must have observed as the waves roll in and extend far up in a thin sheet of water, that the crest of each one forces on before it a film of sand. This, when it has arrived at its extreme limit, and during the moment which elapses between its advancing and retreating motion, is deposited in the form of a minute ridge or line, defining perfectly the outline of the wave. These occur one after the other, sometimes crossing and sometimes parallel, but always marking the limit of the water. Often after many of these are formed, a wave advancing beyond the others, obliterates the whole, and leaves its own line far above them; and if its outline do not correspond with the previous ones, those portions of the former lines are left limited by the last. When the beach dries rapidly from the heat of the sun, these are distinctly seen, preserving most perfectly the outline of the wave in all its minute curvings and undulations. So minute are the ridges, and the amount of matter so small, that a gentle wind is sufficient to remove the whole, and it might seem almost fanciful to suppose that any vestiges of them are preserved; yet after having made repeated observations upon these wave lines, and upon the markings on the strata in the quarries at Lockport, I was forced to the conclusion that the cause of both was identical. During the past summer I examined these quarries, and also the recent operation upon the sandy beaches of Lakes Ontario and Erie, in company with Mr. Lyell, and I now have the pleasure of recording his opinion as coinciding with what has been expressed; namely, that the cause producing the markings upon the sandstone is identical with that producing wave lines upon our present beaches.

In several places west of the Genesee river, on the shore of Lake Ontario, are large bays or ponds, separated from the lake only by a sandy beach, and usually having a narrow outlet, or sometimes none at all, for a considerable time, until the accumulation of water inside forces a passage through the sand. At one of these places, there was a broad flat beach, rising but little above the level of the lake, and sloping gently back to the marshy margin of the pond. A previous high wind had raised the lake, and the heavy waves had washed entirely across this beach into the pond. The surface beyond the highest point where the water flowed smoothly down, was covered with pebbles, some fragments of shells, and the bones and scales of fishes. Every one of these had offered some obstruction to the advancing water; and in that direction, and on each side, there was a depression or shallow excavation, while beyond the obstacle extended a little ridge of sand narrowing and sloping down to the general surface.

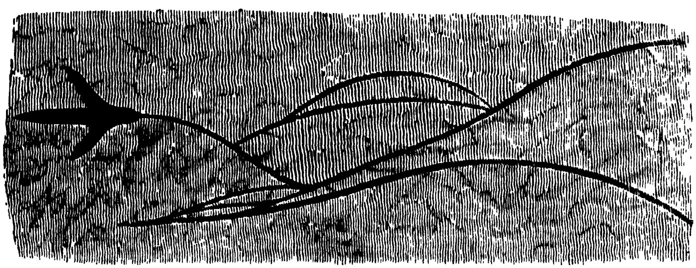
12.



The illustration in the margin exhibits the most perfect analogy to the appearances before described.

On the side toward the lake the surface of the sand was marked with wave-lines, as well as the ridges, exhibiting all the phenomena described, and showing the most perfect analogy with the same appearances upon the strata of the Medina sandstone at Lockport. The illustration No. 13 is from this place, and hundreds of similar ones might have been copied from the sand in the space of a few rods. A heron (Ardea Herodias) had been walking upon the spot but a short time before, and one of the footsteps is represented as it actually appeared in connexion with the wave-lines. In this instance parts of three distinct series of curves are represented.*

13.



Wave-lines on Sand-beach. Long pond, Monroe county.

Should any one doubt the possibility of such slight markings being preserved, he has only to examine the beautiful series of curved lines upon the surface of the strata in the quarries, and thence transport himself to a smooth sandy beach upon the lake shore, and the phenomena exhibited will not fail to convince him that the cause there operating, has also been one of the active powers of nature, in those periods during which few records have been preserved of the relative situation and distribution of sea and shore.

Without desiring to dwell too long on a subject that has been to me of the most thrilling interest, I have still the desire to give all the illustration and elucidation it requires, and to direct the attention of observers to similar appearances in the older strata, by which, perhaps, we may be able to explain more satisfactorily many circumstances attending their formation.

All the appearances enumerated seem corroborative one of another; the Lingulæ, which are a deep water shell, have been drifted, the valves separated and strewn upon the sand; the clouded and mottled surface, and lastly the wave-lines, indicate very clearly that the deposit

* It may sometimes be observed that a wave advancing obliquely upon a beach removes the sand as far as it reaches, leaving a depression seaward; this happens if the sand be light, or saturated with water, and may perhaps take place under other circumstances, but it is only an exception to the general rule.

has been successively a beach washed by waves, and again covered with deposits of sand by the returning waters.

In standing upon the exposed surface of the quarry, one can almost fancy himself still upon the shore of some quiet bay or arm of the sea, where the waves of the receding tide have left these little ridges of sand, which on their return will be obliterated and mingled with the mass around. The shells and fragments, and the clouded sand, all lie around him with a freshness of appearance that might almost make him doubt. But his foot is upon the firm rock, and his hand cannot obliterate the faint waveline, nor remove a single shell from its place. Every thing is firm and fixed, and he is forced to recollect that millions of ages have rolled on, since the sea washed this shore, and the shells lay upon the glistening sand as he may have seen them in the haunts of his childhood. How beautiful, how simple, and how grand is this exhibition; and how much does it illumine the mind as to the mode of production of these older formations which have been considered so obscure. Here was an ocean supplied with all the materials for forming rocky strata: in its deeper parts were going on the finer depositions, and on its shores were produced the sandy beaches, and the pebbly banks. All, for aught we know, was as bright and beautiful as upon our ocean shores of the present day; the tide ebbed and flowed, its waters ruffled by the gentle breeze, and nature wrought in all her various forms as at the present time, though man was not there to say, how beautiful!

10. CLINTON GROUP.

Lower part of the Protean group of the Annual Reports; *Ferriferous slate, and Ferriferous sandrock* of EATON.

(Part of No. 5, PENNSYLVANIA SURVEY.)

This group is one of variable character, consisting of many kinds of deposits, which are not uniform either as to composition or continuation. From this circumstance it first received the name of Protean. This term, also, at that time included the Niagara group, which appears a thin mass in the Third district; but from its greater development and distinctive features in the western portion of the State, that has been separated.

The term Protean is still applicable to this assemblage, which in some places consists of thin shaly sandstones, shales, and even conglomerates; in others, of thin-bedded, impure limestones, shaly sandstones, iron ores, etc., with scarcely any fossils except Fucoides; still again it appears as a duplicate series of shales, limestones and iron ores, with some intermixture of sandy matter, all containing abundance of marine shells; and lastly, it presents itself on the extreme western margin of the State, as a single bed of shale and limestone, with rarely a fossil of any kind. From its superior development near the village of Clinton, in the Third district, it has received that name.

It will be seen that this formation, which is colored green upon the map, extends across the district in a nearly east and west direction, occupying a narrow belt of country just above and to the south of the Medina sandstone. Its greatest width within the district is in Wayne county, and it thins gradually towards the west. Through the greater part of Wayne county, this formation ranges within two miles of the lake shore. Crossing the Genesee below Rochester, it forms for a few miles a low terrace on the north side of the canal, known along that distance as "the Little Ridge." After that it is seen on the south side to within eight miles of Lockport, where the canal is excavated in the rocks of the group; thence westward it appears near the base of the limestone terrace, forming part of the slope. Beyond the Niagara river, in Canada, it can be traced, still of the same character as within the State; and it probably follows the associated rocks through the peninsula.

This formation exists in Ohio, though not so distinctly developed as in New-York. Dr. Locke has detected some of the peculiar fossils, as well as the iron ore, in Clinton county of that State; and from numerous other facts, it appears to have a wide range and very variable lithological character. In Pennsylvania the whole formation is greatly thicker than in New-York; but the products bear a close resemblance. It is there known as the "red and variegated shales and sandstones."

From the destructible nature of its lower member in the Fourth district, it has usually receded some distance from the outcropping edge of the sandstone, and it is only along the water-courses that we find it disclosed. The whole group has for the most part been so denuded as to form no prominent line, but enters into the general equal descent of the country toward the lake.

The harder members of the group appear in all the ravines and water-courses, forming rapids, or low falls. These also sometimes appear in the more level country, and are excavated for wall stones.

The greater part of the group is well developed on a small stream near the former Shaker settlement at Sodus bay, and more perfectly, just above the lower falls of the Genesee. At this place the mass admits of the following subdivisions, in the ascending order:

1. Green shale resting on the Grey band, destitute of fossils, very fissile and unctuous.
2. Oolitic iron ore with concretions, fragments of shells, corals, etc. A few thin layers of impure limestone or shaly sandstone, sometimes intervene between the shale and iron ore.
3. Pentamerus limestone, a siliceous or calcareous amss with thin sandy layers, often having the character of shaly sandstone. It also contains bands of hornstone or chert, consisting mostly of silicified fragments of fossils. This part of the mass is distinctly marked by the presence of large numbers of the Pentamerus oblongus, sometimes crowded together, forming a band a foot or more in thickness, or distributed through the whole rock.
4. A green shale similar to that below, though of a less deep color. It also exhibits one or two bands of limestone, composed mostly of shells of Atrypa hemispherica, which preserves its beautiful pearly lustre. It contains Graptolites, and in some localities where these abound the mass is black.

   In this relative situation in Wayne county, the second bed of iron ore occurs. The ore is more perfectly oolitic than that below, and with fewer concretions, and usually less carbonate of lime intermixed. It appears at Wolcott furnace, and is apparently the bed wrought six miles farther east.
5. A limestone similar to the more calcareous portions of No. 3; and at Rochester containing few fossils except crinoidal joints; it is usually thin-bedded, the layers separated by shale; it contains numerous cavities filled or partially filled with sulphate of lime, sulphate of baryta, iron pyrites, etc. From its situation as the separating mass, it partakes also of the character of the next succeeding group. The Niagara, however, being so well characterized, and the Clinton group an acknowledged variable one, it is thought better to place it with the latter.

The same essential order in the parts of the group appertains to it in several localities in Wayne county, but west of the Genesee river two or more of its members are wanting. The shale and calcareous matter seem equally persistent, but both gradually diminish westward.

1. Lower Green Shale.

This mass is known by its bright green color, and its strong contrast to the subjacent rock. It is found in the eastern part of Wayne county, not exceeding thirty feet thick. It is marked towards its centre by a band of purple shale at Sodus point, and numerous localities in the same neighborhood. In some places in the western part of Wayne county, it diminishes and nearly disappears, and again continues of variable thickness. On the Genesee river it is twenty-three feet thick; farther west, at Medina, it is about three feet; while at Lockport it is scarcely visible, or intermixed with the terminal mass of the Medina sandstone. Again, on the Niagara river it has a thickness of four feet. Wherever seen it exhibits its predominating character, as a soft green argillaceous shale, splitting into thin laminæ, and crumbling rapidly on exposure.

At Sodus, and other places in Wayne county, where this rock is well exposed, it contains thin wedge-form layers of limestone of small extent, which are fossiliferous as well as the shale itself, containing large numbers of crinoidal joints, and fragments of drifted shells and corals, as well as perfect specimens. These are sometimes replaced by carbonate of iron, and the substitution is so entire that the crystalline structure is as perfectly preserved as in those of carbonate of lime.

On the Genesee river, the mass is a pure argillaceous shale, entirely free from any calcareous intermixture, and contains no fossils. At this place, it forms a distinct green band in the river bank at the lower falls; and between this and the middle falls is seen both in the bed and banks of the stream. Below the falls, it forms the same distinct band for a mile or two farther north, and is well exhibited in the road leading from the brow of the hill to the steamboat landing. On exposure it crumbles rapidly into thin minute fragments, and in wet weather forms a tenacious greenish mud.

2. Oolitic or Lenticular Iron Ore.

Argillaceous iron ore of Eaton, including the *lenticular* and *jaspery varieties. Lenticular clay iron ore* of Dr. Beck. *Fossiliferous iron ore* of the Pennsylvania Survey.

Succeeding the green shale upon the Genesee river, is a thin bed of iron ore; this is not present in all situations, its place being sometimes marked by the slightly ferruginous color of the upper part of the shale, or lower part of the limestone above. The quantity of the material seems to have been very small, and from its nature widely diffused; it probably existed in the menstruum, which at the same time held in suspension the materials forming the other associated deposits. In some instances, it has forced its way through all the upper deposits and rests on the lower shale, and in other cases the upper shale has arrested its progress. It appears to have been intermingled with both the limestones, and probably separated from them by its greater specific gravity, falling to the bottom, where the shaly matter had become too firm for its farther descent.

The purple or brownish band which marks the lower green shale at Sodus point, while the iron ore is there absent, and again, the fossils of that division replaced by carbonate of iron, sufficiently prove the intimate mixture and diffusion of the ferruginous matter through the whole.

In the town of Ontario, Wayne county, this bed of ore attains its greatest thickness, which is about two feet. Between this place and the Genesee river, it is scarcely to be found exposed, though constantly near the surface. On the Genesee, its thickness is about fourteen inches, showing a diminution from Ontario of ten inches in about twenty miles. Westward from the Genesee, the rock immediately above is often ferruginous, but I have nowhere seen the ore as a separate stratum. At Medina, Albion, Lockport and other places which offer good sections, as far west as the Niagara river, the ore is absent.

This diminution and final disappearance westward would indicate the place of its origin to be farther east, and beyond the limits of the Fourth district. The existence of large beds of specular and micaceous ore on the northwestern slope of the primary chain of northern New-York, where denudation has been extensive, and large quantities removed, may be the source. A more probable origin of the ore, however, is in the decomposition of iron pyrites, and the production of this oxide of iron. The oolitic-form seems, according to the facts presented by Mr. Vanuxem, due to the influence of thermal waters. Such a condition of the menstruum would hasten the decomposition of the pyrites and the formation of the oolitic ore.

The second bed of iron ore appears but in few places in the Fourth district, and in all except one locality is too thin to be of economical importance. Another fact which is somewhat remarkable, is that the two beds never appear in succession at the same locality, or in the same line of section. In places where the lower one occurs, the upper is wanting; and where the upper occurs, the lower one is not found. This circumstance farther confirms the opinion, that the materials were in a state of mechanical suspension, and the place of their final deposition only determined by the solidification of the strata which opposed their descent.

The deposition of all matter forming rocky strata would take place inversely as their solubility, if in solution, and directly as their specific gravity, if in suspension. The ore is rarely if ever found diffused through the shale, except where that mass contains calcareous matter; but in such points it often pervades several feet in thickness. The iron and carbonate of lime, from their nature, would remain much longer in the menstruum than the clay. The iron, though more soluble than the calcareous matter, would still be carried down by that body on its deposition, and thus what forms a thin band of ore in one place may be diffused through several feet of calcareous strata in another.

The Wolcott ore bed, which is wrought to supply the furnace in that town, appears, so far as I can examine the rocks above and below it, to be the upper of the beds mentioned. Its thickness is much greater here than elsewhere, and it is succeeded by a shaly rock containing a peculiar association of fossils.

At Wolcott furnace, six miles west of this, the upper ore bed is but a few inches thick, and quite insufficient for working; it is seen in the creek, associated with thin beds of impure limestone, shale, etc. At this place it is impossible to ascertain whether the lower bed occurs or not, but in excavations in the Pentamerus limestone there has been no iron ore seen, or at least none has been thrown out with the limestone. In several other localities between this place and Sodus point, iron ore has been discovered, but so far as I could ascertain they are all of the upper bed.* At the Shaker village, Sodus point, the position of the upper bed was not distinctly visible, though all the deposits below were so. Upon excavating the earth, large masses of ore were obtained; and though from the quantity of fragments of the superior rock, I did not find the ore actually in place, there is still scarcely a doubt of its existence at that spot. Its place is in the bed and banks of the stream a few rods above the mill-dam.

The place of the lower bed is here distinctly seen, but the ore is absent, its only representative being the small quantity of carbonate of iron disseminated in the limestone above.

I have not been able to discover the upper bed west of this place; the next locality exhibits a thinning of the lower green shale, with the ore intermixed with the Pentamerus limestone. North of Sodus village, and in the town of Ontario, the ore is evidently from the lower bed, the Pentamerus limestone always appearing above. The last place westward where the ore is seen as already mentioned, is the lower bed, on the Genesee.

3. Pentamerus Limestone of Clinton Group.†

This mass, in some places, is composed almost entirely of thin beds of impure limestone, which alternate with thin layers or laminæ of green shale; in other places it is a nearly pure crystalline limestone, composed of broken valves of Pentamera and other shells, with a large proportion of crinoidal joints. The latter character prevails in some places in the eastern part of Wayne county, and is seen distinctly at Whiting's mill, three miles west of Wolcott furnace. To this structure, producing unequal expansion of the crystalline and uncrystalline portions, is due its power of withstanding heat, which has brought it into use as an ordinary firestone for chimneys, hearths, and some of the less exposed parts of furnaces.

At Sodus point, and a mile northeast of Wolcott furnace, the shells of Pentamerus are imbedded in a shaly mass, with just sufficient calcareous matter to make it firmly cohere. North of Sodus village the mass is free from argillaceous matter.

On the Genesee river this rock outcrops in the banks on either side, and stretches across the stream, forming the middle falls. In this situation we find less shale, but an intermixture of shaly and calcareous sandstone, which in some places predominates. Much of the mass is a crystalline siliceous limestone, very compact and tough, forming excellent building materials, but difficult, from its hardness, to work. The predominating siliceous character at this locality, induced Prof. Eaton to give it the name of Ferriferous sandrock; this term cannot be retained, from the fact that in nearly all localities examined it is comparatively free from sand, and its distinctive feature is calcareous.

In numerous localities in Monroe county it appears as a limestone, and is quarried in many places for the same uses as in Wayne county. The Pentamerus, on the Genesee, is confined

* In some places, from the proximity of the Lake level, it is impossible to ascertain without boring, whether the lower stratum of ore does exist or not.

† This term is used in this manner to avoid confusion, the term *Pentamerus limestone* being used to designate that mass charged with *Pentamerus galeatus* in the Helderberg series.

to a small portion of the rock, and seems gradually to disappear farther westward. In Orleans county the same limestone is entirely destitute of this fossil, but is readily recognized by position and other characters. In many places in Wayne and Monroe counties it contains nodules of hornstone, which sometimes assume the form of calcedony. This matter increases so much in Orleans and Niagara counties, that it forms thin layers alternating with the limestone. Associated with this chert are commonly found silicified fragments of shells and crinoidal joints. At Rochester, distinct layers are entirely composed of the silicified shells of a species of Strophomena.

One mile south of Medina, in the bed of the stream, the limestone is seen separated from the upper member of the Medina sandstone by only three feet of shale. At that locality, the rock is composed of thin irregular layers of impure limestone with much hornstone; the courses are separated by shale, which in the exposed banks of the stream has dissolved out, and left the solid parts piled loosely together like a stone wall. The Pentamerus is not here found, but the rock is abundantly charged with other fossils, particularly the Atrypa congesta, which is rare on the Genesee. About eight miles east of Lockport it is excavated from the bed of the canal for some distance, where it is composed of thin irregular layers of impure limestone and greenish shale, with much hornstone. When we arrive at Lockport, it becomes evident, that from the thinning of the Second green shale of the Rochester section, the two limestones have come together; the Pentamerus division forming but a few feet of the cherty layers in the lower part of the mass. This might have been expected from the thinning of the lower shale at Medina; and at that place there is no evidence of the existence of the upper shale, though the absolute contact of the two limestones cannot be determined. From Lockport, the Pentamerus portion continues to form the lower layers of what is thence one mass of limestone; and it appears in like manner and situation on the Niagara river. At Lockport it has become nearly destitute of fossils, and on the Niagara river it is entirely so, with the exception of crinoidal joints. The lower part of the limestone, as it appears on the Niagara river, is highly magnesian, and from the presence of iron pyrites rapidly decomposes, giving rise to the production of sulphate of magnesia, which at favorable points, along the overhanging mass upon the river bank, may be collected in quantities of several pounds.

What changes this rock may assume beyond the district is uncertain; so far as traced in Canada, it maintains the same characters as on the Niagara river. We know, however, that in the southwest part of Ohio, and in Indiana near the junction of the Blue and Cliff formations (of the Ohio reports), there is a limestone charged with Pentamerus oblongus. The same continues westward, and is seen in Wisconsin and Iowa. From this it is evident, that while this fossil and the mass to which it is confined nearly disappear within New-York, there is a reäppearance of the same at the southwest and west; and that whatever may have been the cause of its non-existence in the western counties and in Canada, it still was living in a remote part of the ocean in great profusion, and perhaps undisturbed by the causes which put an end to its existence here. It was before remarked that the shells of this fossil are nearly all broken, and the valves packed together as if drifted or washed by the waves, few perfect ones being found. At the west, on the contrary, the larger number appear to be perfect; and though in some localities they may have been drifted, still, as a general rule, they have not suffered violent removal. This furnishes, among others, an example of a formation which, after thinning partially or entirely, reäppears in the same direction, even better exhibited than in the first locality. Although the group is much more developed in the Third district, still the Pentamerus appears but rarely, and attains its greatest perfection in Wayne county.

4. Second Green Shale.

This is readily distinguished from the lower green shale by its less deep color, and from being everywhere fossiliferous, while the lower is so only in a few localities. The change is very abrupt from the limestone below to this soft green shale. At Rochester, this mass has a thickness of twenty-four feet, and it maintains nearly the same in other places. At Wolcott, however, it appears to be somewhat thicker, though its upper limit was not distinctly ascertained. It is well exposed at Wolcott furnace in the banks of the creek ; it also appears at the ore bed six miles farther east. At Sodus point it is well exhibited, and large specimens may be obtained covered with Graptolites. Its whole thickness is seen in the Genesee river below the upper falls at Rochester. From this point it diminishes westward, and entirely disappears, as before mentioned, leaving the two limestones in contact.

At Rochester and other places, the mass embraces a band of purple shale three or four feet thick, differing from that around it only in color. A few feet higher it is marked by a line of black, containing Graptolites. This portion is usually exceedingly brittle, apparently from the presence of carbonaceous matter.

About six feet from the top of the green shale, are two, or in some places three, thin bands of calcareous matter, three or four inches thick, composed entirely of shells, principally the Atrypa hemispherica, which still preserves its original lustre, giving the whole mass a pearly or silvery hue. Very beautiful specimens are obtained from these bands, presenting an entire surface of the shells ; it is rarely, however, that perfect shells are found. They seem to have been drifted together in great numbers, and the valves are often separated. Like the Pentamerus below, they indicate a period when the tranquillity of the waters was disturbed, or when from some other cause this portion had become the margin of the sea.

Throughout the deposition of this shale, however, the ocean appears to have been quiet: the mass consists of finely levigated mud, which would not have been deposited during a period of much disturbance. The condition of the fossils usually indicates a very quiet state of the waters; when imbedded in the shale, every part is found in great perfection. The delicate structure of the Graptolites, which apparently the least agitation would destroy, is generally preserved very entire.

The upper part of this mass is often deeply stained externally by oxide of iron, though the bed is entirely wanting. The stain of iron prevails more or less throughout, penetrating all the slaty divisions, and often forming a thin enamel over the green surface. I have seen no minerals in this rock, except in the thin calcareous bands, where sulphuret of iron, sulphate of baryta, and crystals of carbonate of lime sometimes occur, the two latter in small nests or cavities.

Upper Limestone of Clinton Group.

The second green shale, like the first, is terminated above by an impure, thin-bedded calcareous deposit; the layers, which are often exceedingly tough, are separated by narrow seams of green shale. This rock closely resembles the more calcareous portions of the lower limestone. In some localities it contains masses and nodules of iron pyrites, which, on decomposing, leave the spaces filled with anhydrous gypsum, and these sometimes occur in such profusion as to render the rock useless for building purposes: Again, it is more sparingly diffused, and only sufficient to discolor the surface on weathering. The lower part of this limestone is often deeply stained with iron from the decomposition of pyrites; and from the general similarity of the two calcareous masses, one is often led to suspect the occurrence of a bed of iron ore in a similar situation. Toward the Niagara river it becomes more entirely calcareous, and contains less sulphuret of iron.

Some of the strata are of crystalline structure, and greyish blue color, composed in a great degree of comminuted corals or other organic remains. From its unequal crystallization it becomes, like the Pentamerus mass below, a good fire-stone. This character, however, with the intermixture of siliceous and argillaceous earths, makes it generally unfit to be burned for lime.

This division is eighteen feet four inches thick on the Genesee river, and continues throughout the district more uniformly than either of the others; showing about twenty feet on the Niagara. In many places it extends beyond the base of the great Limestone terrace, and forms a narrow plateau to the west of Rochester, often quite exposed from the removal of the superincumbent earth.

The more uncrystalline portions of this limestone dissolve on weathering, and leave the crystallized joints of crinoidea, corals and other fossils, standing out in bold relief. Thus is revealed in a clear manner the materials of the rock, as well as the changes that have been wrought upon them. These fragments of shells, crinoids and corals must once have formed parts of living and perfect individuals, which have lived at the bottom of the ocean, beyond the reach of the destructive agency of the waves; again they have been brought within such influence, and broken down, and their fragments ground together, till they formed the homogeneous mass presented to the eye in the great body of this rock. Afterwards these materials must have constituted a beach, or bar of calcareous sand, extending beyond the limits of the district in either direction. This is the process of formation not only of this individual mass, but of nearly all calcareous deposits. The close alternation of deposits of purely argillaceous matter, with those of calcareous composition, is another subject of the highest interest to the student in these subjects; they indicate changes in the depth of the ocean which have marked the different periods; and they direct us to the influence of causes which are now in operation upon the solid crust of the earth, and visible only by their effects in elevating or depressing the bed of the ocean.

Localities. — The most easterly exposure of the rocks of this group within the district, is at the Wolcott ore bed, where some of the higher shale with fossils, as well as the iron ore, is found. Near Red-Creek village we find the green shale with fossils; at Wolcott furnace, the Pentamerus mass and the green shale above; and at Whiting's mill, three miles west of this place, the Pentamerus mass and lower green shale are seen. At Sodus point we find the iron ore and associated shales and limestone. At the former Shaker settlement on Little Sodus bay, all the members of the group, except the iron ores, are well exhibited, and this is one of the best localities in Wayne county for its examination. The Pentamerus mass forms a fall of twelve feet in the stream at that place; the green shale, with fossils, appears below, in the bed and banks of the creek; and above the fall, the higher green shale with Graptolites, and the upper limestone with Atrypa, are both seen.

In the eastern part of Williamson, a little north of the Ridge road, the green shale with Graptolites occurs, and a short distance to the north of this, the Pentamerus limestone.

North of Sodus village the Pentamerus limestone and iron ore appear in several places.

On Salmon creek, above the forge, the iron ore, green shale and Pentamerus limestone are all exposed, and still farther up the stream are found the thin calcareous layers with Atrypa hemispherica. Again at Ontario, just north of the Ridge road, the green shale with fossils may be seen; and finally, almost every stream north of the road from Wolcott to Rochester, exposes one or more members of the group.

In Monroe county, the group appears near the head of Irondequoit bay, and again in the banks of the Genesee, which is its best exposure in the district. The canal is excavated in the same for some distance, about twelve miles from Rochester. In Sweden it is exposed on a small stream which crosses the canal a little west of Adams' basin. There are also a few other localities, but the exposure is meagre.

In Orleans county, some of its members are seen in the stream south of Albion; also on the Oak-orchard creek, a mile south of Medina, the mass is well exposed, this being the best locality for order of superposition west of Rochester.

In Niagara county, the limestone appears near the village of Middleport, where a small stream crosses it. A short distance west of Reynolds' basin, the canal was excavated in the group, and the piles of fragments of the impure limestones, shaly matter, and hornstone, with numerous fossils, render this an attractive spot. Passing on to Lockport, we find the same rock exposed in the banks of the stream below the village, and, as before remarked, nearly the whole group is represented by the limestone. The limestone and the thin mass of lower green shale are seen in the escarpment at numerous points between Lockport and Lewiston, where it crops out in the river bank.

Thickness. — The thickness of the whole group in Wayne county, wherever it can be measured, is somewhat less than eighty feet; and in some places, from the thinning of the shale, it is little more than sixty feet. On the Genesee river, its different members appear as follows:

	Feet.	Inches.
5. Upper limestone,	18	4
4. Upper green shale,	24	00
3. Pentamerus limestone,	14	00
2. Iron ore bed,	0	14
1. Lower green shale,	23	00
	80	6

At Lockport the calcareous portion is about twenty feet thick, and the shale scarcely definable, apparently mingled with the terminal part of the Medina sandstone. On the Niagara river the limestone is twenty-five feet thick, and the shale below four feet.

Mineral Contents of the Group.

The first mineral which meets the eye is the hornstone of the Pentamerus mass: this often passes into translucent varieties, and forms little cavities lined with calcedony. Fossils which are enclosed in the mass, frequently, on breaking, present a cavity lined with delicate quartz crystals, or calcedony. At Rochester large geodes have been found lined with this mineral, in mammillary or botryoidal forms, producing beautiful specimens. Siliceous sinter and cacholong both occur in the same association, and Prof. Dewey mentions carnelian as occurring here.

The sulphates of baryta, and of lime, are both found in the rocks of this group, and in several localities. The sulphate of baryta occurs in spheroidal cavities in the Pentamerus mass, and more rarely in the upper limestone. Groups of crystals, and cavities lined with the same, of a beautiful flesh-red color, occur in the oolitic iron ore at Wolcott, and more rarely with the ore in other places. Crystallized carbonate of lime is found with the sulphate of baryta, and in other situations. The sulphate of lime is principally confined to the upper limestone, where it often forms masses of considerable size, partially filling cavities which have apparently resulted from the decomposition of iron pyrites. Pyritous copper and green carbonate of copper occur in the Pentamerus mass, and Prof. Dewey has discovered some spiculæ of native copper in the same rock. I have detected the green carbonate of copper in cavities in the calcedony or sinter, at Medina and near Reynolds' basin.

Mud Casts. — The lower strata of the Pentamerus mass, on the Genesee, are of a shaly sandstone; these, when in contact with the shale below, often present surfaces curiously contorted and twisted. They appear as if they had been in a semi-fluid state, and forced along over the yielding mud, previously rendered uneven by the flowing of water over the surface, by which little depressions had been scooped out at short intervals, and into these the subsequent mass was deposited.

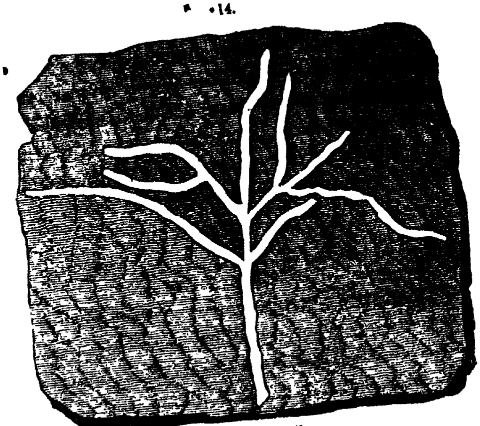
Another appearance attending these lower strata, is the occurrence upon their under side of long straight, or slightly tortuous ridges, standing out in bold relief upon the slab. These I have denominated casts of mud-furrows, and suppose them to have been made in depressions previously existing in the mud, and filled by the subsequently deposited matter. These are of more common occurrence in the rocks of the Portage group, where they will receive illustration. Whatever may have been their origin at the period of the Clinton group, they appear to be widely extended. When in Ohio, Dr. Locke showed me specimens of precisely similar character, and from the same position in that State. They were likewise associated with thin layers, containing numerous crinoidal joints, identical with those so abundant in the same rock at Medina, Lockport and elsewhere. The influences operating upon the bottom of the ocean at these two distant points, are thus proved to have been the same.

Organic Remains of the Clinton Group.

This group is for the most part well marked by its fossil contents, and presents an interesting series of organic remains. From the varying character of its lithological productions, however, the fossils are not so constant in their occurrence as in other rocks; and if the group be examined at distant intervals, scarcely a fossil will be recognized as common to the two localities. A portion of the mass at one place well marked by certain species, may be destitute of fossils at another, or present, for the most part, a different assemblage. It becomes very evident, therefore, that lithological development has had much to do with the occurrence and nature of the fossils, as well as their abundance. It has already been seen that the products of the group fail in a western direction, and at the same time the character of the fossils changes in an equal degree. On the Niagara river, the only fossil which can be said to continue from the eastern extremity of the district, is the peculiar Crinoid of which we find the numerous joints; and these indeed may have been drifted to their present situation. This crinoidal joint (fig. 5, woodcut No. 16), is abundant in nearly all situations, and though apparently an insignificant object, the observer will find it of the greatest use in tracing the lower limestone through the district. The same likewise appears in Ohio in equal abundance.

In the Third District this group is much more extensively developed than in the Fourth, and its products are even more variable. Its most obvious fossils are marine plants, or Fucoids, which everywhere mark its shales and shaly sandstones; but in the Fourth District, rarely more than one species is seen, and this is common in the thin layers of sandy shale succeeding the lower green shale. This species closely resembles one in the Hudson river group, and bboth ear much analogy to the *F. antiquus* as figured by Hisinger. The following figure is from a nearly perfect specimen as usually seen, and it may be considered the lowest fossil of the group on the Genesee river.

14.



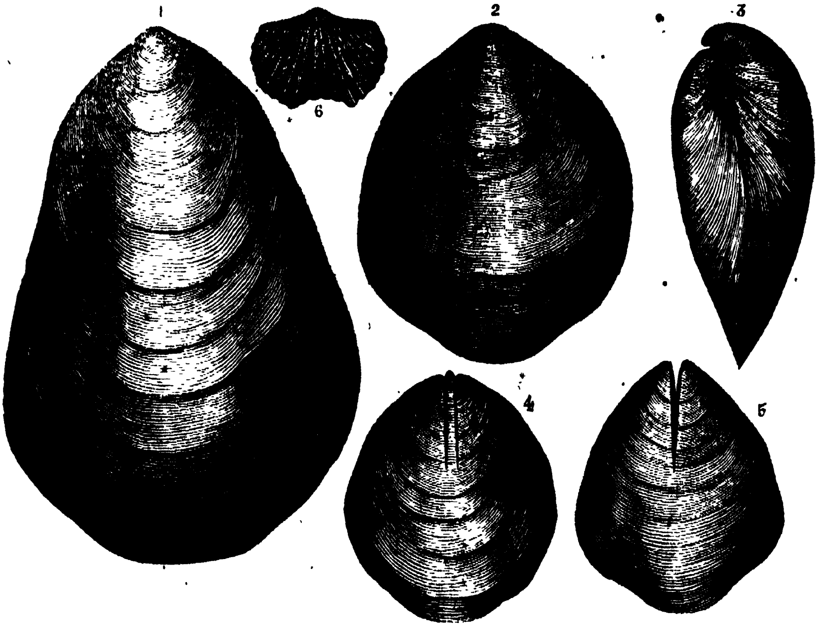
Fucoides Gracilis.

This species is one of the most delicate of the marine plants preserved in our rocks, and the specific name of *gracilis* is proposed. The branches sometimes appear as if nodulose or vesicular. The specimen figured is probably only a branch from a larger individual. It will be observed that the stem and lateral branches are of equal size; it was therefore a floating and probably a flexible plant, as the stem could not have supported branches of its own dimensions. This species beautifully contrasts with the strong and rigid forms from the same group farther east.

In the Fourth District, the lower limestone, as its name implies, is eminently characterized by the presence of the *Pentamerus oblongus* of Murchison. This fossil exhibits a great variety of form as well as of size. The shells are nearly all broken, and so packed together as to indicate that they have been drifted by a current or washed by the waves, while the mass formed the margin of the ocean or an elevated portion of its bed. At Rochester they become an entire layer of about one foot in thickness, but farther east they are distributed throughout the whole rock, and bear evidence of much wearing before being imbedded; they are also frequently much intermixed with green shaly matter.

The following woodcut gives illustrations of some of the common forms.

15.



1 – 5. Pentamerus oblongus. 6. Delthyris brachynota.

Pentamerus oblongus. — Fig. 1 is a view of the larger valve of a full grown individual, showing a great expansion toward the base, and a tendency to a three-lobed character. The concentric lines of growth are strongly marked.

Fig. 2 is the smaller valve of a younger shell, which presents a more circular form, but still the same tendency to trilobation.

Fig. 3 is a side view of a perfect specimen, showing an intermediate proportion between the others.

Figs. 4 and 5 are casts of the upper and lower valve, showing those divisions upon which the generic character depends.

The Pentamerus commences in the Third District, and from its prominent characters furnishes a good guide to the existence of the group as far west as the Genesee river. It sometimes occurs in the iron ore both in the Third and Fourth Districts.

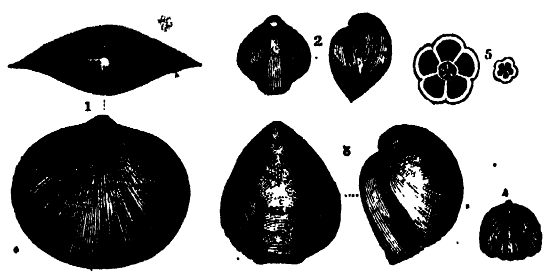
This fossil is typical of the calcareous beds in the Caradoc sandstone of England, and specimens of the mass with broken shells from the Hollies, can scarcely be distinguished from those on the Genesee and in Wayne county. Mr. Murchison has described two species, the *P. lævis* and *P. oblongus*, both of which appear to be represented in our numerous varieties, and are apparently referable to the same shell.

I have obtained beautiful casts of this fossil in a light grey limestone (lower part of the "cliff,") from Springfield and Dayton, Ohio, and have seen them from several localities in Indiana. In Iowa I collected some fine silicified casts of the same, from the cliff limestone, on the Maquoqueta creek. It is therefore a widely distributed fossil, and when more thoroughly examined will doubtless be found typical of certain strata at the west, as in New-York.

Fig. 6, the *Delthyris brachynota* accompanies the Pentamerus, and even continues long after that fossil has disappeared; several specimens having been seen near Reynolds' basin, in Niagara county. It is the only Delthyris known in this rock, and is readily recognized by the relatively short hinge line.

The other fossils of the limestone are represented in the following woodcut:

16.



1. Orthis circulus.
2. Atrypa congesta.
3. Atrypa naviformis.
4. Atrypa plicatula.
5. Crinoidal joint. (Natural size and magnified.)

1. *Orthis circulus.*—This is a beautiful, circular, finely radiated shell, with a narrow area. It is found accompanying the *Atrypa congesta* at Reynolds' basin. It is distinguished from a similar shell in the Hamilton group by its greater length on the hinge line, and the greater proportional width of the shell.

2. *Atrypa congesta* (of Conrad). — West of the Genesee river, after the disappearance of the Pentamerus, we find the lower limestone of the group distinctly marked by the presence of this small Atrypa, which is exceedingly abundant at Medina, and near Reynolds' basin. It is associated with the crinoidal joints like fig. 5 of woodcut. It appears standing out in relief upon the surface of weathered specimens, which are abundantly strewed over the ground a mile or two south of Medina. Near Reynolds' basin it occurs in great numbers, completely covering the surface of certain layers, and large numbers of separate individuals can be obtained among the decomposed portions. This shell appears to take the place of the Pentamerus so far as regards numbers of individuals, prominence, and place in the strata.

It is a smooth shell closely resembling *Atrypa linguifera* of Murchison's Silurian System, pl. 13, fig. 8; but the length of the latter appears to be greater in proportion, and the shell smaller; the mesial elevation of the upper valve also appears more prominent, judging from the figure. This shell occurs in the iron ore bed at Rochester.

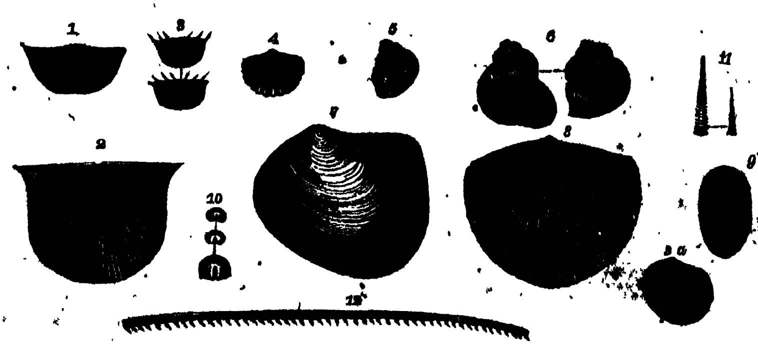
3. The *Atrypa naviformis* is a nearly globular smooth shell, the beak extending considerably, and incurved; the lower valve is much elevated in front, after the manner of *A. linguifera* and *A. congesta*. This shell is typical of the upper limestone of the group, and so far as I know, is found in no other rock.

4. The *Atrypa plicatula* presents three of the folds raised in front, and from six to eight on either side; three of them very distinct, the remaining ones obscure. There is a slight depression in the upper valve, extending from the beak one-third the length of the shell.

5. Joints or plates of *Actinocrinus? plumosus.*—This fossil is found in greater or less profusion in the lower limestone, throughout the extent of the district. It appears in great numbers one mile south of Medina, in the weathered specimens of the rock. Large surfaces are often covered with them, usually presenting the form given in the illustration. A mile west of Reynolds' basin they are equally abundant, associated with the *Atrypa congesta* and *A. plicatula*.

With the crinoidal joint are found some plumose tentaculæ of a crinoid, which apparently belong to the same species. It is provisionally placed in the genus *Actinocrinus*, and this character of the tentaculæ gives its specific name.

In the green shale we find, for the most part, a different association of fossils from those of the limestones, though two or three species are common to both. In the accompanying illustration are presented the most common forms found in both the upper and lower green shale.



1. Strophomena elegantula.
2. S. corrugata.
3. S. cornuta.
4. Atrypa hemispherica.
5. Littorina cancellata (young shell.)
6. Littorina cancellata (old shell)
7. Posidonia? alata.
8. Atrypa affinis? var?
8 *a*. — — (young shell).
9. Calymene? trisulcata.
10. Agnostus latus, natural size and magnified.
11. Tentaculites minutus, natural size and magnified.
12. Graptolites Clintonensis.

All the specimens here figured occur in the upper green shale, and nearly all at Rochester. Figs. 5, 6, 8 and 8 *a*, occur in the lower green shale in Wayne county, being common to the two shales.

1. *Strophomena elegantula.* — This is a beautiful semicircular shell, marked with strong elevated lines, having from four to six fine striæ between each. It occurs in Wayne county, and at Rochester. This shell bears considerable resemblance to *S. transversalis.*

2. *Strophomena corrugata.* (*Jour. Acad. Nat. Science*, Vol. viii, p. 256, Pl. 14, fig. 8.) — This shell is beautifully radiated, the rays dividing, a larger and smaller one alternating. On the hinge margin it is marked with a few oblique folds, which are frequently obsolete in well preserved specimens. This appears to be the fossil of which large numbers are imbedded, and completely silicified in the Pentamerus limestone. It occurs both in the limestone and shale. The specimen figured is from the upper green shale at Rochester.

3. *Strophomena cornuta.* — Shell semicircular, finely and equally striated; hinge line straight; each valve furnished with six small, stiff, diverging spines. This shell closely resembles the *Leptæna lata* of *Von Buch*, as figured in the Silurian System (Pl. 5, fig. 13); but it is much smaller, and apparently more finely striated. The *L. lata* is found in the Ludlow rocks of England, which are equivalent to our Hamilton group. The *S. cornuta* occurs in a situation associated with fossils typical of the Caradoc sandstone of the Silurian System. This shell is abundant in the upper green shale at Sodus bay.

4. *Atrypa hemispherica* (?) (*Silurian System*, Pl. 20, fig. 7). — This little shell has from twelve to fourteen radii. It is usually much flattened, though one valve is much more convex than the other. It corresponds very closely with the figure and description given by Mr. Murchison. It occurs in such numbers in the upper green shale at Rochester, as to form two thin layers before referred to, where the shells retain their natural pearly lustre. This fossil occurs at Wolcott, Sodus, Rochester and Medina, as well as several other places.

5 and 6. *Littorina cancellata.* — Fig. 5 is a young individual of this species, finely and beautifully cancellated over the whole surface. This marking is prominent in young specimens, but becomes obliterated in older ones, as is seen in fig. 6, where two views are given of an older individual of the same species. Some faint longitudinal striæ are here visible, and in other specimens I have detected the crossbarred markings partially worn off. The shell is frequently quite smooth. It is abundant in the green shale at Sodus, and at Rochester; also in the Pentamerus rock at Rochester and Medina.

7. *Posidonia ? alata.* — Shell compressed, alated behind and rounded before, very inequilateral, wider than long; surface rather strongly marked with concentric lines of growth. Found in the upper green shale at Rochester. It is not an abundant fossil.

8. *Atrypa affinis, var. ?* — This shell presents the form and markings of some of the individuals referred to that protean species. The portion within the shaded line is strongly ribbed and marked by lines of growth; without this line, the margin is compressed, and the lines of growth scarcely defined. It often occurs, presenting this form, and appears like the *A. affinis* surrounded by a fringe.

Fig. 8 *a*, is apparently a young individual of the same species. It so frequently occurs of this oblique form, that I have presented a figure.

This shell is abundant in the upper and lower green shale at Wolcott, Sodus and other places in Wayne county, and less common at Rochester and the localities at the west. A similar form, however, is abundant in the upper part of the limestone of this group at Lockport, the variation perhaps due to the nature of the matrix. This, or another variety is abundant in rocks of this group in the Third District, and considered among its disinctive fossils.

9. *Calymene? trisulcata.* — This little Trilobite is one of the fossils occurring in the green shale at Rochester, associated with those here described. Body with eleven articulations; tail with four distinct articulations on each lateral lobe, and six on the central one; the central lobe of the head is marked on each side by three indentations or furrows, which extend about one-third across it. In these furrows it somewhat resembles the *Triarthrus*, and more nearly the *Calymene? Downingiæ* of the Wenlock limestone.* The structure and arrangment of the eyes, however, differ from the latter; and according to the strict definition of the genus *Calymene*, it should be separated. Our specimen is much smaller than *C. Downingiæ*, its length being but half an inch.

10. *Agnostus latus.* — Natural size, and magnified. This fossil is placed among crustaceans by naturalists. It usually presents two views: one with a narrow depression in the centre and an elevation on each side, and flanked by an expanded border; another form where there is only a slight broader depression in the centre, and no elevated ridges — probably the two sides of the creature. This fossil occurs in great numbers in the upper green shale at Rochester, and also at other localities. In the Third District it occurs in millions, and though so small, yet constitutes a large proportion of some thin sandy and shaly layers in rocks of this group south of Utica.

This is the lowest position in which this fossil is known in New-York. It was discovered in the green shale at Rochester, in the second year of the survey; and since that time, it has been found in many other localities.

11. *Tentaculites minutus.* — This fossil occurs with the *Agnostus* and other forms in the green shale at Rochester. The figures are of the natural size, and magnified. It is distinctly annulated near the base, but apparently smooth above. Its minuteness, and the compressed and flattened form in the shale, renders a full examination of the specimen difficult.

12. *Graptolites Clintonensis.* — This fossil occurs in great abundance in the upper green shale at Sodus, Williamson, Rochester, and numerous intermediate points. The serræ or teeth are usually long, and bent or recurved, though others associated with them differ in this respect. I have not yet decided whether one or two species exist. At Sodus the shaly laminæ are completely covered with these bodies, broken into short fragments, and lying in great confusion; more perfect specimens are often found with *Strophomena cornuta.* In the

* Silurian System, p 655, pl. 14, fig. 3

eastern part of Williamson, a little north of the Ridge road, the shale is completely charged with them, and very black and brittle, as if from carbonaceous matter derived from the fossil. The same character of the slate containing them, is noticed on the Genesee. This fact, and other similar ones, together with the carbonaceous nature of the fossil, would argue against placing these bodies among the calcareous polyparia. The specimen figured, resembles in some degree the *G. Ludensis* (Silurian System, Pl. 26, figs. 1 and 2); but in ours the serræ are longer, less closely arranged, and the whole individual more delicate. Since also this fossil is found in rocks much lower than the Ludlow rocks of England, the probability of its being a distinct species is increased, and a specific name indicating its position is given.

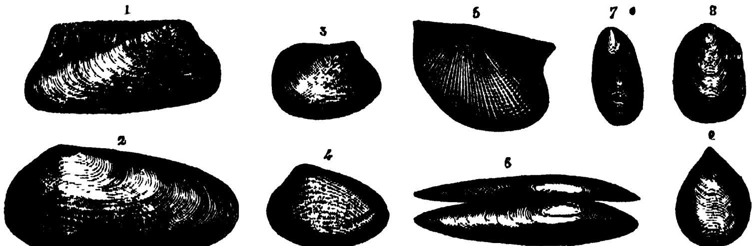
The shale associated with the iron ore at the Wolcott ore bed, though apparently holding the place of the upper green shale, contains an assemblage of fossils mostly different from those of that rock in other places, and also differing from those of the group generally in the Fourth District. Several other forms occur besides those presented in the following illustration, all differing as much from the ordinary ones; while at the same time no fossil was found associated with them, which is common to the group elsewhere. This circumstance, however, adds but another fact to the many, regarding the geographical distribution of fossils in this group, and proving that upon the lithological character of the products depended, in a great degree, the organic forms which inhabited the bed of the ocean.

An exhibition of the lithological development of the Clinton group at different points along its range, together with the fossils of each division, furnishes an instructive illustration of the nature and products of geological formations. We have here changes in the space of two hundred miles, as great as in other formations, when traced over an extent of as many thousands. The two extremities of the group within the State present scarcely any features in common, either fossil or lithological.

While this group contains an assemblage of fossils peculiar to itself, and marking it as clearly as other formations are distinguished by similar characters, a few forms link it with the next group in the ascending order. The *Strophomena depressa* appears here as its lowest position, and continues through several succeeding rocks. The *Delthyris radiatus*, and a smooth species of *Atrypa*, are also common to this group and the Niagara, not appearing in any higher position. The *Catenipora escharoides*, which is abundant in the upper part of the Niagara, first appears in this group.

The forms presented in the illustration No. 18, are from the shale of the Wolcott ore bed.

18.



1 Orthonota curta.
2. Nucula machæriformis.
3. Cypricardia obsoleta.
4. Nucula mactræformis.
5. Avicula leptonota.
6. Cypricardia? angusta.
7. Lingula elliptica.
8. Lingula oblata.
9. Lingula acutirostra.

1. *Orthonota curta.*—Length rather more than twice the height of the shell; posterior slope obtusely carinated. This shell is readily known by its straight hinge line, truncated posterior margin, and numerous plications extending from the oblique fold or keel to the anterior margin. The characters of the genus, as given by Mr. Conrad, are perfectly applicable to this shell. One specimen has been found at Rochester, which is the only one, with the exception of those at the ore bed.

2. *Nucula machæriformis.*—The shell is much elongated, and faintly marked with concentric striæ; beaks scarcely prominent. The elongated form, and scarcely visible striæ, distinguish this shell from all others of the group. It is always much flattened from pressure, and was apparently a fragile shell. It resembles *Machæra* (*Solecurtus*) *costata* in form; and in some specimens, I have seen impressions of a rib extending from the beak, as in that shell.

3. *Cypricardia obsoleta.*—Beaks very prominent; shell marked with faint lines or folds, scarcely striated. Its prominent beaks and rhomboidal form, with the worn or decayed appearance of the shell, are its distinguishing marks.

4. *Nucula mactræformis.*—Shell ovate, marked by concentric striæ which are stronger upon the anterior margin; a slight fold (perhaps from compression) extends along the posterior slope. Height two-thirds the length of the shell. The form and proportions of this shell distinguish it readily from others of the group.

5. *Avicula leptonota.*—This shell is usually marked by strong longitudinal ribs, and crossed by fainter concentric lines; posterior hinge margin depressed. In many specimens the concentric lines are nearly obliterated, and the longitudinal ribs only visible. It occurs in considerable numbers, often crushed, and its form nearly destroyed.

6. *Cypricardia? angusta.*—Shell narrow, much elongated, marked by concentric folds which are more prominent and fewer in number on the anterior margin. The hinge resembles externally the *Cypricardia*, but the internal arrangement cannot be seen.

7. *Lingula elliptica.* — Shell oval, nearly equal in width at each extremity, marked by concentric lines or slight folds, which are scarcely elevated.

8. *Lingula oblata.* — Shell very wide in proportion to the length; surface marked by concentric lines or slight folds, which are stronger and more prominent on the margins; the whole surface covered with exceedingly fine concentric striæ. This shell differs from the last in its proportions, and in having two series of concentric markings which do not appear in the first.

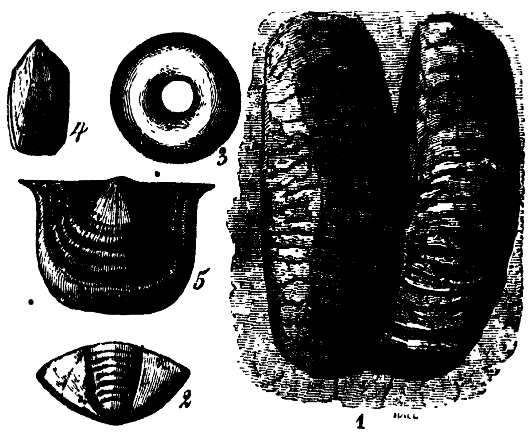
9. *Lingula acutirostra.* — This shell is readily distinguished from the other two by its form, and also from any described Lingula of the New-York rocks. The shell is broad below, tending abruptly to an acute point at the apex; surface marked with a single series of rather coarse striæ. It is larger than the *L. acuminata*, and the surface more strongly marked by the concentric striæ, as well as more abruptly acute.

The three species here described are all found in a single locality, the two last quite numerous. This circumstance is somewhat unusual; the shells of this genus, though often abundant, rarely exhibit more than a single species in a rock or at a locality.

All the forms presented above, with several others, may be obtained in the shale at the Wolcott ore bed, and those of the previous illustration at Sodus point and Rochester; while Medina and Reynolds's basin will afford a rich harvest in the other forms, as well as some not described.

The following woodcut is an illustration of the characteristic fossils of this group in the Third District, and is from Mr. Vanuxem's Report.

19.



1. Fucoides biloba.
2. Tail of Hemicrypturus.
3. Crinoidal joint.
4. Lingula oblonga.
5. Strophomena depressa.

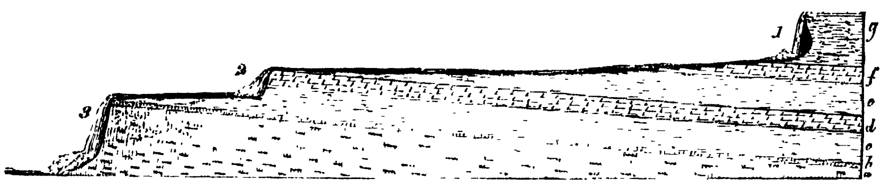
The *Strophomena depressa*, and tail of *Hemicrypturus*, are the only fossils of this illustration which are found in this group in the Fourth District, and they are by no means common.

The other forms have never been met with, though they are abundant farther east. The *Lingula oblonga* is distinguished from either of those just described, by its straight parallel sides and abruptly rounded base, and also by a series of longitudinal striæ, not seen in either of the others.

Sections illustrative of the order of succession among the members of the Clinton group, and its connection with the rocks above and below.

These sections illustrate the connection of the Clinton group with the overlying and underlying rocks, and also show its variations in character and development at different points in the district. The same order of the strata, and nearly the same degree of development, occur in the eastern part of the district, as that exhibited in the section on the Genesee. The sections of this part are omitted, as not showing, in the same conclusive manner, the connection of the group with those above and below.

20.



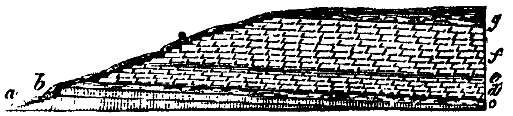
Section on the Genesee river, from the upper to the lower fall at Rochester.

1, 2, 3. Upper, Middle and Lower falls.
g. Shale of Niagara group.
CLINTON GROUP. { f. Upper limestone of Clinton group.
e. Upper green shale.
d. Pentamerus limestone.
c. Lower green shale. }
b Grey band, upper part of Medina sandstone.
a. Medina sandstone.

The section (No. 20) exhibits the order of superposition in the strata forming the *Clinton group*, a part of the *Medina sandstone*, and the lower part of the *Niagara group*. In the banks of the Genesee, this order of succession is as clearly seen as in the woodcut. The green shale rests directly upon the upper part of the Medina sandstone, and extending beneath the Pentamerus limestone, forms, together with that rock, the Middle fall, twenty-five feet. The limestone, however, is the resisting stratum, and about one half the lower part of the shale forms a slope extending towards the Lower fall.

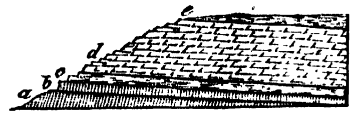
Above the Pentamerus limestone, the upper green shale forms the bed of the river nearly to the Upper fall, the limestone above producing rapids in the stream for a short distance. The whole height of the upper fall is over the shale and lower beds of impure limestone of the Niagara group.

21.



1. *Section of the strata one mile south of Medina.*

g. Niagara shale.
f. Upper limestone of Clinton group.
e. Place of the upper green shale ; no rock seen.
d. Pentamerus, or Lower limestone of Clinton group.
c. Lower green shale of Clinton group.
b. Terminal grey mass of the Medina sandstone.
a. Medina sandstone.



2. *Section showing the Clinton group and associated strata at Lewiston, on the Niagara river.*

e. Niagara shale.
d. Limestone, formed by the junction of the lower and upper limestones of the group.
c. Lower green shale of Clinton group.
b. Terminating grey portion of the Medina sandstone.
a. Medina sandstone.

Section 1 illustrates the order of succession one mile south of Medina, where the lower green shale of the group has diminished to three feet, and there is no evidence of the upper green shale, although the absolute contact of the limestones is not seen. The two limestones preserve nearly the same characters as at Rochester, though there is more hornstone in the lower mass, and its typical fossils are absent.

The upper limestone contains pyrites, and is often iron-stained, presenting numerous irregular cavities. It also contains its peculiar fossil, *Atrypa naviformis.* The shale of the next group follows in the same order as at Rochester.

Section 2 illustrates the order of succession among the strata at Lewiston, and along the Niagara river the same order is preserved. There is little change from Medina to this point, except that the two limestones of the group are here not only in contact, but apparently form a single mass, the lower part differing somewhat from the upper.

View of Niagara Falls from the Canada shore. From a drawing by Mrs. Hall.

11. NIAGARA GROUP.

Geodiferous limerock, and *Calciferous slate*, of Eaton. *Lockport limestone*, and *Rochester shale*, of the Annual Reports of the Fourth District. *Upper part of the Protean group*, of the Annual Reports of the Third District.

(A Part of No. 6, if recognized, in the Pennsylvania Survey.)

[See Section of Niagara River from Lewiston to the Falls, Plate 3; and L. *l*. of woodcut, p. 27.]

This group consists of two distinct members, a shale and limestone, which, possessing many features in common, are recognized as the products of one period; during which, however, there was an important change in the lithological products, and a less one in the organic forms. The shale continues a very uniform deposit throughout the whole extent of the district; while the limestone, from a thin, dark-colored concretionary mass, becomes an extensive and conspicuous rock, constantly increasing in thickness in a westerly direction, even far beyond the limits of the State.

The Cataract of Niagara is produced by the passage of the river over this limestone and shale; and from being a well known and extremely interesting point, as well as exhibiting the greatest natural development of these rocks within the limits of the State, this name is adopted for its designation.

The members of this group are:—

1. Argillaceous, or (in many localities) argillo-calcareous shale.
2. Limestone, presenting several different varieties.

1. Niagara Shale.

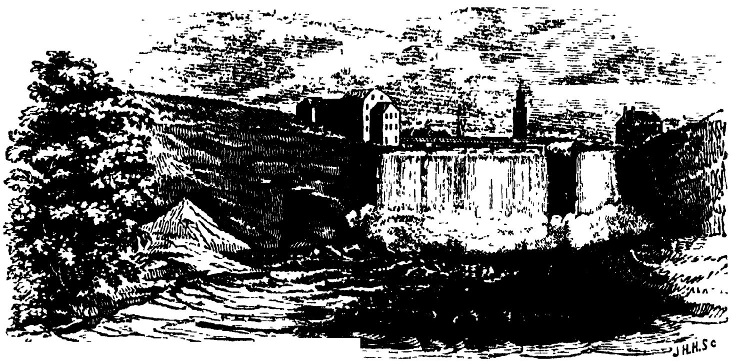
The lower part of the Niagara group exhibits a great development of dark, bluish shale, which on exposure gradually changes to grey or ashen color, and forms a bluish or greyish marly clay. In this state, it is undistinguishable from the ordinary clays; and its outcropping edges, where long weathered, are often considered as clay beds. This character is well exhibited at Lockport, on the northern slope of the terrace where the canal and railroad have been excavated; and also at numerous localities in Wayne and Monroe counties. The depth of tint in the clay differs according to degree of exposure, the outer portions becoming of the usual yellowish brown color of the ordinary soils.

When freshly excavated, the mass is tough, and breaks irregularly, some portions only exhibiting a slight tendency to slaty structure. After weathering for a short time, it cracks in all directions, and soon falls into innumerable angular fragments, when the disintegration goes on till it forms the soft clay. This change seems due to the intimate mixture and decomposition of iron pyrites in the rock; and its presence is also indicated by the production of sulphate of alumina, on decomposition in favorable situations, and upon calcination. In color, aspect, manner of weathering, and other properties, it closely resembles the shale of the upper part of the Hamilton group in the Fourth District. Neither are micaceous, and both are slightly calcareous, probably from the great amount of organic matter. The Niagara shale, however, is destitute of those spheroidal concretions, which in the Hamilton group are more or less common, and in many places abundant. The only approach to a concretionary form seen in this shale, is in the increased thickness of some layers of impure limestone; and this appears rather due to a greater development of corals or other fossils, around which the mud accumulated more freely than elsewhere. A few such examples may be seen in the banks of the Genesee at Rochester.

The lower part of this shale is mostly free from calcareous bands; while towards the middle and in the upper part, we find numerous thin, wedge-form or continuous layers of impure limestone, mostly composed of corals and other fossils, and their surfaces covered with the same, forming beautiful and interesting specimens for the cabinet. The perfect similarity of these with specimens from Dudley in England, together with the identity of many of the organic forms, renders the conclusion unavoidable that the two are formations of the same age. These layers are from half an inch to two inches thick; and from the decomposition and sinking down of the shale, they are usually found broken into fragments. One of the most striking features of this rock is the abundance of its fossils, which will be enumerated in another place. Scarcely a locality can be examined where they do not occur in great perfection.

The higher beds are well developed in the falls at Wolcott village, and the lower part of the formation can be examined by following down the ravine for a mile. This is the most eastern locality in the district where we find the rock exposed. West of this point, throughout the county, it is seen in all the small streams which flow into the lake.

23.



View of the Upper Falls at Rochester.

At Rochester it forms nearly the whole height of the upper fall, and the banks on either side of the river for more than a mile below. This place offers a fine exhibition of the rock, and is one of the best localities in the State for a natural exposure. The constant undermining of the banks precipitates large masses to the bottom, and their fossil contents are thus made accessible. At this locality, its upper and lower limits are both plainly seen. Above it passes gradually into an impure limestone, which forms the beds of passage from the shale to the limestone above. The fossils mostly disappear at this point, and few are found in this part of the mass. Below it terminates abruptly, resting directly on the calcareous beds forming the upper member of the preceding group. There is never any gradual passage from the one to the other, and the peculiar fossils of the shale do not appear till we ascend some distance above the limestone. Nevertheless it is true that two or three of the common fossils of this shale have been found in the limestone below, and at the same time the greater number marking the Clinton group terminate below that rock. It may therefore remain a question, perhaps, whether these calcareous beds should be included in the Niagara group. Since, however, they bear a close analogy to the lower limestone of the Clinton group, and terminate above abruptly without offering any marks of gradual passage to the next higher group, I prefer for the present to include them in the lower, thus presenting a natural lithological assemblage. The presence of a few fossils common to the limestone and shale above would apply equally to all parts of the preceding group, a few forms being common to all parts of both.

The precise arrangement at Rochester is as follows:—The terminating calcareous beds of the Clinton group consist of fifteen or twenty thin courses, each separated by a layer of shale, sometimes of equal thickness to the limestone, though generally thinner. The shale separating the lower courses is green like that below; but higher, it becomes of the same color and character as that above. The interlaminated shale is in all cases destitute of fossils.

The shale is partially exposed in several small streams, and in the low escarpment which extends westward from Rochester. In the town of Sweden, that escarpment has become higher, and the shale is in some places well exhibited. One of the best localities is at Marshall's saw-mill, in the town before mentioned, where the small stream (a branch of Salmon creek) has excavated its channel in this rock. The banks scarcely differ in color and appearance from the soil around, and it is only from fossils that the mass is distinguished from ordinary clay. At one point where there has been a fresh exposure, the rock appears in all its characters, and contains abundance of fossils.

Passing westward from Monroe county, the escarpment constantly rises, and the shale appears in all the ravines and water-courses; and the smallest gorge is often sufficient to afford a good exposure of the rock, which is every where charged with fossils. Even in the banks of ditches, passing through some level grounds, I have obtained many fine specimens from the decomposed portions.

Below Farwell's mills in the town of Clarendon, and again on the south side of Jefferson lake, and along the escarpment between this and Albion, the shale is exposed in many places, and in all yields abundance of its organic remains, which appear to increase in number towards the west.

At Shelby falls, the upper part of the shale, and the siliceous limestone terminating it, both appear; and the former continues in view for a mile north of this point, in the banks of the stream. Thence to Lockport, the rock may be every where examined along the northern slope of the Great Terrace, except in places where there has been too great an accumulation of drift.

At Lockport, both from natural exposure, and from artificial excavations in the construction and enlargement of the Erie canal, this rock in all its varieties is better exhibited than elsewhere west of the Genesee. The banks of the natural gorge where the canal enters the escarpment, appear like immense beds of clay surmounted by limestone. The effect of decomposition has been such as to obscure the natural color and appearance of the mass. Along the sloping sides of these apparent clay banks we find vast numbers of the peculiar fossils of the rock, and every excavation adds a fresh supply to the almost exhaustless numbers. The shells, being purely calcareous, resist the effects of decomposition; while the mass around crumbles down, leaving them in a perfect condition, and entirely separate from the matrix.

Between Lockport and the Niagara river, the shale appears in numerous ravines and gorges which indent the edge of the great escarpment. The whole thickness of the shale is exposed in both banks of the Niagara, extending from Lewiston and Queenston to the Falls. From difficulty of access, however, it does not afford so good an opportunity of investigation as at Lockport and Rochester. At the points where I have been able to examine it, it retains the same characters and affords the same fossils as at localities farther east. Along a part of the distance, it is partially obscured by fallen fragments of the limestone which caps the cliff.

2. Niagara Limestone.

A silico-argillaceous limestone forms the beds of passage from the soft shale below, to the purer limestone above. When freshly exposed, it is often of a dark or bluish color, but soon changes to light grey or ashen; and though variable in character, it is a constant accompaniment of the group as far as observed. It forms a good hydraulic cement, where it has been used for that purpose.

In the eastern part of the district, these beds of passage are succeeded by a dark bluish grey, subcrystalline limestone, of a rough fracture, and separated into thin courses by dark shaly matter. When not too much divided by seams, it forms a durable building material. This, again, is succeeded by a coarse-grained concretionary mass in irregular layers, exhibiting an appearance as if much disturbed while in a semi-fluid or yielding condition. The concretions often present cavities lined with crystals, or the remains of some fossil body. The upper strata are finer grained, with a resinous lustre; and on weathering, the surface is harsh and sandy to the touch; this, however, seems due to the presence of magnesia rather than silex.

In the western part of Monroe county, the hydraulic layers are succeeded by a light colored and very porous encrinital limestone; which, farther west, becomes the compact crinoidal limestone of Lockport.

In the western part of the district, this crinoidal mass is succeeded by a light grey limestone with cavities, and containing many corals. Above is a darker colored mass, still with cavities lined with crystals of spar; and the series is terminated by a thin-bedded concretionary limestone, strongly bituminous, the layers separated by shining black carbonaceous shale.

This rock first appears in the district at Roe's quarry in the town of Butler, Wayne county, where the hydraulic layers are not seen, and the rock has the character of a dark blue limestone, very fine-grained and compact, yielding a bituminous odor on percussion. It is mostly thin-bedded, and exhibits little tendency to a concretionary structure, being readily quarried, and furnishing a good building material where heavy blocks are not required; its principal use, however, is for burning to lime. Farther west the rock outcrops by the roadside, but has not been quarried. It here exhibits the dark greyish color of the higher strata.

This limestone is likewise quarried at Henderson's in the same town, exhibiting a thick-bedded structure, and regular stratification.

It again appears in the town of Rose, at Uttoc's or Miner's quarry, on the head waters of Sheldon's creek. At this place it is thicker bedded than farther east, appearing in courses of two or three feet, having a dark color and granular texture.

It has been quarried at two places on the line of the Sodus canal, where it presents appearances similar to those just mentioned. It is also exposed in the towns of Marion and Walworth, passing thence into Monroe county. The whole length of its outcrop in Wayne county is marked by a range of limekilns, which always indicate the proximity of the rock. The variations which it undergoes in this distance are principally an increase in thickness, and a gradual change to a lighter color in the central portions of the mass. Its concretionary structure is not often well exposed, though it does appear in a few of the strata. Cavities or geodes, lined with calcareous spar, gypsum, etc., are occasionally found, and there is a constant increase of their number and size in a western direction.

The lower part of this limestone, possessing a siliceous character and properties of the hydraulic cement, occurs in the towns of Rose and Williamson.

In Monroe county, the northern margin or outcropping edge of this limestone extends through the towns of Penfield, Brighton, Gates, Ogden and Sweden; in each of these places, numerous localities are presented for its examination. The principal outcropping portion is the dark grey upper mass, which is highly bituminous, and when weathered has a harsh feel like a friable sandstone. On fresh fracture, it is often dark blue, or approaching to black. It appears to be composed of small crystalline grains, which present numerous shining laminæ of a resinous lustre; and the rock, from its aspect, often resembles a sandstone rather than a limestone. It every where furnishes a good lime, but of a yellowish color. Large quantities of bituminous matter are expelled in the process of burning; and this substance frequently flows from the kiln, of the consistence of tar. The rock, on examination, proves to contain no appreciable amount of silex, but is every where magnesian; and it is probably from the mixture of the two earths that the harsh or siliceous-like character is presented. Exposed fragments are often quite porous, from the solution and removal of a portion of the matter.

Its northern limit, through the eastern part of Monroe county, is marked by an accumulation of fragments of the rock, which are rounded rather from weathering in place than from transportation. These always exhibit on their outer surfaces the peculiar porous or spongy texture. That their form and decomposition is due to weathering in the places we find them, is evident from the frequent presence of some silicified fossil which stands out upon the surface in strong relief. In many places this stone is exceedingly brittle, particularly on first exposure.

At the Penfield mills on the Irondequoit, the lower part of the limestone appears in the bed of the stream, and underlies the surface at no great depth for some distance around. It is of a bluish color, very hard and tough, mostly thin-bedded, and separated by seams of shale. In consequence of its hardness, it is rejected as a building stone, and quarries are sought at a greater distance.

At Rochester, the lower beds have the same siliceous character as farther east. They pass upward into a coarsely granular or compact subcrystalline limestone, very irregularly stratified, and the layers separated by greenish shale. The strata are often wedge-form, or irregular in thickness. This portion of the rock is partially composed of fragments of crinoidal stems and other fossils, but so comminuted that their forms are usually undistinguishable.

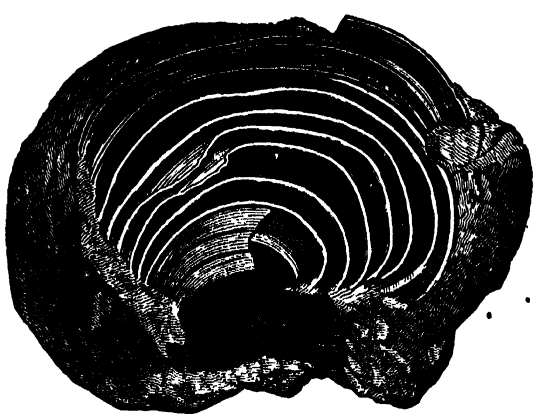
Still above this, the rock which forms the central portion of the mass presents itself in very irregular concretionary or contorted strata. The whole exhibits an appearance as of folding among the laminæ, by which it has partially assumed the form of spheroidal concretions, but still inseparable from the adjoining and surrounding rock, which may be only partially folded or contorted, and connecting this with another spheroidal mass. A very similar example, on a small scale, may often be seen in a very curled and gnarled plank or stick of timber.

24.

Concretionary and contorted strata. Rochester.

This portion of the rock, as it appears in the vicinity of Rochester, is grey and subcrystalline, very hard and tough, exceedingly irregular in its stratification, and difficult to quarry. Sometimes for a short distance the strata are regular, and then separated by seams of shale, and again all trace of stratification is lost, and the whole assumes the contorted and concretionary structure. It contains numerous cavities partially filled with crystalline materials, such as dogtooth and rhomb spar, gypsum, and more rarely sulphate of strontian and the sulphurets of lead and zinc. In many instances, these cavities present a partially decomposed organic body, as a Favosite or some other coral, which seems to have formed the nucleus around which the stony matter accumulated. Sometimes the remains of these are distinctly visible; at others, they are entirely obliterated, the form of the cavity being the only evidence of their having existed.

25.



In the accompanying illustration, which represents the remains of a *Porites*, the transverse laminæ, indicating the stages of growth in the coral, are distinctly preserved, while all the intermediate parts are removed, only a few calcareous crystals remaining in the spaces.

The succeeding portion of the rock, here as elsewhere, is of a grey or greyish brown color, often darker on first exposure, but always weathering to the grey shapeless masses, seen abundantly scattered over the surface. This part likewise exhibits numerous irregular cavities, with calcareous spar and fluate of lime, and blende is more frequently found here than below. Nodules or accretions of light-colored brittle hornstone occur every where; and the fossils are often silicified, and stand out in relief upon the surface. The *Catenipora escharoides* marks this part of the rock, though it is often nearly destroyed or absorbed; still, a careful examination will enable one to detect it, and in more favorable situations fine specimens are obtained. It is this part of the rock which appears at the rapids on the Genesee above Rochester, and elsewhere both on the east and west sides of the river. There are usually some thin-bedded regular strata above this, which are mostly used for burning to lime; the concretionary and irregularly stratified portions of the central division being too impure, and too difficult to be quarried for this purpose. The upper strata are not only readily quarried, but are easily broken into fragments of suitable sizes. It breaks with a dull sound, and presents a slightly uneven fracture.

The lithological characters alone of the two upper divisions are every where sufficient to distinguish this part of the rock from all other limestones in the State; these are, its brittle nature, the glistening surface of the minute crystalline laminæ of which the mass is composed, and its harsh or apparently siliceous character.

The characters, as described at Rochester, are the prevailing ones, for a great distance westward. The dark-colored mass, however, above the beds of passage or hydraulic limestone, thins out, and its place is occupied by a light grey crinoidal limestone, sometimes composed of extremely comminuted particles, at others exhibiting portions of the crinoidal columns and other fossils.

The following arrangement will enable the reader to bear in mind the different parts of this division, which are persistent over a large extent of country, and seem worthy of being noticed, as the mass is so variable in its different parts that it cannot well be described as one.

5. Thin-bedded dark grey or brownish limestone. Few cavities. Highly bituminous. Sometimes contains nodules of hornstone.
4. Thick-bedded dark or bluish grey limestone with irregular cavities, and often siliceous accretions, or hornstone. Surface very ragged from weathering. Highly bituminous.
3. A lighter colored subcrystalline mass, very irregularly stratified, contorted and concretionary.
2. A bluish grey subcrystalline mass, mostly thin bedded, and separated by seams of dark shale.
1. Grey or bluish grey siliceous limestone; hydraulic limestone, or beds of passage from the shale below.

Few points west of Rochester offer so good an opportunity of examining all the parts of this limestone in the order of succession. It is exposed and quarried at numerous places, which will be noticed under the description of the rocks of Monroe county.

In the town of Ogden, the lower part of the limestone, or that following the hydraulic layers, is charged with fossils, (principally *Atrypa* and fragments of the *Trimerus*.) The rock containing them is extremely thin bedded, though a pure limestone. The upper part of the rock in the same town is extensively developed, and appears in very heavy strata, abounding in coralline fossils.

In the next town westward, there is a light grey crinoidal limestone, which, from examinations made elsewhere, is found to come in above the dark compact beds on the Genesee, and below the concretionary mass (No. 3). It is abundant in loose fragments on the surface, but cannot be seen in place except in one or two instances. It is wrought as a fire-stone, and, from its porous nature, serves the purpose very well. It becomes more developed farther west, forming the beautiful and durable crinoidal limestone of Lockport, and extending to the Niagara river.

In the south part of the town of Sweden, the upper strata of the limestone contain an abundance of coralline fossils, which, from the weathering of the surface, stand out in bold relief, exhibiting their structure in a most perfect manner. The best specimens can be obtained from the loose fragments, which are strewed over the surface in great profusion.

In its extension through Orleans county, this limestone forms two distinct terraces; the more northerly one being produced by the lower part of the rock, and the southern one by the higher strata. Its northern limit is from the town of Sweden to Clarendon centre; thence by the south side of Jefferson lake, it continues west turning a little southward, and passes two miles south of Albion and about the same distance south of Medina. The southern terrace, or outcropping of the higher strata, is about two miles farther south.

In its lithological characters, this rock suffers little change throughout this county. Its lower portions retain the character of a siliceous limestone, which continues, though somewhat unequally developed, as far as the Niagara river. At Shelby falls, in the town of Barre, it is unusually thick, and well exposed. From the former place the stone has been burned, and proved a good hydraulic cement. The crinoidal portion of the mass, which is so extensively quarried at Lockport, does not appear so well developed in Orleans county, though it exists in all localities, having the same characters as in Monroe county. The quarries in this rock afford an abundance of good building stone, and lime, and it is easily accessible throughout the whole length of the county. In consequence, however, of this range passing from two to four miles south of the canal, and all the large villages being along the line of the latter, there has been little inducement to open extensive quarries, as stone is more readily supplied from other points.

In Niagara county, this limestone passes through the towns of Royalton, Lockport, Cambria and Lewiston, and extends into the next southern range of towns. Its greatly increased thickness has rendered it an efficient protection to the shale beneath; and this, instead of being worn down and spreading out over a broad surface, as in the eastern part of the district, forms only the northern slope of this great escarpment, often presenting a width of less than one quarter of a mile. This strongly marked feature of the country on the west of the Genesee is entirely lost on the east, from the thinning of the limestone. Nearly the whole width of the formation in Niagara county is of the limestone; while at the east, the shale covers the greater extent of surface occupied by the group.

The two sections of Lockport and Niagara, the one an artificial and the other a natural one, exhibit not only the limestone, but the whole group to the greatest possible advantage. At Lockport the shale, as elsewhere, passes into beds of impure siliceous limestone; and these, in their continuation upwards, are succeeded by a pure crinoidal limestone. So abrupt is this change, that specimens can be selected, exhibiting both rocks in connection, as if one deposit had succeeded the other instantaneously, allowing no lapse of time and no intermixture of the two.

This is a continuation of the light grey crinoidal limestone which first appears in Monroe county, but it has become much thicker and more compact. Near Lockport it is often variegated with red, from the stems of crinoidea which are thus colored. These again lose their color, and the mass is grey. At this place the rock is thick bedded, and in regular courses; it is readily wrought from the quarry, and forms one of the best and most durable materials for construction which the State affords. It has recently been extensively quarried for the enlarged locks upon the Erie canal at this place.

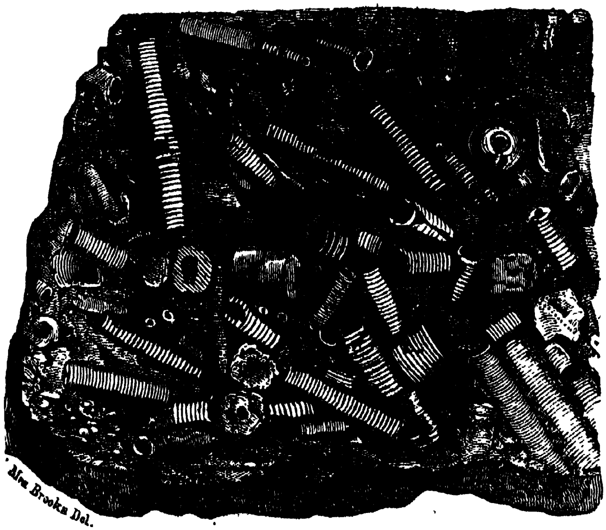
The following is the character of the different beds, in the descending order, the lowest resting on the impure hydraulic limestone. (The numbering is from the lowest upwards.)

5. Thinly laminated blackish grey limestone, with thin laminæ of bituminous shaly matter; the whole exhibiting a tendency to a concretionary or contorted structure, and the surface of the layers marked by small knobs or elevations as represented in woodcut No. 29.
4. Greyish brown bituminous limestone, the lower part with irregular cavities containing spar; this passes upwards into more regular beds of a dark color, containing few cavities, but marked by the presence of blende.
3. A dark colored limestone, with cavities and veins of spar, often concretionary.
2. Irregularly thick-bedded limestone of a light grey color, with numerous cavities containing spar, etc.
1. Encrinital limestone, often beautifully variegated with red; entirely composed of encrinital columns and other fossils, which are always broken and worn.

During the period of the deposition of this limestone, the condition of the ocean seems to have been favorable to the production of corals, as is indicated by the immense number crowded together in the central portions of the rock. Their partial or entire destruction as before described, and their replacement by crystalline matter, renders them a less prominent feature than they otherwise would be. Few shells appear to have lived after the deposition of the lower strata; or if they existed, their forms have become obliterated. The broken and worn fragments of corals and crinoidea indicate, during the earlier periods, a condition of shallow water, as of a coral reef approaching the surface, where the force of the waves destroyed all except some of the more solid forms. Subsequently the water seems to have deepened, and the comminuted matter, produced by the action of the waves upon the higher portions of the reef, settled down in the form of fine calcareous mud, enveloping the living corals at the bottom. Toward the eastern extremity of the formation all these forms disappear, and the limestone is composed of, what we may suppose to be, the finer mud derived from the destruction of the corals farther west. The condition, therefore, or the depth of water at the east, prevented the growth of corallines; while in the west, all circumstances were favorable to their production.

The crinoidal mass forms the capping of the terrace every where in the vicinity of Lockport, and is the same in which all the quarries of importance are situated. It varies in texture from fine grained, where the nature of the component parts can scarcely be detected, to that where the stems are several inches in length. Where weathered, these stems stand out upon the surface in strong relief, forming beautiful illustrative specimens for the cabinet. Plates of the *Caryocrinus ornatus*, and fragments of corals, frequently occur together. The woodcut No. 26 is an illustration from a specimen found near the village.

26.



Fragments of Encrinital columns in Limestone.

These stems lie in the greatest possible confusion, and many of them are much worn. Perfect fossils are rarely found in this rock, all the materials having evidently been triturated by the waves for a long period, while they formed a calcareous beach or bar rising to near the surface of the ocean.

The succeeding mass contains a great abundance of corallines; some of them in the position in which they grew; others turned upon their sides, or entirely reversed. Many of these are in a very perfect condition; others are partially destroyed, and crystalline matter has taken their place. The greater number apparently belong to a species of *Porites* of very delicate structure.

In the third division the cavities are more abundant; and we often find, that surrounding the edge of these, a portion of the fossil still remaining, marks its former extent. In other cases a mass of coral is partially dissolved, with crystals of selenite penetrating it in every direction. Again the coral is almost completely blended with the selenite, as if it had been rendered nearly fluid change took place. Masses of the coral often present cavities, from which crystals en dissolved, leaving the spaces with their sides as plane and smooth as if cut with some sharp instrument. These examples ow how limited may be the influence producing such changes. No effect appears to have been produced in the least beyond the edge of the crystal, or the space it once filled; but by what means solution could take place in right lines, it is difficult to explain. The coral in many such cases has scarcely suffered any change from its living state, presenting the same porous structure as recent specimens.

27.

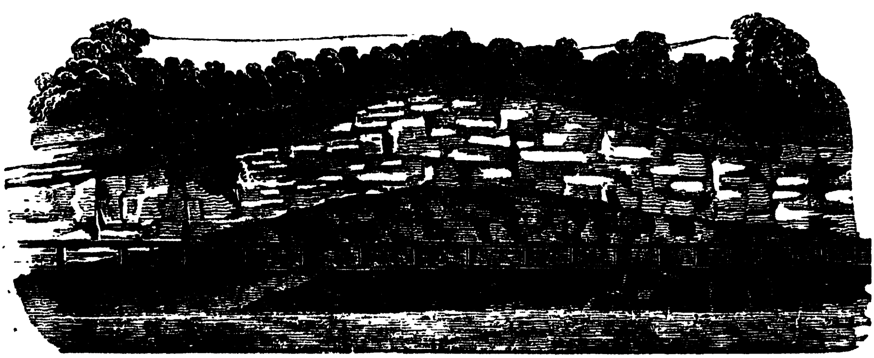
The illustration represents a specimen of *Porites* with linear cavities, from which crystals of selenite or some other mineral have been dissolved. The cavities here shown are their actual size; in this instance being small, but in others they are several inches long; and I have seen a large hemispheric mass of coral completely divided by a plate of selenite, half an inch thick, its limits perfectly defined. Some portions of this selenite still retained the markings of the coral, which apparently was not entirely converted to the sulphate.

An appearance very similar to this occurs in the Water-lime group, and also in the shaly limestone of the Onondaga-salt group. Numerous linear cavities present themselves upon the surface, generally offering no evidence of having been filled; but in some instances, where there has been no exposure, and moisture has had no access, they are still filled with crystals of sulphate of baryta. Specimens have been obtained where the exposed edges were covered with cavities, while the fresh surface presented innumerable acicular crystals imbedded in the rock. In these cases, we may suppose the crystals to have been segregated during the solidification of the mass. But we cannot account in the same way for the cavities in the coral, nor for the presence of crystals; for these could only have taken place after the growth and formation of the solid structure.

Both in this and the next succeeding division of the rock, spheroidal cavities are scattered in great profusion, and without order. Certain layers, however, yield the finest specimens of dogtooth spar, and others of pearl and brown spar; while the selenite and sulphate of strontian are confined to one or two strata, and are rarely found elsewhere. These facts are of interest, and future investigations will probably reach the true cause, whether it may have been in certain genera or species of corals, or from other sources that the sulphates resulted. The anhydrous gypsum which occurs in this rock, fills cavities in a mass lower than the selenite and sulphate of strontian, and principally below the spar, though often occurring with the latter.

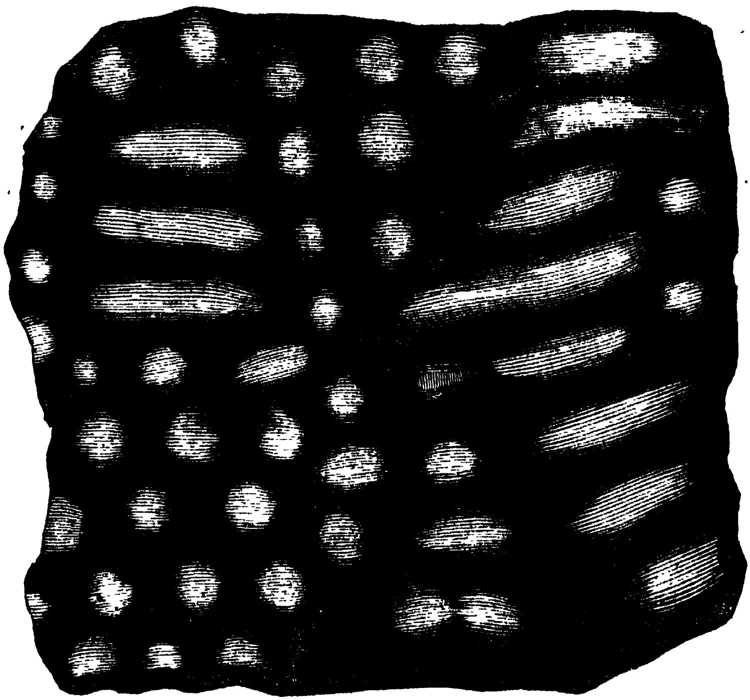
Besides the tendency to spheroidal or concentric concretions, there is sometimes a tendency to a thickening of the strata, probably due to the same influences, and which often produces apparent undulations in the succeeding ones. An example of this kind is given in the following woodcut. It appears in the bank of the canal two miles south of Lockport. The elevation is entirely produced by the thickening of the mass, the strata being horizontal below. The succeeding strata are seen to thin out as they approach this thicker portion.

28.



Farther south the higher strata seen in this illustration disappear, and a mile beyond this point some still higher rise above the level of the canal; these constitute the terminal portion of the rock. They are thinly laminated, from the intervention of a black bituminous shaly matter. The layers are all curved, the extremities bending downward. The surfaces are again covered with little knobs or incipient concretions, the convex upper surface of each having a corresponding concavity on the under side; presenting an appearance as if impressed with the fingers while in a yielding condition. These appear like what may sometimes be seen in a semi-fluid viscid mass when heated, or from which gas is evolved, raising the surface into a great number of small bubbles. Those upon the stone, however, are infinitely more numerous and regular than any thing of this kind. The following woodcut is an illustration, reduced one half, from a specimen from this locality :—

29.



Concretionary structure in the strata south of Lockport.

It will be observed that these elevations are not all circular, but often confluent, forming little rounded ridges, sometimes several inches long, and again interrupted. The knobs in like manner are often arranged in lines, and they not unfrequently present themselves in quincunx order.

I have seen an instance in the same rock where several knobs became enlarged and much elevated, breaking through the superincumbent laminæ ; and the surface of the shaly matter at the junction presented the smooth and striated appearance common, where one hard surface moves over another, as in the sides of faults in strata.

At Porter's quarry, one mile east of Niagara Falls, the structure, though somewhat different from that of the same strata at Lockport, exhibits the influence of similar causes. The whole is thin bedded, and arranged in curved or dome-shaped layers, the ends bending downward, and continuing for many rods with the same regularity as in the figure. In some instances, for a short distance, the layers are much more abruptly curved than in this illustration.

30.

Curved strata—Porter's quarry, Niagara Falls.

The woodcut represents the strata as they appeared, looking in the direction south by east, and against the edges of the layers, which are crossed by vertical joints, having a direction east by north and west by south. The extent of each curve is from one to two feet; sometimes a single one divides and forms two. There is here no evidence of a breaking up of the strata below, and consequently there has been no uplifting process to produce these curvatures. It appears rather due to the accretionary force, which induced a tendency to curving or folding in the laminæ throughout the mass, operating with great uniformity and over a wide extent. These curves seem due to like causes with those small ones at Lockport, which are usually less than one inch in diameter.

There seems no reason to doubt that all these appearances are due to the same action which produces well-defined concretionary forms in other situations, and under more favorable circumstances. The oolitic and concretionary character of this formation in some parts of the Third District, seem to be represented in a great degree by what is here exhibited in the terminal strata.

The same structure exhibited in the two last illustrations occurs in the Third District, as illustrated by the following woodcut from Mr. Vanuxem's Report:

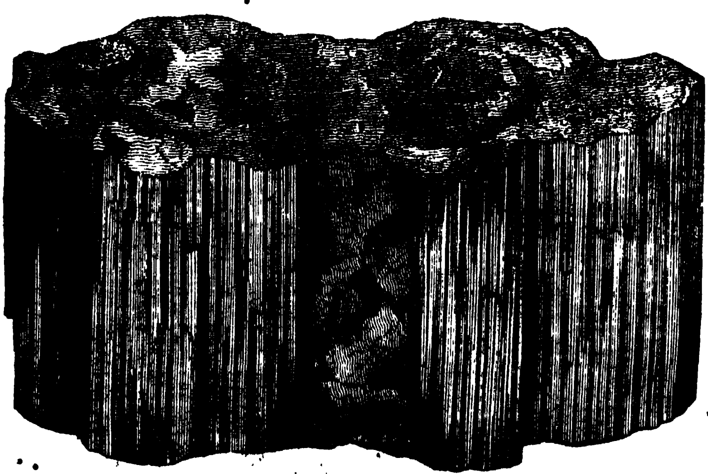
1

2

The drawing fig. 1, is from a specimen, and of the natural size. The curving of the laminæ is precisely as in the quarry at Niagara Falls, and intermediate between that and those of Lockport, where they are much smaller than in this figure. In a few instances at Rochester, some thin strata exhibit the appearance represented in figure 2, where the rock, after being partially hardened, was broken up, and again cemented. The cementing matter is usually crystalline. These appearances are more common in the central portions of the rock, and are not seen in the higher strata.

The lower and middle portions of this limestone, in addition to the regular seams or divisional planes, often present a kind of undulating seam or suture, the projecting portions of one layer closing into corresponding depressions in the other. These, from being scarcely visible, become of considerable magnitude, and the projecting portions on either side an inch or more, and even five or six inches in length. These have been compared by Mr. Vanuxem* to the sutures of the skull, which they often resemble. When separated, the surfaces present a parallel fibrous or striated appearance, and are frequently covered with a film of carbonaceous matter. These appearances, which occur not only in this rock, but in the water lime and some of the higher rocks, were termed by Prof. Eaton, *Lignilites*, from their resemblance to woody fibre. They are not always at the junction of two layers, or as forming a division, but frequently penetrate the solid stratum, and are separable, appearing like a wooden pin driven into the mass. Again they divide the rock into columnar blocks of variable dimensions. The illustration No. 32, is from a specimen where the striated surface is eight inches long, and has separated a portion of the rock into an irregular column.

32.



* Annual Report of the Third District, for 1838, p. 271.

Mr. Vanuxem suggests that this structure is due to the crystallization of sulphate of magnesia in the fibrous form, which penetrated the rock, and produced the striated surfaces; that it has since been dissolved, and that probably the same water which dissolved the saline matter deposited the carbon which invests the surfaces. We find in many instances where this structure occurs, that the interstices are still occupied by carbonate of lime in long fibrous crystals; and it is suggested whether this mineral, as well as some others, may not have been the cause of their production. These appearances are very obvious in many places where there has been a fresh exposure, and weathering removes the carbonaceous matter.*

Topographical features. — In the eastern part of the district the limestone is thin, offering little protection to the shale, which is consequently worn down to a very gentle inclination, presenting a much greater breadth of surface than farther west. The limestone, becoming thicker in the same direction, occupies a broader space, while the shale is seen only in its outcrop. The nature of the two masses has given origin to much interesting scenery along its northern margin; every stream crossing it has its rapids or cascades. The fall and deep gorge at Wolcott village is the first of importance within the district. Several points of minor interest occur between this and the Genesee river; but from the great accumulation of drift, and the absence of large streams, the rocks are not well exposed. On the Genesee, the group gives origin to the upper fall at Rochester, the rapids above, and the cliffs below, which together display both divisions in great perfection. The falls at Shelby, three miles south of Medina, on the Oak-orchard creek, are over the lower limestone and shale of this group. The "mountain ridge," before alluded to, continues a distinctive feature of the scenery from the Genesee to the Niagara river; and the numerous deep and picturesque gorges in the margin of this cliff sufficiently indicate the former existence of streams of great magnitude, or an excavating power operating from the north.

Finally, this group gives rise to the grand Falls of Niagara, the wonder of the world, and a geological monument by which to measure its periods, and enable man to compare the past, the present and the future, and thence deduce the formula for determining the duration of [illegible] eras in years, which are now only known by the exhibition of phenomena which cannot [illegible] dates, or computation of time in human periods.

Localities. — The principal localities have been enumerated in the description of the group; a few of these will give the observer an acquaintance with the variations in character which the rock assumes in its western extension. The most eastern localities are in the towns of Wolcott and Butler, the former exhibiting the shale and the latter the limestone. In order to observe the gradual changes which the limestone undergoes before its full development at Lockport and Niagara Falls, a few other localities in Wayne county should be examined, as the quarries in the towns of Williamson and Marion. Along the Genesee at Rochester we find one of the best exposures in the whole district, and this is a very desirable point for in-

* See also the same structure represented under the Onondaga-salt group.

vestigation. At this place, its characters are intermediate between those in Wayne county and Niagara. In the towns of Ogden and Sweden, the limestone presents some interesting features not observed at Rochester. In the towns of Clarendon and Barre, and at Shelby falls, as well as at many other localities in Orleans county, there are good opportunities for investigating the rocks of this group.

The vicinity of Lockport will give the geologist, or the student, all desirable information regarding this interesting group of rocks; but he must still visit Niagara, to see them in the locality which will be remembered and known for many thousands of years. The rocks of the Niagara group are exhibited along the whole of the immense gorge or chasm of seven miles below the Falls; at first near Lewiston forming about one hundred feet of the upper part, and at the Falls being all that is visible above the river below.

The section of the Niagara river from Lewiston to the Falls (Plate 3), is a transcript of the eastern bank as seen from the Canada shore, and exhibits the order of arrangement among the strata in a perfect manner. At the brow of the terrace above Lewiston, the shale of this group is seen to succeed the Clinton group, and is capped with a few feet of limestone. Thence it dips gradually southward, the limestone increasing in thickness all the distance to the Falls, where the shale, from being two hundred feet above the water as at Lewiston, has approached to within a few feet of it. The river descends in this distance about one hundred feet; and the level is continued in the section from Lewiston, showing this depth of water below the Falls.

The same order of succession is exhibited at Niagara Falls as at Lockport; and by descending the staircase to the ferry, or at Goat island, the character of the strata may be seen as far as the shale. The upper part of the limestone, however, is not there visible, the highest seen being the dark brown mass below the upper one. The terminal portion of the rock is seen nearly a mile east, at Porter's quarry.

Thickness. — The thickness of the shale of this group suffers little variation throughout the district. At Wolcott, its thickness, by estimation, is little less than one hundred feet; at Rochester, it is of about the same thickness; at Lockport, it is eighty-one feet by actual measurement; and at Niagara Falls, and along the river, it preserves the same, not varying more than one or two feet. The limestone is apparently not more than thirty or forty feet thick in Wayne county, but gradually increases westward, being about seventy or eighty feet at Rochester, and one hundred and sixty-four feet at Niagara Falls. This thickness at Niagara is obtained by measuring the perpendicular bank at the Falls, and levelling from thence to Porter's quarry, nearly a mile east of this point, where the higher strata are seen.

Mineral Contents of the Group.

In this group, we find a greater amount and variety of crystallized minerals than in all the other rocks of the Fourth District. The absence of disturbance, or the influence of hypogene or metamorphic masses, leaves the rocks of this district comparatively barren of simple minerals, which, under favorable circumstances, would have been largely segregated, as we find them in some of the lower strata, when in the proximity of crystalline rocks.

From the decomposition of the shale, results sulphate of magnesia, sulphate of alumina, and muriate of soda or common salt, which are found in sheltered situations along the banks of the Genesee and Niagara rivers. Sulphate of alumina, in beautiful efflorescent forms, is produced from the upper part of the shale during the process of calcination. Nodules of gypsum, usually replacing some organic body, are of frequent occurrence. The superior extremity of the *Caryocrinus ornatus* is frequently filled with snowy gypsum, sometimes the plates remaining, but a little separated; at other times, they have entirely disappeared. More rarely, cavities are found lined with dogtooth spar. In the upper part of the shale, and lower part of the limestone, green carbonate of copper is frequently found. Iron pyrites is universally diffused through the shale, and hastens its decomposition.

It is in the limestone, however, that we are to look for the minerals so characteristic of the group. The abundant cavities or geodes, resulting in part, if not entirely from the decomposition of fossil bodies, are always lined or filled with some crystallized mineral. The most abundant are dogtooth spar, pearl spar, brown spar, selenite, sulphate of strontian or celestine, anhydrite, and more rarely fluor spar, crystallized zinc blende and galena. These minerals are variously grouped and associated; the more common forms, however, are found in all situations in the rock, while others are confined to a single stratum or two.

The calcareous or dogtooth spar is usually of a yellowish color, and in small crystals. The fluor spar is in small cubic crystals of a delicate straw color. The blende is often associated with pearl spar, some portions of the rock having all the cavities lined with the latter mineral, to the almost entire exclusion of the dogtooth spar. The latter is more abundant in the darker colored limestone, overlying the light grey which abounds in pearl spar, and is frequently associated with the latter of a delicate pink color.

The celestine often occurs in beautiful groups of crystals, penetrating masses of selenite. Fine specimens of the latter are frequently obtained where the spars are enclosed in the transparent mass.

Zinc blende is more common in the higher dark-colored portions of the limestone, and above the point where the greater quantity of spar and other minerals occur. It is that part of the rock which forms the margin of the cliff at Niagara Falls; and here as well as at Lockport, this mineral is common, though the quantity is not great. Galena often occurs associated with the blende, and sometimes in a lower situation; it is seen in small masses, but more generally in threads or thin veins, often apparently as if filling fissures. I have obtained specimens of this kind at Rochester, where, on fracture, the two sides of the stone presented a thin film of the ore. In excavating the limestone near the Whirlpool, specimens were obtained which were crossed by numerous thin veins, sometimes one-eighth of an inch thick. I was also informed, that during the excavation of the Erie canal at Rochester, several hundred pounds of galena were found in a single cavity. This is perhaps not improbable, and the celestine and gypsum sometimes occur in masses of nearly equal weight.

In some of the geodes, and among the crystals of calcareous spar, there occur long prismatic crystals of a dark brown color, which appear like black hairs; they are attached to, or penetrating the calcareous crystals. This mineral has usually been referred to *Rutile*, but Dr. Beck regards it as *Achmite*.

Iron pyrites occurs in the limestone, as well as in the shale; but in the former, it is usually in nodules or irregular masses.

Native sulphur is of common occurrence in the small cavities in the encrinital limestone at the Cold-spring quarries, two miles east of Lockport.

Calcareous tufa is formed in many situations, where water, percolating through the limestone, finds an outlet in the shale. The deposition forms in the fissures of the rock, and finally accumulates in large masses projecting from the sloping edges, until from its increased weight it falls down. Instances of this kind may be seen in the banks of the Genesee below Rochester, and in similar situations at Lockport and elsewhere.

Springs charged with sulphuretted hydrogen occur both in the shale and in the limestone, though not usually very copious. The localities of some of these will be enumerated under the respective counties in which they occur.

Springs. — From the nature of the two rocks forming the group, the line of junction every where gives origin to springs, which flow over and fertilize the northern slope of the escarpment. The limestone, from the numerous vertical joints, is pervious to water; and toward its northern limit, the soil is often dried in consequence. The shale, from being impervious, holds up the water thus falling upon it, and from the southern dip, operates as a reservoir, affording a constant supply in the springs which break out along its northern edge. This character is more obvious in the western counties; while farther east, from the more gradual slope of the shale and thinning of the limestone, the springs rarely appear on the surface, but the water is disseminated through the soil.

Agricultural characters. — The two members of this group are marked, to a considerable degree, by a difference in the soil. The destruction of the shale has given rise to a clay, which, mingling with the more sandy production of the Medina sandstone on the north, has produced a soil of unequalled fertility; and there is rarely, if ever, to be found a better wheat-growing soil than the portion overlying this rock. In some places it has a greater amount of argillaceous matter than is desirable, and forms a stiff soil; but where the slope of the surface is sufficient for effectual drainage, it produces no inconvenience.

The soil covering the limestone, particularly where it is a little elevated above the country on the north, is of a loamy character, the argillaceous nature of the mass below having had little influence. In many places, however, for a small extent, the surface is clayey, and even extremely so, as if the materials of the lower rock had been deposited upon the higher. An example of this kind occurs a little west of the village of Lockport, where the limestone is covered by a clayey soil, while, a mile or two further east, the soil is a light loam. The latter character also prevails in some places near Rochester, and at other points along the outcrop of this limestone. This character of the soil, together with the rapid drainage to which it is subjected, from the fissures or joints in the limestone, as well as the proximity of the rock to the surface, has given rise to a different growth of timber, which everywhere marks the limestone terrace. While the country on the north and south sustains a forest of maple, beech, elm, ash, and the associated forest trees ; that along this limestone is indicated by oak, chesnut, and others of the same nature.

Following the slope of the limestone southward, the soil becomes more clayey, and the surface more level.

Organic Remains of the Niagara Group.

One of the most striking features of this group, and particularly of the shale, is its vast number of organic remains. Shells and trilobites are the most abundant forms, though several species of Crinoidea are common. Corals of different genera and species are the predominating forms in the limestone, while shells and trilobites are rare. In this group in the Third District, organic forms are rare, few species only being known ; while they become more abundant in Wayne county, constantly increasing in a westerly direction as far as Lockport. Along the Niagara river the means of examination are limited, notwithstanding the fine natural section ; but in all accessible localities, the same fossils are found as elsewhere.

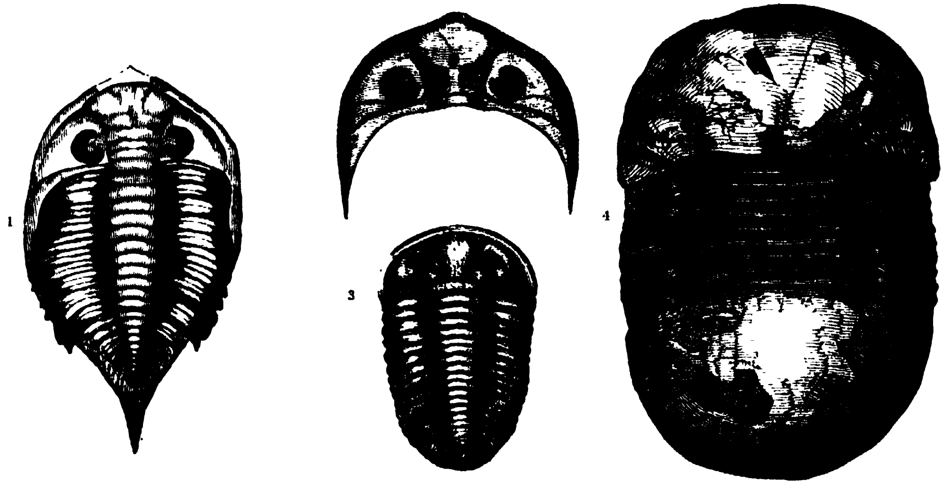
We have, in the shale of this group, no less than six species of Trilobites and nine species of Crinoidea, with as many shells, which occur in no other group within the district, and have not been seen in any other rock elsewhere in the State.

The partial or entire decomposition of the corals in the limestone has, in a great measure, prevented their affording the characteristic distinctions they otherwise might have done.

TRILOBITES.

Among the Trilobites, the following are known as characterizing the shale at Rochester, Lockport and other places. Two other species are known in this group, which will be found figured in a lithographic plate at the end of the volume, and there is still a third form which has not been described.

33.



1. Asaphus limulurus.
2. Head of Asaphus limulurus.
3. Calymene Niagarensis.
4. Bumastis Barriensis.

1. *Asaphus limulurus* (GREEN, *Monograph*, p. 48.) — This fossil is known by the great length of the caudal extremity, which is often produced nearly an inch beyond the articulations. The form figured is the most common, and will be recognized as the most abundant of the Trilobites at Lockport.

This species is remarkably similar in many particulars to the *A. longicaudatus* of Murchison, but differs from it in the shorter tail and the greater width at its base, being much less slender. It has also fewer articulations in the post abdomen, ten or eleven being the extreme number. With these exceptions, our fossil is very similar to the English one, and apparently holds the same place in the series, eminently characterizing the lower part of the Niagara group as that does of the Wenlock; these formations of the two countries being equivalent, so far as we are able to decide.

2. Head of *Asaphus limulurus.* — The head of this species being so abundant at Rochester and other places in Monroe county, where perfect specimens are rare in the ordinary exposures of the rock, that it seemed desirable to present it as it there occurs. The eyes are usually detached, their form only being perceptible. The anterior portion of the buckler is produced in a blunt point, its posterior angles extending backward and terminating in acute points, which, in perfect specimens, reach to the fifth rib of the abdomen. Each side of the middle lobe of the head is marked by three indentations or furrows, the anterior one extending obliquely forward.

3. *Calymene Niagarensis.*—The middle lobe of the head of this trilobite is marked by three rounded protuberances on each side; the front one very obscure, and sometimes scarcely distinguishable; the posterior one very prominent. Eyes small, not reticulated, opposite the central protuberance of the middle lobe. It has thirteen articulations on the back, and eight in the tail. The surface is entirely covered with minute rounded tubercles.

This fossil has usually been referred to *C. Blumenbachii*, as well as to the species in the Trenton limestone; but our fossil differs from the last, in the more rounded posterior angles of the buckler, and in other particulars; from the former it differs in being uniformly of the small size represented, in having but thirteen articulations in the back, and in the less prominence of the protuberances on the middle lobe of the head. It seems extremely doubtful whether all the figures given in the works of foreign authors under the name *C. Blumenbachii*, are of that species. A form referable to *C. Blumenbachii* (*Silurian Researches*, pl. 7, fig. 6), occurs in the Schoharie grit, and several fine specimens have been obtained by Mr. Gebhard of Schoharie. By reference to the table of strata, it will be seen that the fossil described holds a much lower position.

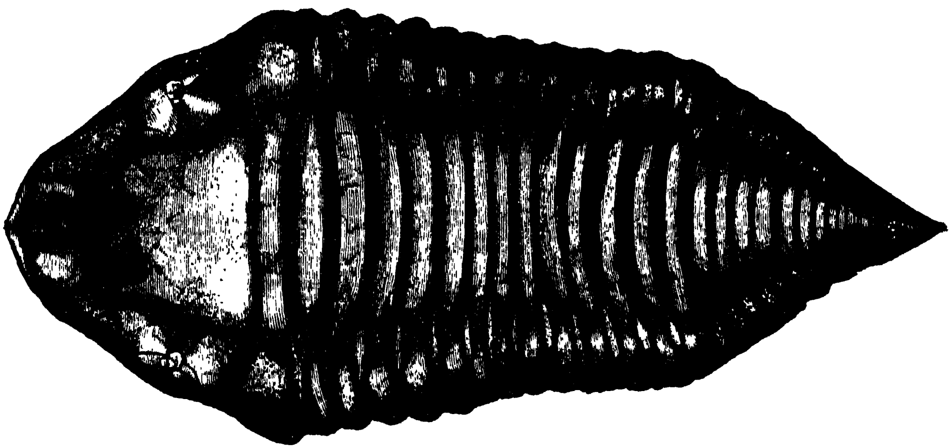
Locality—Lockport, in Niagara shale; also at Rochester and intermediate points.

4. *Bumastis Barriensis* (MURCHISON, *Silurian Researches*, p. 656, pl. 7 bis, fig. 3, *a*, *b*, *c* and *d*; pl. 14, fig. 7, *a* and *b*). "Head round in front; margin raised; oculine protuberances large, surrounded by a depression, on the edge of which, over the eyes, [are] two small ovate prominences; in advance of the eye, and towards the margin, two slight hollows. Eye approaching to semilunar, apparently smooth. The facial suture traverses the oculine protuberances, separates the upper portion of them from the eye, and passes under the margin. Body with no true longitudinal furrows; central lobe only just perceptible by a slight depression in the body only. Ribs 10, those of the lateral lobes terminating in recurved blunt ends. Caudal portion round and smooth, without a trace of trilobation. Surface of the whole animal covered by extremely thin, apparently imbricated lamella, the edges waved or vermiform, the intermediate spaces studded with minute dots."

This trilobite is readily recognized by the similarity of the two extremities, which are much more rounded than in *Isotelus*. It is known at the locality as the "Double-headed Trilobite." Our specimens are usually much flattened, and the oculiform protuberances scarcely elevated. Although there is no distinct trilobation of the body, there is usually a strong undulation in the ribs at the point between the central and lateral lobes. After the removal of the crustaceous covering, the body is sometimes seen to be covered with minute punctæ. In our specimens, the length of the body is from one third to two thirds the length of the caudal extremity: this circumstance, with the apparently more slender ribs, at first induced me to consider it a distinct species.

Locality—Lockport, in Niagara shale. The head and caudal portions of this fossil are often found at Rochester, and in Wayne county, but I have seen no perfect specimens from these localities.

34



Homalonotus delphinocephalus

Homalonotus delphinocephalus. (*Silurian Researches*, pl. 7 *bis*, f. 1 *a*, 1 *b*. *Trimerus delphinocephalus*, GREEN, *Monograph*, fig. 1, p. 82.) — Head depressed, ovate, sub-acute, or rounded anteriorly; eyes prominent, rather small. Body composed of 13 ribs, with intercostal plates; extremities of the ribs directed forward. Caudal extremity distinct, with 12 ribs united, forming a solid crust; tail acuminate. The whole surface is papillose, or scabrous, and in the least exposed portions, this character is often preserved in great perfection.

It is among the most common trilobites at Lockport. The specimen figured is two-thirds the natural size, and they have been seen of twelve inches in length. The young of this species, figured by Green, is often found, and sometimes less than an inch in length. The name *Homalonotus* of Konig has precedence over that of *Trimerus*, but the specific name of Green has been retained by Mr. Murchison.

This fossil and the *Diplcura Dekayi* have often been most unaccountably confounded with each other, notwithstanding their geological relations are so widely different. Dr. Green has quoted Lockport as a locality, where he remarks it is not uncommon. Rochester, in the same geological position, is also named as a locality. All the other places named as producing the *Diplcura*, are in the higher rocks of the system. The separated heads of these species very closely resemble each other, but the nature of the matrix is usually very different; and during all the excavations at Lockport, I have seen nothing referable to the *Dipleura*.

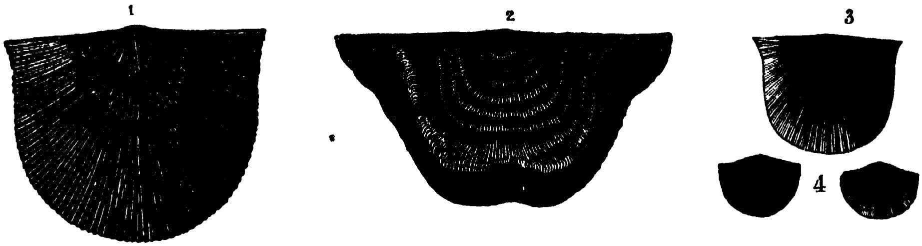
Localities—Lockport, Rochester, Sweden, Wolcott, and numerous intermediate points.

SHELLS.

Strophomena (*Leptæna*), and *Delthyris* (*Spirifer*), are the most abundant forms usually seen. One or two species of *Atrypa* and *Orthis* are scarcely less numerous.

The following are the more common forms of *Strophomena:*

35.



1. Strophomena subplana.
2. S. depressa (lower valve).
3. Strophomena striata.
4. S. transversalis.

1. *Strophomena subplana* (Conrad, *Jour. Acad. Nat. Sci.* Vol. 8, p. 258). This shell is distinguished by the sharp radii which alternate in size, and by the nearly flat valves. It often occurs in beautifully preserved specimens upon the surface of thin calcareous layers in the shale. When imbedded in shale, the radii are not so prominent. It is the largest species of this form in the group, but is often smaller than the figure.

Locality—Lockport, Niagara, Rochester and Wolcott.

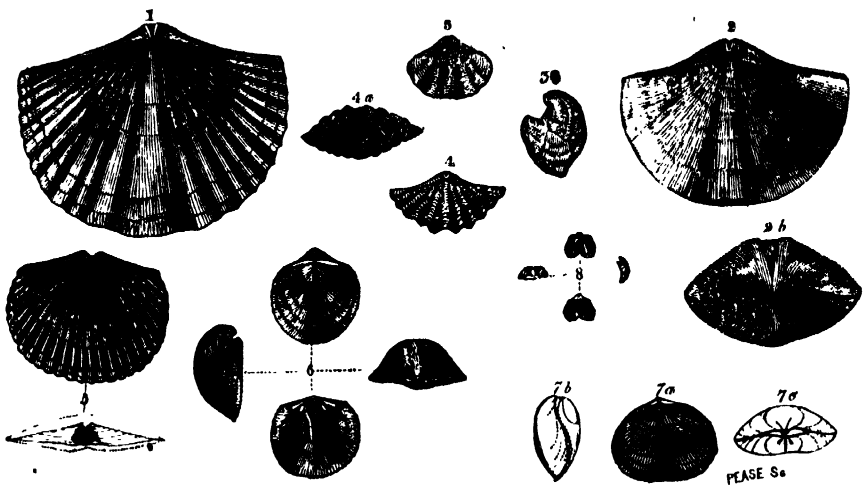
2. *Strophomena depressa.* (*Productus depressus*, M. C. t. 459. *Leptæna depressa*, Dalm. *Swedish Transactions*, p. 106, t. 1, f. 2; *His. Pet. Suec.*, p. 69, t. xx, f. 3. Murchison, *Silurian Researches*, p. 623, pl. 12, f. 2.) — This shell is abruptly deflected in front; the slightly convex or flat surface marked by six to eight folds or undulations, which are crossed by numerous striæ. The sides of the shell at the extremities of the hinge are expanded into wings. This portion of the fossil is usually obscured by the matrix, which when removed displays the form as figured.

The deflected portion of the shell is not as long, and the undulations not as numerous as in the figure of Mr. Murchison. Specimens from the same rock however, apparently of different ages differ in these particulars. The fossil commences its existence in the Clinton Group, becomes very abundant in the shale of the Niagara Group, and continues through several of the higher formations. It occurs in every locality of the Niagara shale, though usually smaller than the one figured, and often apparently more circular.

3. *Strophomena striata,* shell semi-elliptical, lower valve slightly convex, upper one flat, finely and equally striated, the striæ dividing; a few punctulations appear near the margin of the shell, which were probably furnished with minute spines. The valves are usually separated and spread over the shaly laminæ. Its delicate striated surface distinguishes it from others of the group. *Locality*—Lockport; Rochester.

4. *Strophomena transversalis.* (*Leptæna transversalis,* Dalm. l. c. p. 109, t. 1, f. 4; *His. Pet. Succ.* p. 69. t. xx, f. 5. Murchison, *Silurian Researches,* p. 629. pl. 13, f. 2.)—Semi-circular, lower valve very convex, upper one very concave, finely striated, and marked with linear distant, elevated ribs; "hinge inflected; hinge line straight, equal in width to the width of the shell." Our specimens are smaller than the figure of Murchison, and less prominently ribbed. *Locality*—Rochester; Wayne county, and more rarely at Lockport.

36.



1. Delthyris Niagarensis,
2 and 2 *b*. D. radiatus.
3 and 3 *b*. D. staminea.
4 and 4 *a*. Delthyris decemplicata.
5. Orthis Flabellulum (*a*)?
6 Orthis canalis.
7. *a. b. c.* Orthis hybrida.
8. Delthyris sinuatus.

1. *Delthyris Niagarensis.* (Conrad *Jour. Acad. Nat. Sci.* p. 261.)—Semi-oval; ventricose in the middle, (but generally flattened from compression); ribs about twenty-two, rounded, not usually more than ten distinct on each side of the mesial fold, which on the upper valve is prominent, rounded, and expanding towards the base; whole shell covered with fine radiating striæ, and usually a more prominent line in each depression between the ribs, the mark of which is sometimes left in the cast; hinge line shorter than the greatest width of the shell, rounded at the extremities. Width of the shell, one and a half inches; length about one inch, but variable from compression.

This fossil is peculiarly typical of the group, and will be readily recognized by its rounded ribs and finely striated surface, differing from all others of the genus in this part of the system.

Locality—Lockport, Niagara, Rochester, and less abundantly in Wayne county.

2 and 2 *b*. *Delthyris radiata*. (*Spirifer radiatus*, M. C. t. 493. *Silurian Researches*, p. 624, pl. 13, f. 6.) — Semi-oval, ventricose, (often flattened from compression); shell covered with fine radiating striæ, scarcely interrupted by lines of growth; extremities of the hinge line rounded; area moderate; perforation small.

Fig. 2 is from the shale and somewhat flattened; 2 b, is from the succeeding limestone and is more ventricose, not having been compressed.

This shell, in its various phases, resembles too closely the figures, both in the Mineral Conchology and the Silurian Researches to be referred to any other species. The description in the latter corresponds with our largest specimens. It ranges from the iron ore beds of the Clinton group to the Niagara limestone, but is more abundant in the shale of the latter group.

Locality—Wolcott, Rochester, Lockport, and numerous other points.

3 and 3 *b*. *Delthyris staminea*, n. s. (References. *Spirifer crispus? Silurian System*, p. 624, pl. 13, f. 8. *Delthyris crispa*, Dalm. l. c. p. 122, t. iii, f. 6; *His. Pet. Suec.*, p. 73, t. xxi, f. 5.) — Semi-circular, lower valve very gibbous, and produced into an incurved beak, upper one moderately elevated in the centre; ribs, commonly two in the upper, and three in the lower valve on each side the mesial fold, crossed by numerous elevated, thread-like lines; beaks remote, extremities of the hinge line rounded; area large. Cast of shell smooth.

This shell resembles the figure of *Spirifer crispus?* (*Silurian Researches.*) Hisinger's figure differs from Murchison's and is less like our shell. I have obtained casts of a shell very similar, if not identical with this one, from the "coralline limestone," below the water-lime at Schoharie.

Locality—Common in the lower part of the shale at Lockport and Lewiston, less abundant at Rochester and Wolcott.

4 and 4 *a*. *Delthyris decemplicata*, n. s. Sub-triangular, gibbous, ribs ten, finely striated longitudinally, and crossed by undulating imbricated lamellæ, which are less prominent on the mesial fold; mesial fold of the lower valve deeply impressed toward the margin and elevated in front.

This shell is distinguished from the last by the greater number of ribs, which are crossed by imbricated lamellæ, while in *D. staminea*, these are simple elevated lines. From compression these two shells often approach each other in form. There are usually four ribs in the upper, and five in the lower valve, on each side the mesial fold. It much resembles *Spirifer octoplicatus*, M. C. t. 562, f. 2 and 3; but the surface is striated, the mesial fold is not plain, but the lamellæ are less prominent than on the ribs.

Locality—Lockport and Lewiston, occurring with the last named species, and more abundantly.

8. *Delthyris sinuatus*. (*Terebratula sinuata*, Sowerby *in Linn. Trans.* Vol. xii. p. 516, t. 28, f. 5 and 6; *Delthyris cardiospermiformis*, *His. Antechn.* Vol. iv. t. 7, f. 6. Dalm. *sur les Terebratules*, p. 124, t. 3, f. 7; *His. Pet. Suec.* p. 74, t. 21, f. 9. *Spirifer cardiosper-*

miformis, Von Buch, *sur les Spirifers et Orthis*, t. 1, f. 7. *Silurian Researches*, p. 630, pl. 13, f. 10.) Obcordate, deeply two-lobed, striated longitudinally; lower valve convex, with an incurved beak, upper one flat or slightly concave; area triangular, large in proportion to the size of the shell.

Our specimen is smaller than the one figured by Murchison, but it agrees so closely with his figure and description, as well as with the figures of Von Buch and Hisinger that there remains no doubt of its identity. This shell resembles the *D. varica*, Conrad, *Jour. Acad. Nat. Sci.* Vol. viii. p. 262, pl. 14, f. 20; but in that shell the valves are nearly equally convex, and the hinge line less extended.

Locality—Wolcott, Sweden, Monroe county.

5. *Orthis flabellulum* (*a*)? (*Silurian Researches*, pl. 21, f. 8. *O. callactis?* Dalman). — Semi-oval, with 24 to 28 simple, rounded, smooth radii, which are crossed by a few lines of growth; the radii continue strongly marked quite to the beak, their breadth being equal to the spaces between them; hinge line slightly arched, a little less than the width of the shell; upper valve flat, the lower one slightly convex. Length 8 lines, width one inch.

In Murchison's figure the ribs are broader than in our shell; the description corresponds with the exception that there are oftener 26 than 24 radii. I have seen a shell which is apparently identical with this one, from the limestone of the Clinton group, associated with *Pentamerus oblongus*. It differs from a similar shell in the Trenton limestone in the greater number of radii, and the less convexity of the lower valve. The radii in the latter are often bifurcate, while they are never so in the former.

Locality—Lockport; Rochester.

6. *Orthis canalis* (*Silurian Researches*, p. 630, pl. 13, f. 12, *a.*; also pl. 20, f. 8. *Orthis elegantula?* Dalman. Von Buch *sur les Spirifers et Orthis*, pl. ii, f. 3, 4 and 5).—Semi-oval, finely radiated, radii dividing towards the margin; lower valve very convex, with a produced incurved beak; upper valve nearly flat or with a slight depression along the centre, which is rarely characteristic in our specimens; hinge line shorter than the width of the shell.

This shell is every where found in the shale of the Niagara group, and is one of its most characteristic fossils. It is somewhat variable in form, being often nearly circular; and is evidently identical with the figure of Murchison, and is probably the same shell figured by Dalman. Von Buck remarks in his description of this shell, that, it is found of precisely the same form as the Swedish specimens, but a little smaller; at Castle Hill, Dudley, and at Wenlock Edge, Shropshire.

In the *Delthyris shaly limestone* of the New-York system, there is a shell almost precisely similar in form to this one, but more robust; the lower valve is very convex, almost carinated in the centre, the upper one slightly convex, and marked with a depression along the middle; hinge line longer in proportion to the shell. The similarity of form in these two shells which are really distinct, renders it a matter of interest to ascertain the relative position of the Swedish, English and American species, and whether the former may not be identical to the larger one here mentioned.

The *Orthis striatula* of the Trenton limestone differs from this shell in the less convexity of the lower valve, and in the more strongly marked radii which are crenulated, or crossed by elevated lamellæ which extend across the depressions between them; the beak is less incurved and the shell more circular in form.

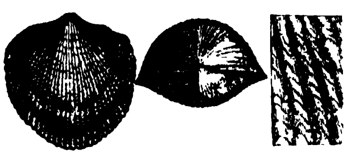
Localities—Niagara, Lockport, Sweden, Rochester, Wolcott.

7. *a. b. c. Orthis hybrida. Silurian Researches*, pl. 13. f. 11. Lenticular, radiated; radii dividing towards the margin, lower valve most convex; upper one slightly depressed in front; front rather straight or a little impressed; area narrow; hinge line short.

The specimen figured is somewhat larger than the one in the *Silurian Researches*, but the more abundant form is like that. It is usually convex near the beaks and flattened toward the margin, the valves appearing equal. The shell occurs with *O. canalis* and the other forms here figured, few of them rising above the shale of the *Niagara group*, and none of them known above the *Niagara limestone*.

Locality—Lockport, Sweden, Rochester and Wolcott.

37.

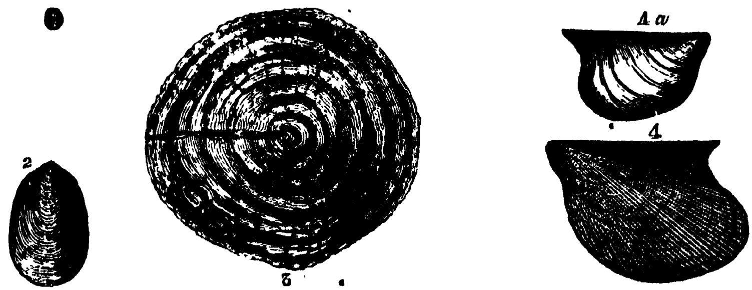


Atrypa affinis. (*Terebratula affinis*, M. C. t. 324, f. 2. *A. reticularis*, Dalman, Hisinger, &c.)

The illustration presents the common form of this variable species as it occurs in the shale of the Niagara group. The shell is marked by about twenty-four radii which bifurcate about one-third of the distance from the beak to the margin. The whole surface is closely imbricated by the projecting laminæ of the shell. This structure is visible in the enlarged portion.

This shell is common in all localities and abundant in many places. It is usually much flattened, rarely presenting the rotund form of the figure. Several other species of this genus are common in this group, and some of them will be figured at the end of the volume.

38.



1. Orbicula? squamiformis.
2. Lingula lamellata.
3. Orbicula corrugata.
4. Avicula emacerata.

1. *Orbicula? squamiformis*, n. s.—Oval, depressed; apex nearer to one extremity of the shell; surface covered with concentric lines, which diverge on the posterior part of the shell. Shell translucent. Longest diameter $\frac{3}{20}$ of an inch.

This fossil corresponds very closely with the *Patella? implicata* (*Silurian Researches*, p. 625, pl. 12, f. 14, *a*.). I had supposed it to be the young of fig. 3; but its oval form, and the lateral situation of the apex, preclude the idea. It occurs on the surface of the shaly laminæ with other fossils, always presenting the appearance of a thin translucent scale.

Locality—Rochester and Sweden in Monroe county.

2. *Lingula lamellata*, n. s. — Oval, somewhat broader towards the base. Shell covered with concentric, slightly undulating, elevated lamellæ, wrinkled at the sides; gradually rounded at the base. Beak sharp, scarcely elevated.

Perfect specimens of this fossil are not of common occurrence. The surface is not striated, but the shell appears as if composed of concentric laminæ with elevated edges.

Locality—Lockport, Rochester, Sweden.

3. *Orbicula corrugata*, n. s. — Orbicular; surface strongly wrinkled, and covered with finer concentric undulating lines; muscular impression on the under valve very distinct, and often extending half way from the apex to the circumference.

This fossil is easily distinguished from any other in the rock, by its orbicular form and wrinkled surface. I have seen one or two specimens which exhibit the two valves only partially separated, and there seems no doubt of the propriety of its reference to this genus.

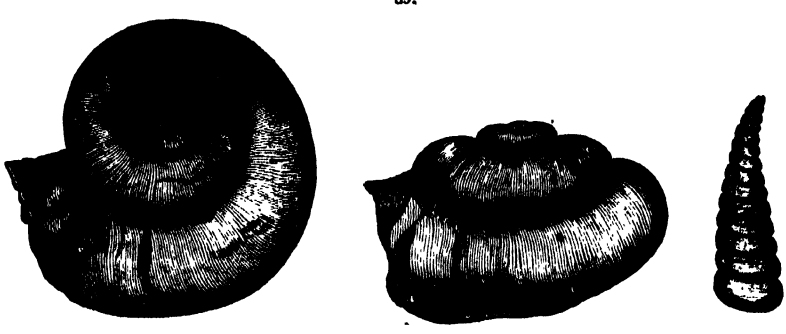
Locality—Rochester, Sweden, Lockport, Wayne county.

4. *Avicula emacerata* (Conrad, *Jour. Acad. Nat. Sci.* Vol. 8, p. 241, pl. 12, f. 15). — Lower valve slightly convex, wider than high, finely radiated; radii equal, diverging toward the margin, crossed by elevated concentric lines, giving the whole surface a cancellated appearance. Upper valve smaller, nearly flat, plain, or with a few concentric lines, and sometimes a few radii on the posterior wing; posterior wing acutely angular; anterior one slightly rounded at the extremity, very short.

From some specimens, it would appear that the radii on the larger valve become obsolete with age, as several large valves have been seen without them.

Locality—Lockport, Sweden.

39.



1 and 2. Euomphalus hemisphericus. 3. Cornulites arcuatus.

1 and 2. *Euomphalus hemisphericus*, n. s. — Convex, hemispherical; volutions about four, crossed by striæ and elevated lines of growth.

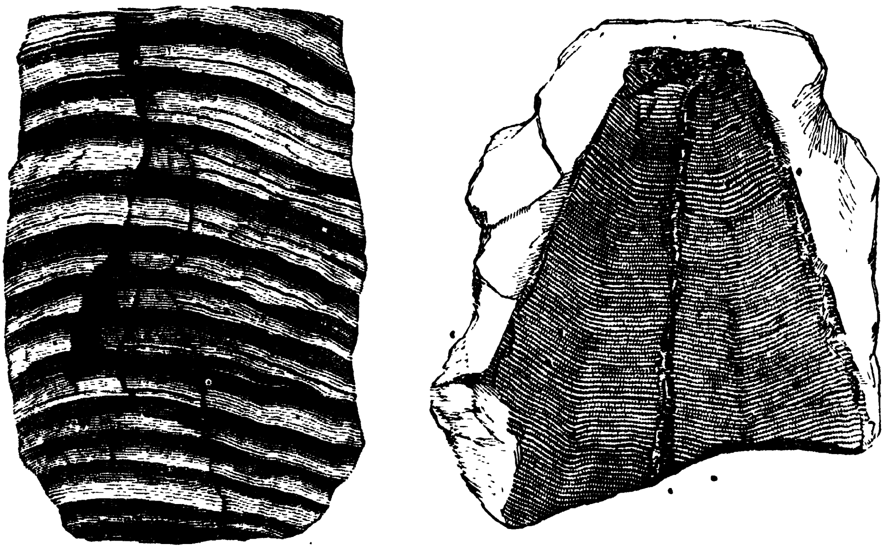
This fossil usually occurs as a cast in the Niagara limestone, and consequently the characters of the shell are not perfectly known.

Localities—Rochester and Lockport, in limestone.

3. *Cornulites arcuatus* (Conrad, *Jour. Acad. Nat. Sci.* Vol. 8, p. 276, pl. 17, f. 8). — Conical, rapidly attenuated; composed of a series of cup-form disks, placed above and inserted within each other at the margins.

The annulations are more rounded than in *C. serpularius* of the Wenlock limestone (See *Silurian Researches*, p. 627, pl. 26, f. 5). It is easily distinguished from any other fossil in the group, or even in the system. It occurs in single specimens at Rochester in the limestone, and at Lockport in groups, in cavities which are partially filled with spar. The fossil is usually nearly destroyed, its form being left invested with crystals, and sometimes a small central tube or siphuncle? is all that remains.

40.



1

1. Orthoceras annulatum. 2. Conularia quadrisulcata.

1. *Orthoceras annulatum?* — Very gradually tapering; ornamented with transverse rings, and numerous undulating lines; siphuncle central. Diameter 1½ to 2 inches.

In many respects, this resembles the figure of *O. annulatum* (*Silurian Researches*, pl. 9, f. 5); and more nearly the figure of the same in *Mineral Conchology*, t. 133; but it is destitute of longitudinal furrows or arched laminæ. Since, however, that species is variable in its characters, it may be the same. The specimen figured is a flattened fragment from the shale, and is one of the ordinary fossils of the group, being found in all localities. In specimens from the limestone, the annulations are stronger and more acute.

Locality—Lockport, Rochester, Sweden, Clarendon, in shale and limestone.

Several other species of Orthoceræ occur in this group, among which are forms closely resembling, if not identical with *O. virgatum* (*Silurian Researches*, pl. 9, f. 4), or *O. undulatum* (*Mineral Conchology*, t. 59), and *O. imbricatum* (*His. Pet. Suec.* p. 29, t. ix, f. 9; and *Silurian Researches*, pl. 9, f. 2).

2. *Conularia quadrisulcata?* (Miller, *M. C.* t. 260, f. 3 and 4; *His. Pet. Suec.* p. 30, t. x, f. 5; *Silurian Researches*, p. 626, pl. 12, f. 22). — Conical; crossed by obliquely transverse furrows and ridges, which are not always equal. The ridges are finely and beautifully crenulated, and the furrows crossed by grooves which are a continuation of the spaces between the crenulations of the ridges. Shell compressed; in shale, much expanded, and larger than specimens usually figured. It is ordinarily found in fragments of a much smaller size.

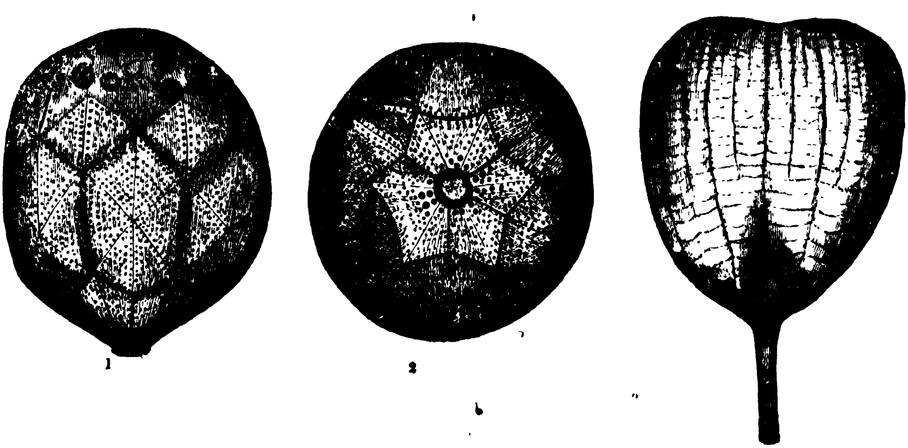
Since the character of the surface is so similar in this and other species, it is not improbable that several have been confounded under this name.

Locality—Lockport, Rochester.

CRINOIDEA.

The species of this family appear to have been more abundant in this group than in any other in the State; and there are probably as many species, well identified, from the Niagara shale, as from all the other rocks of the New-York System. An explanation of their structure will be found in another place; nothing more being intended in these illustrations, then to present the usual appearance of the fossil.

41.



1, 2. Caryocrinus ornat   3. Cyathocrinites pyriformis.

1, 2. *Caryocrinus ornatus* (Say, *Jour. Acad. Nat. Sci.* Vol. 4, p. 289).— This fossil usually occurs separated from the column, and destitute of arms or tentacula. From its spheroidal form, it has received the name of "*Petrified Walnut.*" It is composed of plates which are tuberculated on the surface, having generally a double row of larger ones along the line from the centre to each angle of the plate. The dark lines in the figures indicate the junction of the plates. The points of attachment of the arms are visible near the top of the specimen. Fig. 2 is a view of the base, presenting the point of attachment of the column, the form of the pelvic plates, and the bases of the costals. Separate plates are often met with, and they may always be known by their strongly tuberculated surface.

This fossil occurs in great numbers at Lockport, and in many instances covered by a coral which had grown upon it after the destruction of the former, as is evident from its often covering the point of attachment of the column and arms, and closing up the aperture on the crown.

The *C. loricatus* of Say, was probably a specimen which had undergone some modification in the form of the plates, from injury or otherwise, a circumstance apparently not uncommon among the Crinoidea.

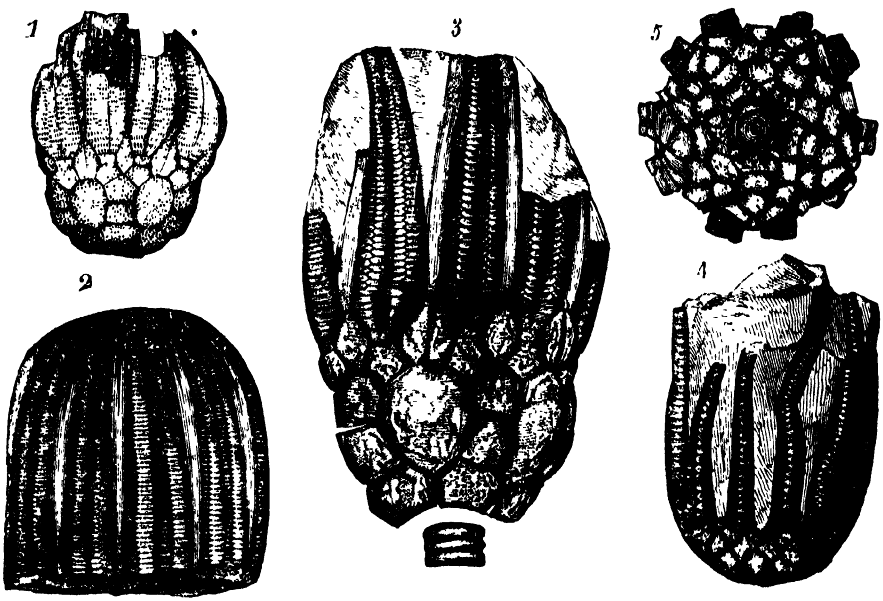
Locality—Lockport, and more rarely at Rochester and Sweden.

3. *Cyathocrinites pyriformis* (*Silurian Researches*, p. 672, pl. 17, f. 6. *Ichthyocrinus lævis*, Conrad, *Jour. Acad. Nat. Sci.* Vol. 8, p. 279, pl. 15, f. 16.) — This species is known by the great width of the plates near the base, which unite laterally, and divide in ascending until they form the arm divisions; the latter fold inward toward the centre, sometimes nearly closing. The upper part of the column is very slender, and composed of thin plates, which join by a suture formed by the elevated lines which radiate from the centre. The surface is faintly ornamented.

From the many specimens seen, which vary in form and proportions to a considerable degree, I have no doubt of the identity of the fossils figured by Mr. Murchison and Mr. Conrad.

Locality—Lockport.

41.



1. Hypanthocrinites cælatus.
2. Hypanthocrinites decorus.
3. Hypanthocrinites decorus.
4. Marsupiocrinites (?) dactylus.

1. *Hypanthocrinites cælatus*, H.—Pelvic plates 5, hexagonal, equal in size, supporting on their upper edges five quadrangular costals, resting upon the superior lateral edges of the pelvic plates, are five large (nine-sided) intercostal plates. Each costal supports a nearly regular pentagonal scapular plate, resting upon the upper oblique lateral edges of which, and the intercostal plate are two pentagonal arm joints, and upon each one of these rests a somewhat quadrangular hand-joint, which supports two fingers composed of thin plates joining in the centre by their cuneiform edges producing a longitudinal suture. Upon the superior edge of the intercostal plates rests a double, somewhat conical plate, supporting a longitudinal rib, which separates the pairs of arms and fingers. There is a similar *single* conical plate resting on the superior lateral edges of the arm joints, and supporting in like manner a longitudinal rib. These apparent ribs are partitions or dissepiments, which reach nearly to the centre, separating the internal part of the crinoid in ten cells or compartments.

This species bears a close resemblance to the next, but differs from it in the following particulars: The whole structure is smaller, the plates are covered with tubercles or tuberculated undulating lines; the arms are deeply sculptured or corrugated, so as to render the suture almost invisible. The single conical plate supporting the rib is not truncated below, and does not rest on the scapular. It is plainly referable to this genus of Mr. Phillips, and to the genus *Eucalyptocrinites* of Goldfuss, as it is impossible that the figure which he represents, pl. 64, f. 7, should have had no column. The plates which Mr. Phillips describes as costals are in fact the pelvic plates, as can be plainly seen in the specimen here described, the upper portion of the column still remaining enclosed.

Locality—Lockport, Sweden, Monroe county.

2 and 3. *Hypanthocrinites decorus.* (*Silurian Researches*, p. 672, pl. 17, f. 3.)—The description of the last corresponds with this except in the few particulars noticed. This is apparently the fossil described by Mr. Phillips. The ribs, however, instead of being rounded and elevated toward their upper extremities, as there represented, are grooved (as in fig. 2,) with a few slight tubercles, as if fitted for the attachment of some muscle or integument. (This may possibly arise from an exfoliation of a part of the rib.) The tubercular plates surrounding the mouth are not seen in the specimens figured, though they are in others. Fig. 2 represents the upper portion, which is broken off just above the plates, presenting a view of the internal cavity beneath.

Locality—Lockport.

4. *Marsupiocrinites?* dactylus*, Hall.—Pelvic plates five, pentagonal,† slightly recurved at the base; first costals five, pentagonal, supporting five hexagonal second costals; intercostal plates five, equal, and regularly hexagonal, resting on the superior lateral edges of the first costals. Scapulars five, pentagonal, resting on the superior edges of the second costals, and supporting upon their superior lateral edges two obliquely cuneiform hand joints; intercostals(?) ten, somewhat unequally six-sided, resting on the superior lateral edges of the second costal and intercostal plates. Upon the inner superior lateral edge of the interscapular plate rests one edge of the hand joint, and upon the superior edge rests the base of the second hand joint, which supports a finger composed of a double series of plates, uniting by their lateral cuneiform edges, producing a longitudinal suture in the finger. The fingers are arranged somewhat in pairs, and separated by a cuneiform plate which rests upon the edges of the hand joint. Between each pair of arms are two plates, one pentagonal, and the other minute, quadrangular, both resting on the superior lateral edges of the interscapular plates.

The upper figure represents very clearly the structure of this crinoid; the plates are slightly ornamented on the surface, and joined at the edges by a suture. The column is composed of a double series of plates, one extending beyond the other, and are ornamented on their edges.

Locality—Lockport.

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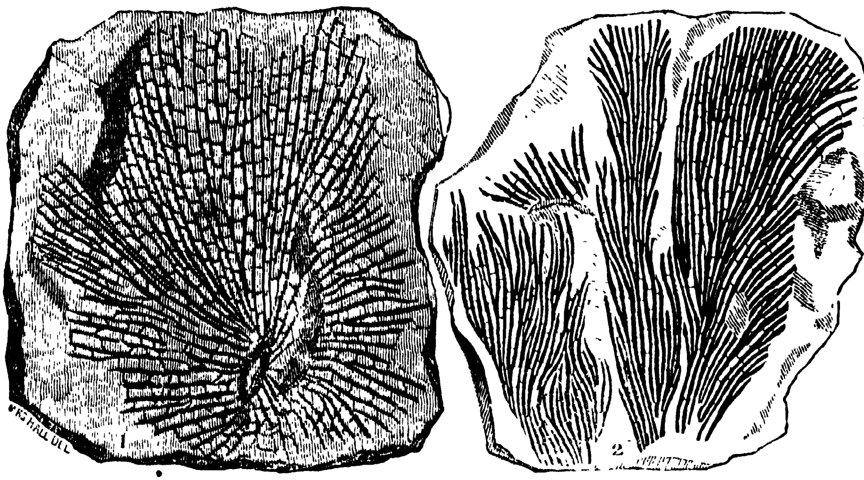
* This fossil is provisionally referred to this genus of Mr. Phillips, though it will probably require to be separated.

† They are represented in the wood cut as triangular, but the lateral edges join, forming a short side.

CORALS.

Numerous forms of this class of fossils occur both in the shale and limestone. Few of the solid or stone building corals are seen in the shale, its forms usually being referable to Retepora, Fenestella, and genera of similar structure. There are also some other forms of this class of fossils, which appear referable to the corticiferous polyparia.

42



1. *Gorgonia? reteformis.* No visible axis; branched or expanding from a centre (axis?); branches flattened, wrinkled and indistinctly striated, anastomosing so as to form a reticulated structure; no visible pores or papillæ.

In general appearances this fossil closely resembles *Gorgonia assimilis*, (*Silurian Researches*, pl. 15, f. 27,) to which I had referred it. There is, however, no solid axis, a central point or depression being visible, from which the coral expands. It is probably the same as fig. 28, ut supra. The figure is from the central portion where the margin is destroyed. I am indebted to Dr. Fassett of Lockport for a perfect specimen, six inches in diameter. I have another imperfect specimen where the margins are destroyed, and which must have been 18 or 20 inches in extent when perfect.

It occurs in the shale at Lockport, usually in fragments.

2. *Gorgonia?* Expanding from a base or point of attachment, branched; branches bifurcating as they ascend, slightly diverging and united at intervals by slender filaments. The whole forms a delicate and beautiful expansion, often extending over several inches. Its perfect form is unknown. No pores are visible, and both this and the preceding species present merely a film of carbonaceous matter. They are provisionally referred to Gorgonia, and if not strictly belonging to that genus are closely allied.

43.

1. ———— ? This fossil is completely flattened, presenting no solid substance, except a thin carbonaceous film. It appears like a collection of fine hairs arranged obliquely on a central axis like the tail of some animal. It resembles in structure some of the solid corals where the pores are oblique to the direction of the axis, but here there is no defined margin, and the calcareous matter, if ever existing, has been removed.

2, 3. *Coral resembling Isis.* This fossil has a calcareous stem and the external structure is much like some of the recent corals. Figure 2 represents the natural size, and fig. 3 is a portion magnified. It is the only coral presenting this structure which I have met with in the New-York rocks. It occurs at Lockport, with the last, in the shale of this group.

Since there are numerous corals in this shale still retaining their calcareous character and some of the expanded or net-like forms, which are always clearly referable to structures of this kind, it seems natural to infer that those forms where only a thin carbonaceous film remains, with no visible pores, or structure like the stony corals, should be referred to some other division of the Polyparia at least, and perhaps even to some of the more gelatinous or less solid forms than Gorgonia.

The fossils figured in the preceding wood cuts with the exception of two or three species, are, so far as known, confined to this group. From the identity of many of these with forms described by Mr. Murchison, from the Wenlock shale, and limestone of England, we have inferred that the Niagara group of New-York represents, to a considerable degree, that formation. Though the Wenlock limestone contains some forms identical with those of the lower limestones of the Helderberg division, which in New-York are separated by the Onondaga salt group one thousand feet in thickness, yet we can account for this apparent difference upon the supposition that the latter formation does not exist in England, and that the higher limestones come down upon the lower, or equivalent of Niagara, and the whole are recognized as one formation, as the same are in Ohio and the southwest.

The fossils common to the two formations can be seen by the references in the descriptions; they are: *Strophomena transversalis*, *S. depressa*, *Orthis canalis* or *O. elegantula*, *O. hybrida*, *Delthyris radiatus*, *D. sinuatus*, *Atrypa affinis*, *A. imbricata*, *A. cuneata*, *Conularia quadrisulcata*, *Bumastis Barriensis*, *Homalonotus delphinocephalus*, *Hypanthocrinites decorus*, *Cyathocrinites pyriformis*.

These are the principal forms though there are several others which are very similar if not identical to those figured in plates 12 and 13 of the *Silurian Researches*. The occurrence of so great a number as here given, and which with two or three exceptions are all confined to this group, leaves no doubt of the perfect identity of these formations whatever may be inferred of others.

12. ONONDAGA SALT GROUP.

Calciferous slate, or *Second greywacke with Shell limerock*, of Eaton (*Canal Rocks*, p. 124). *Gypseous marls and slates* (Annual Reports).

[M. of Woodcut, page 27.]

Succeeding the Niagara group, we find an immense development of argillaceous shales and marls, with shaly limestones, the whole embracing veins and beds of gypsum. The general aspect is a light ashen, or approaching to drab color, with some portions of dull bluish green. The lower part is of deep red with spots of green, very closely resembling some of the more shaly portions of the Medina sandstone (as before described at Lewiston and other places). Succeeding this, where penetrated beyond the reach of atmospheric influences, the rock is greyish blue like the ordinary blue clays, with bands of red or brown. This portion and that succeeding it are often greenish and spotted, and contain seams of fibrous gypsum, and small masses of transparent or reddish selenite and compact gypsum. From this it becomes gradually more greyish or ash-colored, with thin strata of argillaceous limestone, which is sometimes dark, though generally of the same color as the mass around. The whole terminates upward by a grey or drab limestone, called by Mr. Vanuxem the *Magnesian deposit.*

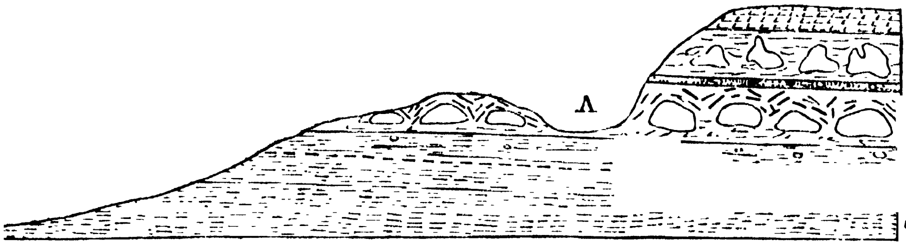
This group receives its name from the great development of the products in the county of Onondaga. In an economical point of view, this is one of the most important groups in the system; containing all the workable beds of gypsum in Western New-York, and giving rise to the salines from which nearly all the salt in the State is manufactured. It extends east beyond the limits of the district, and west beyond the Niagara river into Canada; maintaining the same general characters, and containing beds of gypsum. Some of the shaly and porous limestones of the upper part of the group appear still beyond, forming the island of Mackinaw, if we may judge from similarity in character, though the connexion with rocks above or below is not there visible. Its resources, except in certain places, are at this time undeveloped; and it is only when its limits and extent shall become known, that its immense value will be appreciated.

From the character of the group, it has been deeply excavated by the ancient denuding agency, and it occupies a depression throughout the greater part of the Fourth District; while from the accumulation of drift upon its surface, and the absence of deep streams, there are few points where good sections can be obtained. The absolute contact of this group with the one below has nowhere been observed in the district; yet from the small space intervening, and no rock being known in this place, there remains no doubt of the order of succession. In the Third District, its connexion with the Niagara group is seen in several places, both together being exposed in the banks of ravines.

Localities. — By reference to the Geological Map, it will be seen that this group occupies the southern part of Wayne and the northern part of Ontario and Seneca counties; the southern part of Monroe county extending southward for a short distance into Livingston on the Genesee river; the northern part of Genesee and Erie counties, and a small portion of the southern part of Niagara. Its greatest width in the district is at its eastern extremity, where the denudation of the higher rocks give this formation a greater southern extension by several miles than it has farther west.

The best section of the group which I have been able to obtain, is along the country south from Rochester. The lower portions are developed only at a few points, but their characters are known from several borings which have been made to great depths for the purpose of obtaining water. The higher portions of the group with the gypsum beds and the porous limestone are exposed on Allen's creek at Garbutt's mill. From these observations the following section has been constructed.

44.



f. Terminal mass of the deposit, which is a light grey or drab-colored impure limestone, with cavities sometimes containing crystals, and often embracing shaly beds.

c, d, e. Shaly and compact impure limestones, with shale and marl, embracing two ranges of plaster beds. Between the two ranges of plaster beds is a bed of shaly limestone, *d.* with some imperfect hopper-shaped cavities, and a harder grey limestone, with numerous pores, sometimes very minute.

b. Green marl and shale, with some shaly limestone, containing veins of fibrous gypsum, selenite, and small nodules of gypsum.

a. Green and bluish green shale, with bands of red.

There are no well marked lines of division between the different portions of the deposit as here enumerated, but each one taken as a whole is sufficiently well characterized.

1. The red shale forming the *lower* division of the group, and so well developed in the Third District, I have not been able to find west of the Genesee river. It appears in the eastern part of Wayne county, as indicated by the deep red color of the soil which overlies it. At Lockville the greenish blue marl with bands of red has been quarried from the bed of the canal.

West of the Genesee this is the lowest visible mass; the red shale has either thinned out or lost its color, gradually becoming a bluеish green; while otherwise the lithological character remains the same. On first exposure it is compact and brittle, presenting an earthy fracture; but a few days are sufficient to commence the work of destruction, which goes on till the whole is resolved into a clayey mass.

Since a deoxidation of the coloring matter of the red shale would produce the green color of the lower mass as developed in the Fourth District, it is, perhaps, not improbable that this cause has operated on a large scale, changing the color of the mass by the same process which has produced the green spots and bands in the same rock farther east.

The green marl of the lower division appears near the canal at Fairport, and again at Cartersville. On the west side of the Genesee this portion appears on the surface in but few places. The bed of the stream at Churchville exposes the greenish blue marl, and in digging a well at the same place this was found at a depth of thirty feet below the surface. About one mile southeast of Churchville, at Wiley's mills, the green marl is seen in the bed of the stream. At this place it embraces one or two thin strata of impure drab-colored limestone. These localities are near the northern margin of the formation, the limestone being visible within a short distance on the north side of Black creek. In an excavation half a mile east of Churchville, some loose masses of the Niagara limestone were found, but no rock of this group.

In the northern towns of Genesee county, the lower portion of this group were seen in several places, mostly however as excavated from wells. The depression along the line of the Tonnewanta creek, which is near the northern margin of this formation, prevents any exposure of the rock. Along the whole distance to the Niagara river, the surface is deeply covered by drift, and it is only in a few points or from artificial excavations that the mass becomes visible.

2. The prevailing features of the *second* division of this group are a green and ashen marl, with seams of fibrous gypsum, and red or transparent selenite, and often embracing nodules of compact gypsum. This occurs in the vicinity of Lyons, and at numerous points farther west. It crops out on the road some distance northeast of Newark, and at Lockville it has been excavated from the bed of the canal for the construction of the enlarged locks. Here it contains seams and small irregular masses of reddish lamellar gypsum. Its general character at this place is a greenish grey compact argillaceous marl, which crumbles rapidly on exposure, and forms a tenaceous greenish clay. Near Newark the mass is variegated with red, and red spotted with green, and some portions are of a light ashen color. It is marked by the presence of reddish and transparent lamellar gypsum, and seams of fibrous gypsum. The same occurs farther west, and is seen in the banks of the canal near Palmyra.

Thence to the Genesee river it is scarcely seen upon the surface, but has been found in digging wells.

Westward, we find the same rock in Bergen, Byron, Elba and Alabama, in Genesee county. About one mile north of Bergen Centre the greenish gypseous marls are excavated along the line of the railroad. In digging wells in the same neighborhood, these marls with fibrous gypsum and selenite are usually encountered, and it generally requires that they be penetrated to a considerable depth before a permanent supply of water can be obtained. This character is the prevailing one through the counties of Monroe and Genesee.

There are few points where a natural exposure of these rocks can be obtained, and it is principally from artificial excavations that we have any knowledge of their character.

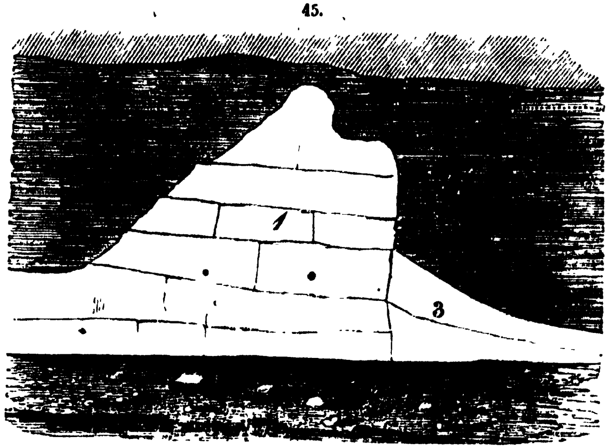
Throughout its whole extent in Erie county, there is scarcely a natural exposure of the rock, and the depth of the drift is so great that it is only in a few points that excavations have been made to any considerable depth below it.

3. The *third deposit* embraces all the gypsum beds of the district which are of economical importance. Although this mineral occurs in the deposit below this, as before stated, in seams and small nodules, yet it has never been discovered in quantities of any importance, and there is no probability that much will be found. The greater part of this division consists of grey or ash-colored marls and shales, with thin bedded shaly limestones, which are usually of the same color, though sometimes much darker.

Owing to the deep denudation in the direction of Seneca and Cayuga lakes northward, the whole group has been removed to so great a depth as to offer no evidence of its existence. Along the line of the Erie canal, the middle division appears a short distance before reaching Clyde. The third division, with the higher range of plaster beds, appears at Seneca falls, and along the outlet of the lake for three miles eastward. Extensive beds of gypsum are here exposed in both banks of the gorge, the largest on the north side. The surrounding mass is a light ashen friable marl, with a few thin strata of impure limestone towards the top. Where exposed alone, it has the character of a loamy clay, containing some carbonate of lime; and in the vicinity of the masses of gypsum, contains some of that mineral disseminated through it. The enclosed masses of gypsum are somewhat conical, though often irregular from the encroachment of the enclosing rock. The marl and gypsum are both stratified, the lines of division in the former often extending through the latter. There is usually a considerable admixture of earthy matter in the gypsum, and it appears as if segregated from the mass during its consolidation, by a well known law of attraction among particles of the same kind.

The following woodcut is an illustration of the largest mass seen along the outlet below Seneca Falls village, and gives the usual appearance of the beds of the upper division, as exhibited in the Fourth District:

45.

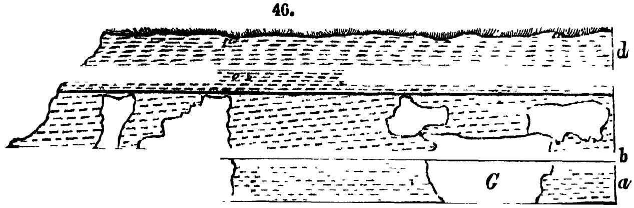


1. Compact granular gypsum, with lines of stratification.
2. Soft decomposing gypseous marl.
3. A lateral extension of the bed, with a greater admixture of argillaceous matter.

Along the outlet of Canandaigua lake, in the town of Phelps, we find a good exposure of the higher range of plaster beds. The general appearance, and the character of the succeeding masses, are like the same at Seneca Falls. The marls are mostly ash colored, with a few strata of more siliceous character which are bluish. The only beds explored are those appearing in the banks of the outlet, though it is known to exist farther north. On the south side of the outlet, there are several beds worked near the stream. The higher groups of the Water-lime and the succeeding limestones limit the extent of this deposit within a distance of half a mile to a mile south of the outlet. Few beds have been opened west of this town along the outlet, though several are exposed. The principal beds in this neighborhood, are those of Mr. Hildreth, on the south side; Norton & Co., Vandemark & Co., Cook, Robinson and Vanderhoff, on the north side.

Some of these quarries present interesting features not noticed elsewhere. The following illustration is of Norton & Co.'s quarry, and Vandemark's presents nearly the same appearance.

46.



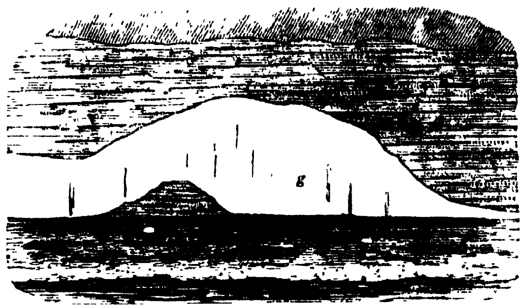
G. Beds of Gypsum, as exposed in the face of the bank.

a, a. A thin stratum of tough silico-argillaceous limestone, extending through the plaster beds, and continuously through the adjoining rock.
b. Soft shale or marl, filling the spaces between the beds of gypsum.
c. Two feet of compact, and slaty limestone, the harder portions with irregular cavities.
d. Six feet soft greenish shale.

The continuation of the impure stratum of limestone through the beds of gypsum, renders this an interesting exposure. The beds are likewise divided in the same way by a layer of slaty limestone at the line represented as the base of this diagram, and below this the gypsum continues to the depth of seven feet. These occurrences prove the manner in which this mineral has been segregated from the surrounding rock. The softer portions of the marl readily gave way for the formation of these masses, which were more strongly attracted together; on the other hand, the shaly siliceous mass, which continues through the beds, seems to have possessed attractive force equally with the particles of gypsum, thus maintaining its position while the softer portions were displaced.

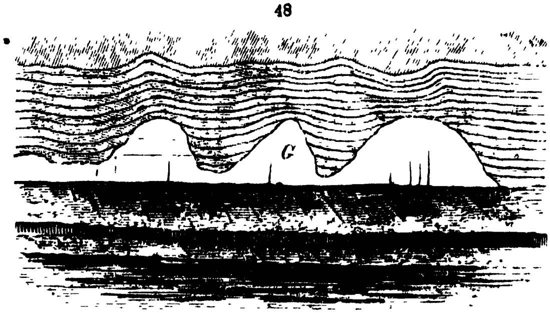
Almost all the gypsum effervesces with acids, showing the presence of carbonate of lime, and its dull earthy color is owing to admixture of argillaceous matter. The beds of gypsum are usually horizontal at the base, resting on the same kind of marly deposit as that above. In a few instances, the base is irregular or undulating, resting on an uneven bed. The illustration No. 47 presents an example of this kind, where the marl rises above, and the base is partially enclosed in the gypsum.

47.



The strata are slightly undulated, always rising gently towards the mass and descending from it. This is doubtless caused by the nature of the two substances and their comparative power of resisting atmospheric and other agencies. The gypsum is compact and little affected by air or moisture, while the numerous seams of the surrounding marly and shaly mass freely admit water, which, from the soft and yielding nature of the rock, gradually removes portions which are carried off in the outlet of the springs and streams, thus diminishing the quantity, and causing a slight sinking down between the beds. The illustration No. 48 exhibits the usual appearance of the strata in these situations.

48



The enclosed bed of gypsum exhibits a more continuous character than usual, presenting three conical or dome-shaped elevations, separated by the nearly horizontally stratified marl.

The lower range of beds, as seen in Monroe county, are nowhere known in this part of the country. At Seneca falls the soft marls are succeeded above by some harder layers of impure limestone, with irregular cavities which are lined with calcareous matter, in mammillary forms, evidently a recent deposition from solution. Connected with these strata, and just below, are some small masses of dark colored, crystallized gypsum, in stellated forms. These porous layers are succeeded by a darker and more pure, compact, brittle, limestone, which is the highest rock visible at this place. This would appear to be the terminal deposit of the group, but it is not marked by the striated or columnar appearances usually seen, and the irregular cavities which are sometimes lined with crystalline substances.

South and southwest of Newark, in Wayne county, the limestone separating the two ranges of plaster beds is seen on the surface in several places, presenting an appearance as if cut or hacked. These markings extend but a few inches continuously, and have two directions, frequently crossing each other, and evidently partake of the nature of joints, the rock breaking in these directions much more easily than elsewhere. This character is prevalent in that portion of the group throughout the district.

At the locality just named gypsum, in small rounded masses, is found at some depth below the surface, but it is nowhere quarried in this neighborhood. The surface presents, in a small degree, what is more fully developed in Monroe county, being covered with small mounds or dome-shaped elevations, caused by the sinking down of the strata between the beds of gypsum.

The rock surrounding the higher range of beds is usually more argillaceous than in the lower, the latter being frequently a compact, slaty limestone, enclosing a small quantity of soft marl immediately surrounding the mass of gypsum. It is probably owing to this character of the rock that the lower gypsum beds are purer and more free from admixture of argillaceous matter than those above.

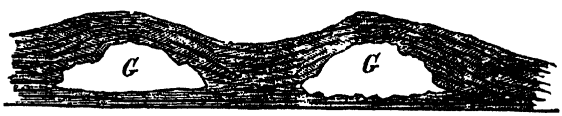
In the Annual Report of 1839, it was stated that the gypsum (principally crystalline) near Newark, the beds near Port-Gibson, and south of that point, and those on the Canandaigua outlet belonged to three distinct ranges. There still seems good reason for treating them in the same manner, the two upper ones belonging to the two regular ranges of beds, and that near Newark being perhaps only a greater development of the second division of the group which usually presents only thin seams or small nodules of this mineral.

Westward, along the Canandaigua outlet, there is little gypsum seen after leaving the town of Phelps; though the rocks of the higher part of the group are still visible, even as far as the point where the course of the outlet bends southward. West of this point, as far as Mud creek, the great accumulation of drift does not admit any exposure of these deposits. That they exist along this distance there can be no reasonable doubt; and more especially since a bed of gypsum has been discovered near the village of Victor. This fact also leads to another observation, which should be borne in mind as applicable to a large portion of the country occupied by this formation east of the Genesee, and within the limits of the Fourth District. Many of the hills apparently of drift or alluvial, and rising from fifty to one hundred feet above the surrounding country, are in reality composed of outliers of these marly deposits, with only a thin covering of the loose materials.

The same remarks made in reference to the western part of Ontario county, apply equally to that portion of Monroe county on the east side of the Genesee. Although the gypsum beds have not been found, there is every reason to believe that they exist beneath the superficial accumulations.

On the west side of the Genesee river, the third division of this group, embracing the two ranges of plaster beds, occurs on Allen's creek at Garbutt's mills. The upper part of the section on page 119 is constructed from this locality. The lowest range of beds is best developed on the north side of the creek, where the rocks are covered with only a small depth of soil. The surface is raised into small rounded hillocks of a generally uniform height, and with depressions communicating over a considerable space, giving the appearance as of little mounds of earth. After removing the soil to a small depth, the rock appears, presenting the same convex or rounded contour as the surface above. The strata are usually thin, and present an appearance as if broken up by some elevating force from beneath. Below the rock lies a spherical mass of gypsum, upon every side of which the strata dip till they assume their original horizontal position. The proximity of these masses however is often so close that the strata continue undulating, being depressed between and elevated above the beds of gypsum. The woodcut below represents a section of two beds of gypsum at this place.

49.



The elevation and breaking up of the strata was doubtless caused in part by the expansion of the gypsum during solidification, (it being more or less crystalline,) while the strata above were partially indurated. In the lower beds, where the surrounding mass of rock is principally a soft marl or shale, no such evidence is perceived, except perhaps in a slight degree. (See woodcut, page 123.) In this case the surrounding mass was probably in a yielding condition at the time of the solidification of the gypsum, and consequently the particles of the one gave place to the other, presenting no evidence of force. This is further proved by the continuation of a semi-crystalline silìceous stratum through a bed of gypsum, while the marls above and below, though doubtless originally equally continuous, have been displaced to give room to the gypsum, which with a stronger tendency to concentration, has accumulated into flattened spheroidal or low conical masses. Wherever the carbonate of lime was in such proportion as to induce a tendency to crystallization, the strata appear to have become in some degree consolidated before the gypsum; on the other hand, where the proportion of argillaceous greatly predominated over the calcareous matter, the tendency to crystallization was lessened or entirely prevented, and the gypsum consolidated before the surrounding mass. The same operations appear to have gone on here, as we often perceive in artificial compounds, where the tendency to crystallization is much stronger in one body than in another.

These beds of gypsum are usually from four to eight feet below the surface; few being worked at the latter depth, the expense being too great. There is sometimes an appearance of a third range of beds, but this is not continuous. The rock above is so much broken as freely to admit the surface water, and thus broad fissures are often worn in the softer marls; and sometimes even in the mass of gypsum.

The dome-shaped elevations are said by the inhabitants not to appear till after the settlement and clearing of the country, and it is a general opinion that the gypsum continues to form at the present time. It is even asserted that stone walls have been overturned, and the foundations of buildings elevated by this process. Since the rocks must have become consolidated, and the gypsum formed, long anterior to the settlement of the country, as is evident from its appearance in the banks of streams, which excavated their channels long before the present vegetation flourished, these apparent phenomena must meet some other explanation. In the natural state of the country, the great accumulation of vegetable matter would prevent the prominent appearance of these little mounds, even if they existed. Since, however, we know that the surface water is rapidly drained off in these depressions, readily finding its way between the strata and through the fissures, it carries with it a small quantity of the soil, which is repeated at every successive rain. As a natural consequence, the original inequalities of the surface of the strata are gradually developed, and in some places the more elevated parts become denuded of the soil which covered them.

Beyond this point, there is a considerable space in the western part of Monroe county, where no beds of gypsum are known.

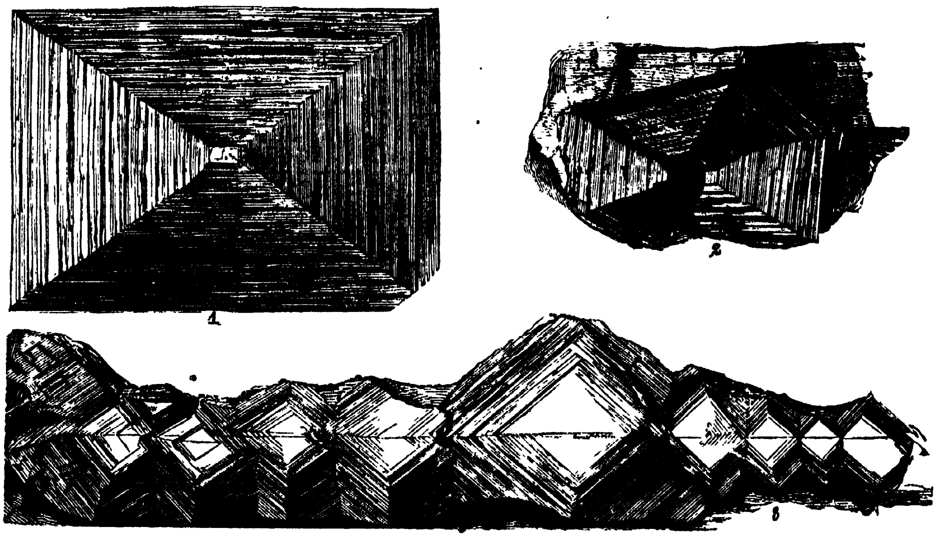
In the north part of the towns of Leroy and Stafford in Genesee county, the lower range of beds appear, and are extensively worked at a few places. There is no evidence of the higher range of beds through these towns, or at any point farther west, and it seems probable that they have discontinued. In this county, the second range appear to be as well developed as elsewhere in the district. These beds are overlaid by the porous rock, which is so strongly marked in the Third District; here, however, the pores are rarely larger than a pin's head, and usually compressed. This character is well developed at several beds, though not so obvious in all. The quality of the gypsum varies very much, the most easterly beds being very impure, and if not protected from the weather, will soon crumble down. Farther west the gypsum is more pure, and in some of the beds entirely free of foreign admixture, furnishing a good material for hard-finished walls. The same appearance of the surface is presented as in Monroe county, and it is sought for as an indication of the existence of the gypsum. The masses are all more or less spherical, and the strata above are elevated and broken as before described.

Throughout the whole width of Erie county, this formation is covered to so great a depth with drift or alluvion, that there are only one or two places known where the rocks of the lower divisions are seen. The principal point is on the farm of Mr. Martin, in the north part of the town of Clarence. The rock is that portion coming between the two ranges of plaster beds; it consists of several thin strata of limestone, with cavities of the size of flax seeds, several often communicating, forming linear ones. A few incipient hopper-shaped cavities were observed, but their forms were quite indistinct. Some portion of the rock here exposed exhibits a tendency to a concretionary or contorted structure, presenting abrupt curvatures of the laminæ, which could only have resulted after deposition. The surface of the strata presents the appearance before referred to, as if hacked with an axe, being the result of a weathering of the joints upon the surface.

The porous rock indicating a position between the two ranges of plaster beds, occurs on Grand island; and at a low stage of the river, fine specimens may be obtained. The group extends beyond the Niagara, and appears on the Grand river in Canada.

In several places in Wayne and Monroe counties, imperfect hopper-form crystals and cavities appear in this portion of the group, but I have rarely observed them in Genesee or Erie counties. The most perfect which I have seen, are at Garbutt's mill on Allen's creek. These are, however, far from being as perfect as those of the Third District, figured in the report of Mr. Vanuxem, from which the following illustration is taken.

50.



*Hopper-shaped crystals from the marl of the Onondaga salt group, town of Lenox, Madison county.**

The frequent occurrence of these forms in that portion of the group where the brine springs exist, and their disappearance in a westerly direction, is in accordance with the views entertained regarding their production. If the salines are dependant for their supply from the solution of salt once filling these cavities, it appears futile to expect important brine springs in situations where these do not occur in the strata. This might therefore furnish a guide to the proximity of salt water; but since the formation is often deeply covered with drift, the springs are usually more obvious than the hopper cavities.

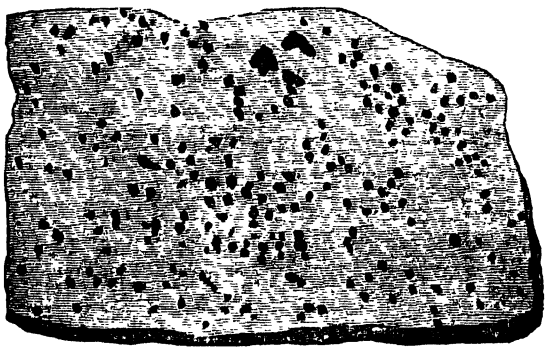
The small round or flattened pores before alluded to, usually occur in a layer above the lower range of plaster beds, but I have occasionally seen some of them in a higher situation.

* Report of Third Geological District, p. 102.

This rock holds the place of the porous or vermicular limestone of the Third District, which in many places closely resembles a vesicular lava. In the Fourth District these pores are rarely larger than flax seeds, though sometimes several of them communicate with each other, and not unfrequently they are filled with gypsum.

The following illustration is from a specimen where the weathering has slightly enlarged the cavities, and presents the common appearance of the larger pores. From this size, they diminish till they become microscopic.

51.



Porous limestone of Onondaga salt group.

In addition to the kind of cavities just described, we often meet with small linear ones, which, in some parts of the shaly and marly limestones, are abundant. These are probably produced, as in the Water-lime group, by the removal of crystals. For an illustration of these forms, see the description of the Water-lime group in the following pages.

Fourth or Upper Deposit of the Group.

There is rarely any well defined line of demarcation between the shales and shaly limestones of the last deposit, and this division. Still, however, it is often of considerable thickness, and as a whole quite different from the rocks below. It is called by Mr. Vanuxem the *Magnesian deposit,* from the striated or columnar surfaces like those described under the Niagara group, page 95. These form a distinguishing feature, which does not appear in the lower rocks of the group.

This division consists usually of thin-bedded impure limestones, drab or ash-colored, and sometimes presenting a bluish tint on first exposure. The composition is that of a silico-argillaceous limestone, and is the rock from which nearly all the hydraulic cement in the district is obtained. From this circumstance, it has been distinguished as the *Water lime,* or *Hydraulic limestone,* in the Annual Reports of the district. Finding, however, that the rock distinguished as the Water-lime group in the Third District was a superior mass, and which in the Fourth District contains no rock fit for hydraulic cement, the one in question is referred to the Onondaga salt group, of which it forms the terminal division.

From being more enduring than the lower divisions of the group, it is more obvious, and can be traced almost uninterruptedly through the district. In Seneca county, it does not appear in its usual characters; the highest rock of the group being a fine-grained, dark-colored, and greyish brown mass, which apparently represents the lower part of this division. Between this and the succeeding limestone, there is an interval which is probably occupied by this mass, but too deeply covered to be visible. It appears on the east side of Cayuga lake, coming down to the lake shore.

Passing into Ontario county, we find this division much better developed, and possessing its characteristic drab color. The mass may be traced almost uninterruptedly from near Oakes' Corners in Phelps, to Manchester village. East of Vienna, all the strata of this division are highly calcareous, and burned only for common quicklime. The principal quarries and kilns are within one and a half miles of the village. It is also used for buildings and enclosures, the layers being sufficiently thick. On exposure, it becomes stained with iron, and in almost every locality is highly bituminous.

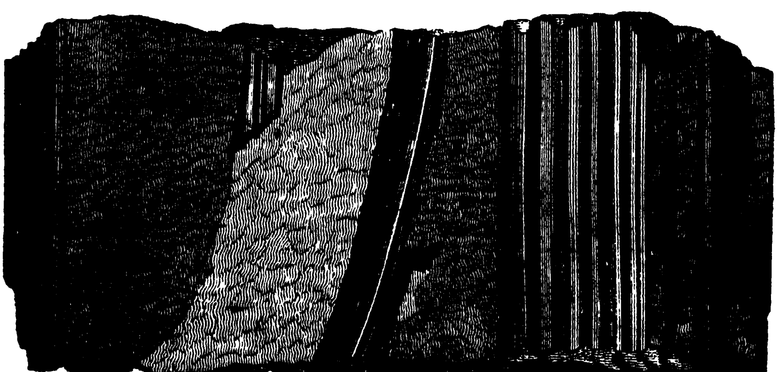
At East-Vienna, this rock is burned for hydraulic cement, of which it is said to produce a very good quality. Two miles farther west, at the quarry of Mr. Maffit, large quantities have been used for this purpose. At this place the stone varies little, in external characters, from that burned for lime. It consists of three distinct varieties: two only are used for the cement, while the lower course is composed of thin layers of tough, argillaceous, bluish limestone, which on exposure, breaks into small irregular fragments. This portion, on burning, melts into a coarse porous slag, externally glazed and yellowish; and in mineral characters, it is precisely the same as the strata which pass through the gypsum beds on the north side of the Canandaigua outlet. The second stratum consists of thin courses, externally drab-colored, siliceous in texture, and harsh to the touch. This is succeeded by a few layers of unequal thickness, lighter in color than those below, and much more calcareous. Of the two last mentioned varieties, each at intervals partly takes the place of the other, so that the thickness is variable, and the dividing line has an undulating direction. The depth of the two masses together is from three to seven feet. If the lower of these is burned alone, the cement will not "set" under water; and the upper burned alone is found to be too calcareous, and less enduring than the more siliceous cements. To obviate the difficulty, both are burned together, but without due regard to proportions. From the nature of the materials, it is evident that the proportions of siliceous and calcareous matter must be very variable; and too little attention has heretofore been given to this circumstance, and to the nature of the ingredients, in the manufacture of hydraulic cement.

West of the last named quarries, the water-lime appears in numerous localities south of the outlet, and near the road leading from Vienna to Manchester; but here it is used mostly for enclosures, and at Manchester village for building stone, some of the layers being two or three feet thick. It is too soft and argillaceous for hydraulic cement or good lime.

Above the village of Fredon this rock is seen in all its varieties for half a mile on Mud creek; and along the line from Manchester to that village it approaches the surface and could easily be obtained in any required quantity. Thence it extends west to the quarries in Mendon, though the surface of the intervening distance is mostly covered with deep alluvium.

At Mendon the strata of this division are exposed in the bed of the stream below the falls. There is also a quarry a few rods below the village, where the stone is wrought for buildings, step-stones, and other purposes. At Tinker's, near the west line of the town, this rock crops out on the side of a hill, and it has been extensively quarried. This point offers a good exposure of the rock; the strata are from half an inch to eighteen inches thick, generally from four to eight. The higher layers for about five feet are thin and argillaceous, of a light grey color. Eight feet below the surface is a bed which is very soft and porous, crumbling rapidly on exposure to the air. The greatest depth penetrated is twenty-five feet; the lower layers are the hardest, some of them having parallel seams of siliceous matter like agate, extending through them; and all of them are more or less of this character.

The vertical striated surfaces, supposed to be caused by the crystallization of sulphate of magnesia, (the lignilites of Prof. Eaton,*) occur both in this quarry and at the village of West-Mendon. These vary from a scarcely perceptible seam or suture in the rock to a columnar mass several inches in length. In some instances these columns are curved as if the action whatever it may have been, operated more powerfully on one side than the other. The following woodcut illustrates an example of this kind, where a single fascicle is curved, while the others in the same specimen are straight.



Lignilites or Epsomites, Mendon, Monroe county.

These striated surfaces in this part of the salt group differ from those in the Niagara lime-

* Canal Rocks, page 134.

stone, in being more smooth, and I have never seen the interstices filled with calcareous matter. They are usually invested with a carbonaceous film, and present a black shining surface.

The mode of formation in these bodies is supposed first to have been the crystallization of sulphate of magnesia in the fibrous form, shooting up in the same manner as water suddenly congealed in a porous or spongy soil.* Common salt will also produce the same appearance where the ground is saturated with it; and it would appear also that gypsum will take the same forms, and present many of the same phenomena of these lignilites.†

No. 53.

Vertical suture in argillaceous limestone, Mendon, N. Y.

The suture-like seams before spoken of usually occur as horizontal lines of division, the striated surfaces vertical. In the quarries at Mendon I observed some of these sutures in a vertical position, and the striated surfaces parallel to the place of stratification. The illustration represents the usual appearance of these seams when on a small scale. These sutures sometimes separate, presenting a surface covered with toothlike projections.

They will be readily recognized by any one after seeing these illustrations, and since they are known to be widely diffused and occurring in greater or less perfection in nearly all the calcareous strata of the system, and even in the higher rocks, they have become subjects of interest. The great limestone formation of the west, holding the place of the carboniferous of Europe, and apparently identical with that rock, is marked by similar sutured divisions, and small columns like wooden pins driven into the rock.

After leaving Mendon, this rock is not seen on the east side of the Genesee river; the first point west of the river where it appears is on the "Street farm," belonging to Mr. Wadsworth of Geneseo. The lower part is composed of thinly laminated strata; the laminæ often lighter and darker in color, giving to the mass a striped appearance, which is very common at many other places, and is one of those characters which serve to distinguish the rock at distant points. The upper part is thick bedded, of an ashen color, and contains irregular cavities sometimes filled with greenish clay; at others containing celestine, calcareous spar, and zinc blende. The more compact portions of the rock have been quarried and used for structures on the Genesee Valley canal. The following is the character of the strata as they appear at this place; there is no connexion with any other rock visible either above or below.

* See Report of Third District, page 107.

† See an article in the American Journal of Science and Arts for Jan. 1842, by Dr. Locke, on some beautiful forms of gypsum discovered in the mammoth cave in Kentucky.

1. Irregular mass, much broken up by the denuding agency	3	feet.
2. Light drab or ash-colored limestone with irregular cavities	4	"
3. Thick bed like No. 2, with cavities containing celestine, etc., slightly striped below	4½	"
4. Consists of two strata, which are ash-colored and striped with darker; brittle after exposure; siliceous	5	"
5. Thin-bedded, bluish, and striped with lighter colored; bed of quarry	4	"

About three miles farther west, at Caledonia village, the terminal strata are thin-bedded and of a light drab color, and more argillaceous than in many other localities. The rock also appears on the farm of Donald McKenzie, one mile north of Caledonia village, and at numerous places along the brow of the terrace west of Mumford's mills. In some places the rock is porous, or contains irregular cavities; in other places, it is compact and regularly bedded.

At Leroy falls, the whole thickness of this rock is exhibited, together with its connexion with those below and above. The upper part is thin-bedded, in regular strata; the middle consists of several thick strata; the whole of a light drab color.

At Morganville in Genesee county, nearly the same order of the strata occurs; the thick beds are more siliceous than at Leroy falls, and they contain some irregular cavities. The connexion of this group with the higher masses is well exhibited in the bed of the stream at this place, while the fall is over the thick-bedded portions of the deposit under consideration.

By making examinations along the northern slope of the terrace which extends westward from the Genesee, this rock may be seen in nearly every ravine or gorge which indents the regular outline. It appears beneath the cherty layers of the corniferous limestone, two miles north of Batavia. The thick-bedded portions form the falls of the Tonawanda on the Indian reservation. At Falkirk in Erie county, this mass, capped by the corniferous layers, has formed a fall and rapids of seventy or eighty feet. It again appears at Clarence Hollow, in a few thin-bedded strata, with cavities lined with spar; and again at Williamsville, in thin regular strata, which are burned for hydraulic cement.

Three miles east of Buffalo, the same strata appear in the bed and banks of Conjockety creek. The upper beds contain cavities filled with rhombic spar and sulphate of strontian. Many of the smaller cavities which abound in the higher layer, are produced by the destruction of a species of *Turbinolopsis*, casts of which sometimes remain studded with minute crystals.

At Black-Rock the higher strata of this deposit appear, having the same character as just described. The *Turbinolopsis* was abundant at this place, and its casts remain partially filling the small cavities.

This rock is the product of a period intervening between the deposition of the great mass of the salt group, which is mostly a mud deposit, and the commencement of the limestone formations above. The character, therefore, partakes of the nature of both, being an argillaceous limestone, with a small admixture of siliceous matter which probably resulted from an intermingling of the materials which gave rise to the Oriskany sandstone, or a thin deposit which seems to be its representative, and every where follows this rock in the Fourth District. The ocean, which had been rendered turbid by the immense deposit of mud forming this group, became gradually more clear, the supply ceasing, and at the same time the calcareous matter was furnished from another source, at first mingling with this, and finally giving rise to an entire distinct formation, contrasting in the strongest degree both in lithological characters and in the production of an immense number of organic forms.

While the deposit we have last considered forms a link, showing the gradual progress from one to the other of these groups, the passage from the Niagara group to the Onondaga salt group is abrupt, offering no gradation in character of products or in the continuation of fossil species. So far as we know at present, throughout the whole western part of the State, no trilobite and but two shells of the Niagara group reappear in any higher rock. The intervention of the salt group seems to have exterminated them, and though limestones succeeded, yet the same forms did not reappear, notwithstanding the circumstances appear to have been favorable to the existence of many similar ones.

From the sudden change in the nature of the deposit, and the great accumulation of mud, it would appear that the Niagara limestone, which, from its abundance of corals, must have been formed in a comparatively shallow sea, sunk down to a great depth, allowing this accumulation above, of one thousand feet in thickness. Such a change, with the immediate repetition of a similar rock, could scarcely have happened, without some violent influence like the breaking out of a mud volcano at the bottom of the ocean, by which this product was spread rapidly and widely over its bed. The elevation of one point, attendant on such an eruption, would naturally be accompanied by a corresponding depression of another, and this portion is probably that upon which we have been making our investigations. This deposit, forming the greater part of the salt group, is moreover unlike any other formation in the State, except the marly portion of the Medina sandstone. The presence of large quantities of common salt, sulphate of lime, and even free sulphuric acid, indicates an origin different from the geological deposits forming the greater portion of the groups of the New-York System. The rarity of fossils is another circumstance indicative of a different condition from that attending the other groups. The great amount of finely levigated mud might, however, have rendered the ocean too turbid for their existence; and it is very evident that in an ocean where free sulphuric acid existed, organic forms would soon be destroyed; and though other circumstances were favorable, this alone would prevent their existence.

Shrinkage cracks.—These phenomena, which were illustrated under Medina sandstone, appear in the upper division of this group. The more argillaceous strata at West-Mendon, where the surfaces are exposed, present all the appearance of the clayey bed of a shallow pond which has been dried by the sun, the whole surface being divided into irregular polygonal figures. The cracks are filled with the succeeding deposition, which differs a little in character, and the lower one having previously become partially indurated, very clearly marks the cause. These appearances are less abundant in this district than farther east. The same strata at Schoharie, and in the Helderberg, are strongly marked by these shrinkage cracks, which, in the slabs used for flagging stones, are as clearly defined as in a recent clay bed.

Minerals. — The principal mineral of this group in the Fourth District, is gypsum, of which many thousand tons are annually used. Sulphate of strontian, the sulphurets of zinc and lead, or galena and blende, with rhomb spar, occur in the higher division of the group. The gypsum is the only one of importance, all the others occurring merely in small specimens fit for the cabinet.

Sulphuric acid. — This substance, which is usually regarded as a volcanic product, occurs in this formation in numerous localities. The most productive, and the best known, is the "Acid Spring," in the southwest corner of Byron in Genesee county. This place was examined many years since by Prof. Eaton, and his account corresponds with its present condition. The place presents a low blackened mound of vegetable earth, charred by the acid, and entirely destitute of vegetation. At the time of my examination, there was no water flowing from it, though the soil a few inches below the surface is quite damp. The surface is composed of vegetable matter intensely sour to the taste; this is underlaid by a clay or sandy clay, also intensely sour. It presents this character for the distance of several rods around, and during the driest part of the season, is always moist. Several large stumps of trees stand upon this mound, the roots of which, and perhaps the trunks themselves, have furnished the vegetable matter. I was informed, that in the early settlement of the country, a copious spring of intensely sour water issued from the top of the mound; that in digging about it for the purpose of making it deeper, the whole was lost, and since that time it has only flowed in the spring of the year. The water is considered a specific in many diseases, and is carefully preserved, and even carried many miles to be used as medicine.*

Several wells in the town of Bergen yield a slightly acidulated water, particularly in the dry season of the year. One of these, belonging to Mr. Gifford, and which was mentioned in the Annual Report of 1840, contains so much acid as to coagulate milk, and is unfit for culinary purposes. Several other similar instances occur in this part of the county, where wells are rendered useless by the presence of this acid. I was also informed of two other springs of the same kind, which I did not visit. One of these, Dr. Beck has examined, and finds the water a dilute sulphuric acid, and the earth of the Byron spring yields scarcely any other product.

Brine Springs, or *Salines.* — This formation, as before remarked, is the one which gives origin to all the productive salines of the State. Thus far no valuable ones have been found west of Cayuga lake, though borings have been made at different points. As was remarked in a previous page, the hopper cavities are not found in any degree of perfection in the Fourth District, though they are of frequent occurrence in imperfect forms; and if their perfection or abundance be relied on as the indication of strength or quantity of brine, it may be inferred that the springs of Onondaga are superior to any that will be found to the west of this point. From what is already known, it is not impossible that in some favorable situation, springs may be found which will repay the labor and expense of working. Still, while the brine of

* Annual Report of 1840.

Onondaga county continues so copious, and of a quality so superior, there is little probability of any thing being found of equal value in the Fourth District.

The origin of these brine springs has been so fully discussed by Mr. Vanuxem and Dr. Beck, that it is quite unnecessary here, to enter into a detail of the numerous facts and their natural inference, which to a great degree are already before the public. The addition of new facts may hereafter place the subject in another aspect, and since there are now many arguments supported by facts, which apparently favor directly opposite hypothesis regarding the origin of the brine, it seems desirable that more information should be collected before the subject can be finally decided in the minds of all. The rocks of this group, particularly the lower portions, are far less accessible than farther east, consequently the means are less for ascertaining the nature and origin of these brines. It is quite evident, however, that the source, whatever it may be, is less prolific in a westerly direction from Cayuga county than in that county and Onondaga, which presents the greatest development of the group.

Were it not that the deep excavation at the outlet of Seneca and Cayuga lakes has removed the upper portions of the group, and at the same time affords a means of escape for the saline waters, we might expect to find brine springs of good strength in this place. The recent borings at Montezuma demonstrate the existence of strong brines at that point, and the occurrence of brine springs on the east and west margins of the marsh, where circumstances seem unfavorable, also offer facts favoring this view.

The Galen salt spring in the town of Savannah formerly yielded a sufficient supply of water for the manufacture of salt in the early settlement of the country, but the proportion of saline matter was only about nine per cent. This spring is directly on the western edge of the Cayuga marsh.

At Clyde, a deep boring was made for salt water, where no spring previously existed; small quantities of strong brine were obtained, but the work was abandoned after penetrating four hundred feet.* More recently a spring has been discovered a little east of the village, and a boring to some depth has been made; the water is sensibly salt to the taste, but it has not been analyzed, having only come to notice when the survey was nearly completed. Salt was formerly manufactured from a spring about two miles east of Lockville. These springs are all in this group, and indicate a common origin with those farther east.

In Monroe county I am not aware of any brine springs in this formation, though several are known in a lower rock. The only brine spring which I have seen in the Onondaga salt group west of Wayne county is in the town of Elba in Genesee county, on the land of John G. Satterlee. It is the most copious and strongly impregnated saline in the Fourth District. The fact of its origin being in rocks of the same formation as those of Salina and Montezuma, renders it the more interesting. When I saw this spring the water was flowing from one point in quantity about as much as a common pump would supply, and of a decidedly saline taste. The vegetation is destroyed for several rods around the place, and there are

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* See Report of Dr. Boyd, page 318, Annual Report of 1838.

indications of another spring coming into this from the west. In an adjoining field on the east there is another spring, and several more in the vicinity. All these however are inferior in strength to the first. The principal spring rises in a marsh, on the margin of which formerly were several wells, and from these salt was manufactured.

The rock is eighteen feet below the surface, and the portions brought up in excavation and boring are a grey marl, with nodules and seams of gypsum, being apparently the rock below the lowest range of plaster beds. Several years since, a well was dug as far as the rock, and a boring was made of fifty feet deeper. A wooden tube of two inches in diameter was then placed in the opening, and the water immediately rose in it several inches above the surrounding surface, and flowed over the edge, keeping the tube constantly filled. At this period, and for some time afterwards, a larger quantity of water flowed off than had risen in the well previously, and the vegetation for some distance was entirely destroyed; even small trees, for a quarter of a mile along the course of its outlet, were so much affected as to destroy the leaves.

The situation of this spring, the copious supply of water, and the numerous smaller ones around it, show a concentration of the saline matters which nowhere else appears in the Fourth District. The quantity of water is greater, as well as stronger; and it is very probable, from all the facts in the case, that it will eventually prove valuable as a saline for the salt manufacture. Since the supply of this article so essential to the wants of man, is one of interest to the State, and since the salines of New-York are superior to any others in the country, it is very desirable that a little attention be given to increasing and extending this source of State wealth.

Wells and Springs. — Along the southern borders of this formation, the water, which has accumulated in the fissures of the limestone above, finds its outlet in springs which are copious and abundant. This part of the formation is well watered; but in its middle and northern extension, however, this group produces few springs or running streams, and the wells, unless dug to great depth, fail in dry seasons. The strata are pervious to water, by the numerous seams and fissures, particularly that portion containing gypsum beds, and the division next below. Water is not readily obtained, unless by sinking to the level of the water courses of the surrounding country. This often requires great depth of boring or excavation, and from some of these we have derived much information of the character of the strata. Wide fissures, evidently water-worn, are often met with in the excavations; and these have probably resulted from the enlarging of the natural joints of the rock, by which the water first found access.

Agricultural characters of the Onondaga salt group.

The belt of country occupied by this group in the north part of Seneca, and in Wayne county, is mostly covered by a series of parallel hills and valleys. The hills consist of gravel or a mixture of gravel and sand, and sometimes are entirely arenaceous; while the valleys are of clay, with varying proportions of gravel and sand. Farther west this regularity ceases, though as a general characteristic the surface is one of low hills and valleys, the latter presenting a clayey soil, while the former consist of gravel or an admixture of clay and gravel. These hills of gravel are often composed of rounded pebbles, with a large proportion of half-worn fragments of the marls and shaly limestones of the Salt group; and where freshly exposed, these are constantly crumbling from atmospheric agency. In the western part of Genesee, and along the whole width of Erie county, the surface is more level, and the hills of gravel are less prominent; still, however, it has some features in common with the surface farther east. We find slight elevations of loamy or gravelly soil, covered with oaks; while the broad flat clayey bottoms support maple and beech, with some evergreens.

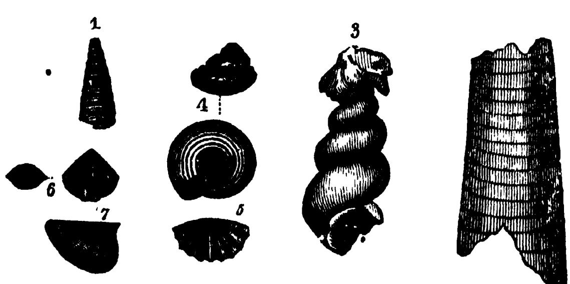
The prevalence of what are termed "Oak Openings," or tracts which are covered with oak trees rather thinly scattered, but fresh and thrifty; and in other places, tracts of the same timber in closer growth, with all the shrubs and smaller vegetation intermingled, indicates a fertile soil, and one capable of yielding good crops of grain. Neither is the fact at variance with the inference; for along this whole extent, there is rarely a better wheat-growing country to be found.

Organic Remains of the Onondaga Salt Group.

From the nature of this formation, being one of finely levigated mud, with a large proportion of saline ingredients, and even free acid, which is destructive to all organisms, and particularly to the testacea, it might be inferred that few of these forms would be found. If they have ever existed in any considerable numbers, they are no longer visible; but the stronger probability is that they have not existed at all, except in the few cases and the rare intervals which have been observed.

Nearly all the forms seen in this group in the Fourth District, are presented in the accompanying woodcut; the shells almost entirely removed, casts only remaining. Since the group is not identified by its fossils, these are chiefly interesting as presenting the continuation of vital energy from the last group upwards. The specimens figured were all collected by Dr. Boyd, in Wayne county.

54.



1. Cornulites.
2. Orthoceras lœve.
3. Loxonema Boydii.
4. Euomphalus sulcatus.
5. Delthyris.
6. Atrypa.
7. Avicula triquetra.

1. *Cornulites*, n. s.—This species differs from the one in the Niagara group, in being much smaller, quite straight, and the upper edges of the rings thinner. The upper edges of the rings are not horizontal, but depressed on one side uniformly, producing a sort of seam or suture.

Locality—Near Newark, Wayne county.

2. *Orthoceras læve*, n. s.—Smooth; annulations numerous; very gradually tapering; siphuncle central.

This is the only known Orthoceras of the group, and differs from any in this part of the system, in its smooth shell, gradually tapering form, and numerous septæ.

Locality—Newark, Wayne county.

3. *Loxonema Boydii*, n. s.—Very gradually tapering; last whorl somewhat ventricose, slightly umbilicated; mouth imperfect. The marks of the arched or undulating striæ, so characteristic of the genus, are impressed upon the cast in a few places, and a little of the shell is preserved. The summit of the spire is concealed in the matrix, and from its fragile nature, it is impossible to remove it.

This shell is named in honor to the memory of Dr. G. W. Boyd, who was zealously engaged in the New-York Survey during the first two years after its commencement; and afterwards, until his death, in the Geological Survey of Virginia.

Locality—Near Newark, Wayne county.

4. *Euomphalus sulcatus*, n. s.—Shell rapidly tapering; whorls about four, last one much expanded; surface marked by spiral furrows and elevated lines of equal width, which continue into the umbilicus; aperture circular; umbilicus large.

The figures are from two different shells, the lower one representing the base being much the larger. The lines and furrows of equal size readily distinguish this shell from any other in this part of the system. It resembles the *E. sculptus*, (*Silurian Researches*, p. 626, pl. 12, f. 17,) in many respects, but is a smaller shell, and has four whorls.

Locality—Newark, Wayne county—abundant.

5. *Delthyris* —— ?—This species is about the size of *D. decemplicata* of the Niagara group, and since only casts have been seen it is left for further investigation.

6. *Atrypa* —— ?—This species is apparently identical with a form abundant in the Niagara shale, but which has not yet been identified or named. It is interesting as showing one form of that group which continued beyond the middle period of the salt group.

Locality—Newark, Wayne county.

7. *Avicula triquetra*, n. s.—Shell obliquely subovate or cuneate; marked with concentric striæ; posterior wing large, abruptly acute; anterior wing very small.

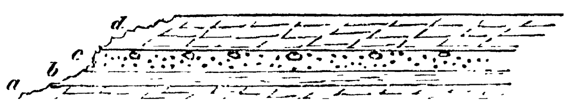
Locality—Near Newark, Wayne county. The same apparently, appears in Genesee county in the shaly limestone above the plaster beds..

In addition to the fossils here enumerated, the *Eurypterus lacustris* of Harlan is said to occur at Williamsville in Erie county. I have not been so fortunate as to meet with it, though some fragments of a crustacean have been obtained from that locality.

Localities of superposition among the rocks of the Onondaga Salt Group, and the next succeeding rocks.

All the sections here presented and other similar ones are constructed from a careful examination of the rocks, and none are given except where the actual junction of the two groups is visible. In some instances much time has been spent in searching for the precise point of contact, in order to ascertain whether the change from one rock to another was abrupt, or whether it was by gradual intermixture of the superincumbent mass. The object in presenting them is to direct those who are examining these rocks to points where the contact of two groups can be seen—always a point of interest to the geologist, for there he finds the termination of a condition of things which gave origin to peculiar forms of animal existence, but few of which were continued beyond.

55.

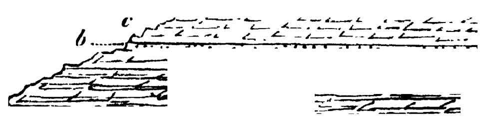


Section at Vienna, Ontario county.

d. Onondaga limestone.
c. Oriskany sandstone, with concretions, four feet.
b. Some thin dark layers of impure limestone, representing the Water-lime group—two feet.
a. Terminal mass of the salt group—used for hydraulic cement.

Nearly the same order among the strata is to be seen a few miles west of this point. The next section shows the order at Tinker's quarry in West-Mendon, Monroe county.

56.



c. Onondaga limestone, containing numerous coralline fossils, and embracing nodules of chert.
b. Coarse greenish sandstone or conglomerate, representing the Oriskany sandstone—four inches.
a. Upper part of Onondaga salt group, exhibiting about twenty-five feet in thin courses of a light ashen color, and entirely destitute of fossils.

Section at Morganville, Genesee county.

1. Onondaga limestone, with fossils; in several courses,	3 feet.
2. Oriskany sandstone, very distinct,	4 in.
3. Hydraulic limestone in thin courses,	4 feet.
4. Hydraulic limestone in thick strata—one being 6 to 8 feet thick—siliceous in character, and embracing numerous irregular cavities,	22 "
5. Hydraulic limestone in thin grey layers, with seams of blue marl,	12 "
6. Bluish marl, crumbling into irregular, angular fragments,	5 "
7. Grey and greenish marl, with some portions very compact, 10 or 12 feet of the lower part filled with small cavities or pores like those in the rock covering the gypsum,	19 "

This section not only presents the contact of the two groups, but exhibits the gradual changes in the upper part of the salt group where it passes from its usual marly and shaly character to the impure limestone which terminates the whole.

At Black-Rock, the junction of the two groups is plainly visible, the salt group terminating with a drab limestone containing numerous irregular cavities, and succeeded by the Onondaga limestone, there being no representative of the Oriskany sandstone.

About three miles east of Black-Rock there is a quarry where the junction of the two groups is plainly visible. The limestone below the Onondaga is channelled or grooved into trenches of six or eight inches deep, and as much in diameter, in which the latter appears to have been deposited.

In the eastern part of the State there are several formations succeeding the Onondaga salt group, which at the west are only meagrely developed, or are entirely wanting. Some of these have apparently existed, and were swept off by denudation previous to the deposition of the higher masses. Others have probably never extended far westward, one or two of them scarcely appearing beyond Schoharie county, where those limestones forming the Helderberg division are better developed than elsewhere in the State.

These rocks and groups will be enumerated in their proper order.

13. WATER-LIME GROUP.

Water-lime Group of Manlius (Annual Reports). *Water-lime rock?* EATON. *Tentaculite limestone.*

(PART OF No. 6, PENNSYLVANIA SURVEY.)

The only locality in the Fourth District where the rocks of this group are known to contain their characteristic fossils, is in the town of Phelps, Ontario county. Near Vienna village, and at Maffit's quarry, about two miles northeast of this point, are some thin layers which succeed the rock usually burned as water-lime, and which is the upper part of the salt group, as before stated. These layers contain the fossils typical of the group. It is understood that in the Third District these fossiliferous layers embrace the rock burned for hydraulic cement, whence the name of the group.

In Schoharie county, where these fossiliferous layers are well developed, they embrace no hydraulic limestone, and the salt group lies immediately beneath them, the more compact portion of which is known as the water-lime.

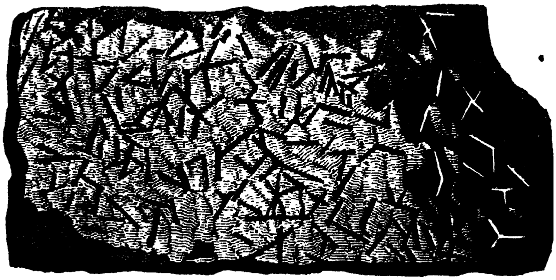
In the Annual Reports of the Fourth District the term water-lime has been applied to the terminal mass of the last group, as being that rock from which hydraulic cement is prepared in numerous localities, and possessing all the essential qualities of that substance. The rock, therefore, known as the water-lime throughout the counties west of Cayuga lake is described as the upper division of the salt group, and which according to the Report of the Third District does not correspond with the water-lime of that portion of the State, but with the *magnesian deposit* of the Onondaga salt group.

These explanations seem necessary to a right understanding of the matter, since it is desirable if possible to render a description of the rock under the name by which it is commonly known.

The strata identified by their fossils as the water-lime group consist of thin courses of dark colored or bluish limestone, often not more than half an inch thick, and when struck by the hammer emit a ringing sound. The characters are much the same as this rock presents where it has been examined further east. The Favosites which are usually an accompaniment of this group when fully developed, do not appear here.

The thin layers when exposed to the atmosphere present numerous linear cavities, which cross the surface in all directions and cause a destruction of the mass. When freshly exposed or when a layer is split, the centre will be found presenting the same linear cavities containing acicular crystals of sulphate of baryta. These, as the stone becomes exposed are dissolved and the cavities left. The crystals and cavities cross the fossils as well as the other parts of the stone separating them into numerous divisions.

57.

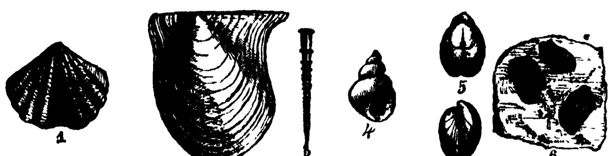


The illustration represents a small portion of the stone as it appears, one part presenting the cavities while at the other extremity the crystals still remain.

In some parts of the salt group, cavities of this kind abound, but I have never seen them filled with any crystalline substance. These are probably due to a similar cause, viz. the solution and removal of some crystalline matter by atmospheric agency.

The fossils of this group (except No. 1,) occur at Maffit's quarry as before stated. They are not however well preserved, though their forms are easily recognized. These are all figured by Mr. Vanuxem in the Report of the Third District.

58.



1. Orthis? (Delthyris) plicatus.
2. Avicula rugosa.
3. Tentaculites ornatus
4. Littorina antiqua.
5. Atrypa sulcata.
6. Cytherina alta.

Water lime, or Hydraulic cement.

The subject of water lime as a cement in situations exposed to moisture, or to alternations of wet and dry conditions, is one of the highest interest to the people of the State of New-York. The great extent of our canals, where this substance is largely used in locks, aqueducts, culverts, etc., renders it desirable that the utmost precaution be taken to provide a material which shall meet all the requisitions. Since, however, it is acknowledged that much of the cement is of inferior quality, and as the subject is especially taken under the direction of the engineers to guard against the use of improper materials, it is plain that there is room for improvement in this product, either in the article selected, or in the manner of preparing it.

In order to produce a cement of the desired quality, the admixture of certain ingredients in the proper proportions is required. The material selected and used sometimes produces this desired quality, and sometimes it does not; but if the quality were always uniform, and the treatment in preparing it the same, there would be as much certainty in the result as in the burning of common quicklime. The evil, however, lies in the following circumstances. The rocks used as hydraulic cement, along the Erie canal and the lateral canals, hold two distinct positions, but both similar in regard to the nature of their ingredients. The lowest position is the beds of passage from the shale of the Niagara group, to the limestone above. These beds consist of shale, or argillaceous matter with an intermixture of arenaceous and calcareous earths. The passage from the shale is gradual, the proportion of the other earths constantly increasing: in the upper part the first is in small proportion, and the latter in excess. The central beds are those best fitted for hydraulic cement, while the upper are too calcareous, and the lower too argillaceous.

In like manner, the second position of the water lime is at the passage of the argillaceous marls and shales of the salt group to the more pure calcareous formations above; consequently there is a gradual diminution of shaly, and an increase of calcareous matter, with occasional bands of pure shale. Now it is evident that the rock, taken indiscriminately, will produce a lime of very variable quality, from the constantly varying composition of the rock. A single stratum, indeed, at an interval of a few rods, may often be of a quality and composition very different from the same at another: this may happen, too, without any very sensible difference in the external appearance. It requires, therefore, the most constant attention in the selection of the material, and a due degree of care in the preparation. There will always be, however, a tendency to excess of argillaceous matter in the cements as they are at present selected; and this substance ensures their gradual but constant and certain destruction, to the injury of the structure in which they are used.

The quality of the sand used in the preparation of the cement, is another subject of importance. In one part of the State, what is called sand, differs essentially from the material which is known by the same name in another. In many places a pure siliceous sand is not to be found, calcareous and argillaceous earths forming a considerable proportion. In other places, the sand is purely or principally siliceous. The subject of cements has, however, been placed before the public in the Annual Reports, and it would be unnecessary to go into further detail in this place. The position which these substances occupy is indicated in the description, and the places through which they pass is readily found by reference to the Geological Map.

14. PENTAMERUS LIMESTONE.

(PART OF No. 6, PENNSYLVANIA SURVEY.)

According to the Report of the Third District, this rock, being one of the subordinate divisions of the Helderberg series, disappears from thinning out, in the vicinity of Oneida creek. It is not recognized in the Fourth District as a distinct rock, though the characteristic Pentamerus, or one very similar to it, has been found near Buffalo. This circumstance with others, induces the belief that some of the lower rocks of this series appear farther west but that they have not yet been distinctly recognized. The constant association of the *Pentamerus galeatus* (*Atrypa galeata*, DALMAN, HISINGER; MURCHISON, *Silurean Researches*, p. 623, pl. 12, f. 4), with this rock gives the name by which it is known. It will not be confounded with the Pentamerus limestone, which is a subordinate member of the Clinton group, the typical fossil of which is the *Pentamerus Oblongus* (see page 70). Another singular fossil of this rock is the *Lepocrinites Gebhardii.**

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15. DELTHYRIS SHALY LIMESTONE.

Catskill Shaly Limestone. Geol. Report of the Third District.

This rock is enumerated in the order of succession, though it does not occur in the Fourth District.

As its name implies, it is a shaly mass, or consists of shaly with alternating beds of compact limestone. Its present and former name is derived from the abundance of the *Delthyris macropleura* of Conrad which everywhere marks the rock. The name of Catskill Shaly Limestone, which has been proposed on account of its great development on the Catskill Creek, is found to be objectionable, as it at once carries the mind to the Catskill Mountains, a very different group of rocks, thus tending to propagate a false impression. Since the name now used has been previously adopted, there can be no objection to continuing it.

It is an exceedingly interesting rock from the great number of species, abundance and perfection of its fossils, many of which are very similar to those of the Niagara shale, and of the Wenlock shale of England, some indeed appear to be identical with those of the latter rock. Fossils appear in this rock very analogous to the following forms, which are figured in

* See Report of the Third District, page 117. Also the forthcoming Report of the Second District, under the head of Pentamerus limestone.

pl. 13 of the *Silurean Researches*. *Orthis hybrida*, *O. canalis*, *Atrypa rotunda*, *A. linguifera* and several others. *Spirifer? pisum* (*Silurean Researches*, pl. 13, f. 9) is identical with a fossil found in this rock.

This rock is the lowest position yet known where the remains of fishes have been found. A specimen of the defensive fin bone (Ichthyodorulite) of some unknown species, more than eight inches long and imperfect at both ends, has been found in this rock. Its greatest breadth is about one inch, and a transverse section presents the form of two very acute triangles with their bases in contact, forming the centre of the bone.

I have lately seen some fossils from near Point Abino in Canada, which appear referable to forms found in this rock in the Third District, particularly the *Atrypa lævis* of Mr. Vanuxem.

Since this rock is not known to extend within the Fourth District, no illustration of its numerous and beautiful fossils are given.

16. ENCRINAL LIMESTONE.

Scutella Limestone of the Annual Reports.

(Part of No. 6, Pennsylvania Survey.)

This mass has no existence in the Fourth District, thinning out east of the central part of the State, and appearing in force only in the region of Schoharie and the Helderberg.

It contains a great abundance of a flat or saucer-shaped pelvis of a crinoid, from the resemblance of which to the Scutella it received the name, *Scutella limestone*. Broken columns and other remains of Crinoidea, in a perfectly crystalline condition, are very abundant in this rock.

17. UPPER PENTAMERUS LIMESTONE.

(Part of No. 6, Pennsylvania Survey.)

This mass succeeds the last, resting directly upon it. Mr. Gebhard junior, of Schoharie, has clearly demonstrated that by its peculiar assemblage of fossils it is distinguished from any other rock. Among these, is a species of Pentamerus, in shape like *P. Galeatus*, but quite smooth, and evidently a distinct species. Several forms of Atrypa also occur in this rock, very similar to those below.

The thorough practical acquaintance of Mr. Gebhard with all the rocks of this part of the system, and his nice discrimination of their fossil contents, renders his opinion decisive in such distinctions.

18. ORISKANY SANDSTONE.*

(No. 7, OF THE PENNSYLVANIA SURVEY.)

This rock, where best developed in the Fourth District, is a coarse, rather loosely cemented, purely siliceous sandstone, of a yellowish white color. It contains some flattened nodules of chert or flint, and cavities lined with the same mineral, approaching in appearance to chalcedony. In the upper part of the rock are numerous concretions of dark-colored or nearly black compact crystalline sandstone, very hard and tough. These vary in size from an inch to five or six inches diameter; their external character is much like boulders of some hard primary rock.

In other localities in the district this rock is scarcely recognizable. In Monroe county, its only representative is a layer of greenish conglomerate about four inches thick. (See illustration No. 56.) It is composed of coarse sand and small pebbles, with some fragments of the light-colored argillaceous limestone derived from the next rock below. At one or two other points it appears as a coarse sandstone of a few inches in thickness, resting on the Onondaga salt group. The last place in the district where it has been noticed is in the bed of Black creek at Morganville in Genesee county.

The general absence in the district of the four last-named rocks, either from thinning out or from subsequent denudation, forms an interesting subject of inquiry. The Oriskany sandstone seems to be deposited in depressions formed either from the natural inequalities in the surface of the previous rocks, or arising from denudation. The presence of worn fragments and pebbles of the argillaceous limestone of the salt group proves that denudation did take place after the latter rock had in some degree become indurated.

Farther west where there is no representative of the Oriskany sandstone, the surface on which the higher limestones rest is very uneven, consisting of abrupt elevations and depressions very similar to the channelled bed of a powerful stream. There have, however, been no grooves or striæ observed; but since the appearances just noticed are usually seen in the face of cliffs, or in the sides of quarries, it is by no means certain that such marks do not exist. Should this fact once be established, it will open a vast field, both for observation and speculation. The absence of rocks, whether from thinning out, owing to want of material, or to removal since deposition, involves some interesting points of inquiry.

In the present case, if the formations between the Water lime and the Oriskany sandstone, which appear in the eastern part of the State, have never been deposited in the west, then the

* ORISKANY. The aboriginal name of this place is *Areskana*, signifying the residence of the God of war, and was a place where the *Aganousioni* or *United Braves* held their war councils.

For this information my readers are indebted to Giles F. Yates, Esq. of Schenectada, who has given much attention to the aboriginal names along the Mohawk valley.

Water-lime, and more extensively the Onondaga salt group, must have remained, exposed above the surface of the ocean, or forming its bed, in situations beyond the reach of any detritus or deposition. The production of these four rocks, *Pentamerus limestone*, *Delthyris shaly limestone*, *Encrinal*, and *Upper Pentamerus limestone*, each marked by a distinct assemblage of fossils, must have required a long period of time; and we can scarcely conceive of a condition of the ocean which would continue so long free from deposits of some kind, even though at great depths or distance from land. Since the point of greatest development of these rocks is less than two hundred miles from where they entirely disappear, it is impossible that if the Water-lime or Onondaga salt group formed the bed of the ocean, there should not have been some deposition made upon its surface, and which has subsequently been removed.

The evidence of shrinkage cracks in the upper part of the Salt group is a more prominent character in the eastern part of the State, where the rocks in question are well developed, than in the western part. Still in both places they exist, and are proof of the exposure of the surface above water. If we are unwilling to admit of this denudation to a considerable degree, we shall be forced to conclude that the Onondaga salt group was elevated above the ocean, and formed dry land, while the eastern portion was yet depressed below its surface, allowing the deposition of these limestones.

Since also these formations are absent throughout the whole or a large portion of the western States, the same cause which operated here has also operated over this great extent, and we shall either admit a vast tract to have been elevated above the ocean, or that denudation has operated over this wide area.

From all that we know, however, there seems not the least probability that all these rocks ever extended far westward; for there is a gradual diminution of the material, as appears where the strata are exposed toward their westerly termination, and if the ocean covered all the surface beyond, the deposit has been so slight that subsequent operations have removed it. This seems the more probable conclusion, since we should expect to find evidence of the fact, had so large a surface remained above the ocean during this period.

One of the most characteristic features of the Oriskany sandstone, is the abundance of small cavities which have been formed by the destruction of fossils. These present themselves in all cases where the rock is well developed. The porous nature of the mass has admitted the percolation of water, which has dissolved the calcareous matter of the shells, usually leaving casts of their internal structure. Where free from organic remains, it forms a fire stone of approved quality.

This sandstone is well known in Pennsylvania and Virginia, constituting an important formation; and according to Prof. H. D. Rogers,* it is seven hundred feet thick in the former State. In New-York its greatest thickness is not more than thirty feet, and usually much less.

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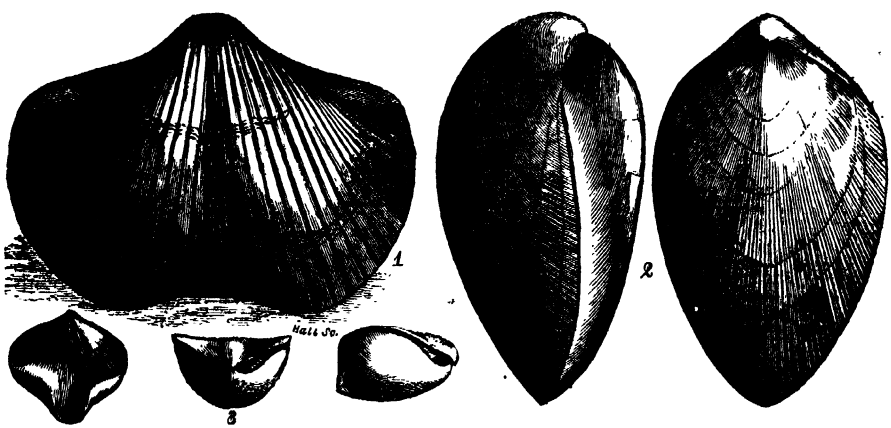
* Geological Report, 1838, p. 51.

It is not everywhere the purely siliceous sandstone which appears in the western part of the State. At Schoharie and in the Helderberg generally, it is a siliceous limestone, very compact and tough where penetrated beyond the influences of the weather; but very rough and with numerous cavities upon the exposed surface. It received the name of *Shell grit* from Prof. Eaton, from the abundance of its fossils and its siliceous character.

Organic remains of the Oriskany Sandstone.

The most obvious of the fossils of this rock are figured in the following woodcut from Mr Vanuxem's Report:

59



1. Delthyris arenosa. 2. Atrypa elongata. 3. Atrypa peculiaris.

1. *Delthyris arenosa* (Conrad, *Geol. Report*, 1839, p. 65.) Shell semi-oval, depressed in front; extremities of the hinge line rounded; surface marked by about sixteen or eighteen flat ribs on each side the mesial fold, and four or five on the fold; ribs, particularly near the margin of the shell, crossed by elevated undulating lamellæ or lines of growth; beak incurved; area rather large.

2. *Atrypa elongata* (Conrad, *Geol. Report*, 1839, p. 65.) Shell ovoid, crossed by numerous sharp radii, which extend from the beak to the base and sides; lower valve gibbous in the middle, with an elevated ridge extending from beak to base; lateral margins often straight.

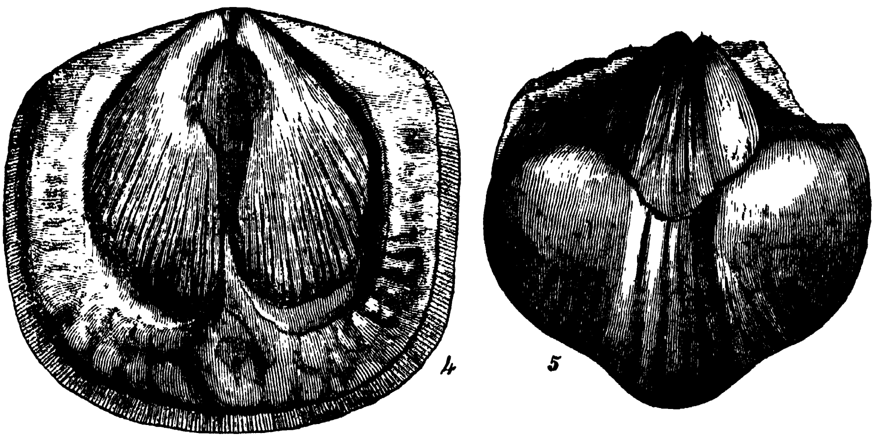
This is an exceedingly abundant fossil, the radii often becoming obsolete towards the beaks. It is often less contracted at the base than the figure.

3. *Atrypa peculiaris* (*Annual Report of* 1841, p. 56.) Lower valve flat, concave towards the base with the margins elevated, the front extending into a linguiform projection; superior valve convex, front margin folding over the edge of the lower, and joining by a few serræ or teeth.

This shell is known by its peculiar projection in front, the strong depression in the lower valve toward the margin, and the folding down of the edges of the upper valve.

The fossils here figured are perfect, the shell remaining entire. Casts of these, however, are the more usual forms seen. In the following woodcut two of these casts are represented:

69.



4. Cast of Atrypa unguiformis. 5. Cast of Delthyris arenosa.

4. *Atrypa unguiformis*, Conrad. (*Hipparionix proximus*, Vanuxem, *Final Geol. Report*, p. 124, fig. 4.) This fossil, usually found as a cast, so much resembles the impression of a horse's hoof, that it has for a long time maintained the name, and even by well-informed persons it was considered as the impression of the hoof of some animal.

This is one of the common forms in the rock, and will be readily recognized.

5. *Delthyris arenosa*, ut supra. This is the usual appearance of the cast; it is distinguished by its projecting beak, which is often broken off much shorter than here represented.

In addition to the fossils here figured, there are numerous other forms which are almost equally abundant. At Vienna, Ontario county, I obtained a species of Ichthyodorulite about four inches long; the specimen however is too imperfect to represent in a figure. Several others were seen in some blocks of stone from the same place, which were used in the glass factory at Clyde. These however were partially dissolved by the percolation of water through the porous sandy mass, and only a loose spongy substance remained. This is the second rock in the ascending order in which remains of fishes have been found.

From the researches of Prof. W. B. Rogers in Virginia, and Prof. H. D. Rogers in Pennsylvania, we learn that the *Delthyris arenosa* and *Atrypa elongata* are equally abundant in the same rock, and one of the distinguishing features of the rock are the cavities resulting from the removal of the calcareous matter of the shells. These facts show the wide distribution of species over similar beds. It should be remembered also that these fossils so abundant in this arenaceous deposit are often as numerous in almost purely calcareous beds forming the termination of the mass. It seems very probable also that the original deposit was more calcareous, and that the porous character of the rock may have resulted from the solution and removal of calcareous particles.

The connexion of this rock with those above and below it, is represented in the sections accompanying the Onondaga salt group, which show its diminution and final disappearance in a westerly direction.

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19. CAUDA-GALLI GRIT.

Cocktail Grit of Dr. Eights.

This rock is an argillo-calcareous sandstone, passing into a greenish shale with thin laminæ of sandstone and sandy shale.

A portion of this rock is characterised by the presence of a Fucoides or some analogous vegetable form, which when seen in parts, as they frequently are, have a fancied plumose appearance, whence, with the lithological character, the name of the rock is derived.

This rock is not known in the Fourth District, though it is well characterized in the middle and eastern parts of New-York and also in New Jersey, as we learn from the Report of Prof. Rogers.

20. SCHOHARIE GRIT.

Grit Slate of EATON.

This rock is a very fine-grained siliceous limestone or calcareous sandstone; when weathered, the calcareous matter disappears, leaving a porous siliceous mass of a brownish color, from the presence of hydrate of iron. In this condition it presents numerous casts of its peculiar fossils. It abounds in a species of Pleurorhyncus, Orthoceras and numerous forms of corals. The rock is well developed at Schoharie and in the Helderberg, but does not extend far westward. It is unknown in the Fourth District, but with the last and several others it has been enumerated in the order, that the numbering might be continuous, and a complete series of the rocks of the system be given in their order of succession, believing that such a course would facilitate the comparison of the groups in different parts of the State. There are formations at either extremity of the State which do not exist or are only partially developed at the other, and if the practice of describing these in their respective order in the report of each District be followed, neither would present a complete series of the rocks of the system. This course will give the inhabitants of the western part of New-York a knowledge of what exists elsewhere and which are wanting in that region, and also show them the points at which they are introduced in the middle and eastern parts of the State.

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21. ONONDAGA LIMESTONE.

Included in the Corniferous Limerock, by Prof. EATON. *Grey Sparry Limestone of the Annual Reports.*

Throughout the greater part of the Fourth District the impure limestone terminating the Onondaga salt group is succeeded by the Onondaga limestone with usually the intervention of a few inches of sandstone before noticed, which in ordinary observations might be entirely overlooked. There is also sometimes a thin band of nonfossiliferous bluish grey limestone. The range of this formation is in an undulating line having a general east and west direction throughout the district, extending eastward to the Hudson river and westward far beyond the Niagara into Canada. Its northern outline is everywhere well marked, forming together with the next succeeding rock the second great limestone terrace, which rises to the south of the valley marking the range of the Onondaga salt group.

By reference to the geological map accompanying the Reports, the course of this rock will be readily traced through the District from Cayuga lake to the Niagara river, being indicated by the blue band following the ochre color. The great depression southward in the line of outcrop at Cayuga lake, the Genesee and Niagara rivers indicate the great amount of denudation it has suffered at these points which are the ranges of ancient valleys, formed at the same period in which nearly all the large lake valleys and river channels of western New-York were produced. The same cause and, in some places, more recent operations have produced minor indentations in the outline, many of which are too small to be noticed in the map.

This rock is subordinate in thickness and continuation to the next succeeding mass, and was not separated from that by Prof. Eaton. Indeed for all practical purposes they may be regarded as one formation; the lower part, where fully developed, being marked by an assemblage of fossils which sufficiently distinguish it.

Its usual characters in the Fourth District are a light grey color often approaching to white, more or less crystalline in structure, and containing numerous fossils. In many instances this mass, like the encrinal limestone at Lockport, seems almost entirely composed of broken and comminuted fragments of crinoidea and corals, sometimes extremely attenuated, and at other times fragments of large size are preserved. These fragments of crinoidal columns, with some of the other fossils, are frequently of a pink or reddish color, and give a beautiful variegated appearance to the mass, particularly when polished. The more comminuted portions containing some earthy matter of a dark color, frequently embrace large fragments of Favosites, a perfect Cyathophyllum, or some other fossil of a light color, which forms an agreeable contrast with the surrounding mass. This character may be seen in the stone of which the Court House at Batavia is constructed, and which is from the town of Le Roy.

Sometimes the mass is fine grained, more compact in texture, and of a darker color; when it has this character, few fossil remains are detected in it. The layers are usually separated by thin seams of greenish shale, which often divide blocks of the stone into wedge-form and irregular laminæ. These seams, barely colored with the greenish deposit, often exist in the stone, where they are scarcely visible, though a blow with the hammer separates the block. In selecting specimens where much vertical depth is required, this is frequently a great inconvenience.

Where thinly laminated by these seams of shale, and the surface covered with encrinital columns and plates as it usually is, the rock bears a most striking resemblance to the Wenlock limestone of England, as seen in some specimens from Wenlock which were presented to me by Mr. Lyell. So complete is the resemblance in some instances, that one might almost be mistaken for the other. Judging, however, from the general character of specimens, and the description of Mr. Murchison, there is a greater amount of shaly matter intermixed with the Wenlock limestone, than with our rocks of the same period.

The similarity or even identity of specimens from Dudley in England with those from the Niagara group has been remarked; and if this inference be correct, of which there seems no doubt, then we find a wide separation here between rocks which in England constitute one group. That such is the fact however appears plain, for there are many fossils of the limestones above the salt group, which are identical with the Wenlock formation, while the identity of so many species in the Niagara group leaves no doubt of perfect correspondence. We are therefore to look upon the salt group as a formation, on this continent, coming in at a period during which, in England, the rocks are supposed to belong to a continuous group, or to be parts of one formation.

The Onondaga limestone in many places contains nodules, or thin interrupted layers of chert or hornstone (usually called flint); and sometimes the Favosites are partially dissolved and the cavities lined with silex in the form of chert, chalcedony or crystals of quartz. The alimentary canal of the crinoidal columns is frequently lined with crystals of quartz, and the chambers of Orthocera, as well as the cavities of other shells, often present the same appearances.

Its characteristic features, when well developed, and which are always much more prominent than the lithological or mineral characters, are the presence of Cyathophylli, Favosites, and fragments of crinoidal columns. These always accompany it in situations where it is sufficiently developed to be of much importance either in economical consideration or geological interest.

In Seneca county this rock is scarcely visible, or forms only a very subordinate layer and destitute of its characteristic fossils. In the adjoining county it becomes of more importance, first appearing as a thin layer near Oakes' corners, and along the terrace to East-Vienna; at the latter place it appears in the bed of the creek resting directly on the Oriskany sandstone, and succeeded by the cherty layers of the corniferous limestone. It is but a thin mass at this place, being little over two feet thick. At another point southeast of this the Onondaga limestone is entirely absent.

At Wayland's quarry, northwest of Vienna, this limestone appears in several strata following the water-lime, and marked by its characteristic fossils. A short distance to the southwest of this quarry it appears again, containing Favosites and other fossils. The rock at all these places is compact, of a greyish blue color and less marked by seams of shale than in many other places.

At Manchester and in the bed of Mud creek at Freedon it is but slightly developed, being a thin layer of a greyish blue color and destitute of fossils. It retains the same character as far as Mendon in Monroe county, where it is better developed and contains a larger number of corals and Cyathophylli. It has also the same character, or is even more fully developed, in the town of Rush, where it disappears before reaching the Genesee river.

On the west side of the Genesee, it appears at Caledonia, still a thick compact mass, with a few thin layers separated by shale, and containing a great number of Cyathophylli, Favosites, and other fossils. For some distance north and west of this place, it maintains the same character, and the surface is strewed with fragments which contain its typical fossils.

North of Le Roy village, on Allen's creek, the rock resting on the Onondaga salt group is a compact sub-crystalline greyish blue limestone, containing no fossils; this is succeeded by twenty feet or more of chert in thin irregular layers, with scarcely any calcareous matter. This cherty mass contains the usual fossils of the Onondaga limestone, and they are persistent as far as the hornstone continues. The cherty layers are again succeeded by thin-bedded compact, bluish or greyish blue limestone, marked by fossils typical of the next higher rock. This example furnishes an instance where the fossils of the lower limestone pass into the hornstone, which eminently characterizes the next rock, and from which its name is taken. Should such cases prove to be of frequent occurrence, it might become a source of difficulty in identifying these rocks. The fact is stated as occurring, not for the purpose of throwing difficulty or obscurity in the way of the observer, but to prepare him for some variations in character, which will ever be found in all subdivisions which can be made; and if he be not previously made acquainted with them, he is likely to experience more difficulty in endeavoring to force rocks to accord with arbitrary descriptions, than from a knowledge of any such variations from the general rule.

About two miles northeast of the point just described, the cherty mass has greatly diminished, and the Onondaga limestone in its typical characters is presented in several thick-bedded regular strata. It is of a light grey, often approaching white, composed of comminuted fossils, and marked by the presence of large numbers of crinoidal columns, Cyathophylli and Favosites. The crinoidal portions are often reddish or pink, and give a beautiful variegated appearance to the rock. The quarries at this place belong to Messrs. Clifford and Rich.

Half a mile farther west, there is another similar quarry. The rock is extensively wrought, sawed into slabs, and polished for hearthstones, mantels and other purposes. It is also much used for buildings. From these quarries the stone for the Court House at Batavia was obtained. There is scarcely a better locality in the district for an exhibition of the typical features of the rock.

Following the outline of the terrace westward, this rock appears in several points, though but obscurely developed, sometimes being represented by a single stratum of less than two feet in thickness. In the town of Newstead, Erie county, its place is marked by a thin band, almost entirely composed of Favosites and other corals, with a few calcareous laminæ, and a large proportion of shaly matter. The latter is partially decomposed, and the coralline masses appear as if imbedded in a ferruginous mud.

At Clarence Hollow this limestone is but meagrely developed, a thin stratum resting on the terminating rock of the salt group, being all that is seen. A mile west of this point, however, it is well developed, appearing as a grey sub-crystalline rock, very coarse grained, and crumbling under a blow of the hammer. At this place it abounds in its typical fossils, and in some places the mass is nearly composed of crinoidal columns and Cyathophylli. From this place to some distance west of Williamsville, it continues to be a well-marked and highly important rock. In some points it contains large numbers of silicified corals, and some irregular nodules of hornstone, which render it unfit for lime burning. Every point, however, where free from these substances, and the grey crinoidal mass well developed, is marked by one or more limekilns, and it will be found a convenient guide to this rock throughout Erie county to inquire for these.

The best locality for examination of this rock is on the farm of Mr. Youngs, in the town of Amherst, a mile west of Williamsville. At this place the rock is well exposed in all its varieties. Being a point from which large quantities of lime are taken to supply the city of Buffalo, the rock has been quarried at several places, much increasing the facilities for observation. The grey crinoidal mass is much better developed here than I have elsewhere seen it, the masses of coral are larger and more numerous, and finer specimens can be obtained. On the brow of the hill it is succeeded by the next rock, which however appears to contain little hornstone.

From the point just noticed, the rock diminishes westward, and at Black-Rock there is but a thin stratum marking its place. At the same time the chert or hornstone of the next rock increases, and Cyathophylli and a few masses of Favosite have been found in the strata composed in a great measure of this material.

From the facts mentioned, the inquiry naturally suggests itself, as to the conditions under which this rock was deposited. It has already been seen that at some points it attains considerable thickness, very remarkable for the abundance of its fossil contents, as well as the character of the rock, while at others it forms a thin stratum scarcely distinguishable except by its position. The materials of the formation therefore have either been very unequally distributed over the bed of the ocean, lodging in depressions of the previous surface, or these greater developments are only local, the materials being derived from the growth of coral and other organisms in or near the situation they now occupy. Although the former cause may have operated to some degree in many localities, it will not account for the phenomena witnessed in all. The thin strata forming connecting links between the points of greater development are probably the finer portions of the thick strata which were transported by the water and spread over the bottom, where few or no organic forms existed. In this respect, these thick portions resemble a line of detached coral reefs, which we may fancy to have skirted the margin of this ancient ocean, and like many modern ones they may have flourished for a long period entirely disconnected, and with a deeper ocean between them. That these deposits are local, or have for the most part been produced in their present situation, seems proven from the abundance of coralline forms, many of which retain the position in which they originally grew. Some of the masses of Favosite are several feet in extent, and from one mass several wagon loads were taken on the supposition that it was gypsum. It is plain that such as these could never have been transported far, even if they have been moved at all. It is true that many of the smaller ones are broken up, and others are found turned upon one side, or completely reversed, showing the action of waves. The Crinoidea which appear to have formed a large share of the deposit, are broken up and their remains scattered, though columns of a foot or more in length sometimes occur. The Cyathophylli are generally thrown down, though they are usually perfect.

From the fragile nature of the Crinoidea, any force sufficient to overturn the broad-based Favosites and other similar corals would destroy these, and scatter their fragments over the bottom, filling up the spaces between the other corals. Many other small or fragile corals, as well as Crinoidea also existed, but of all these we only find fragments, which bear evidence of being broken and worn previous to imbedding. In these situations fossil shells are few, and it is only when the mass is more evenly distributed that they increase in number.

Now all these circumstances seem plainly to indicate that at these points of thickening there was a part of the ocean bed, on which these corals had established themselves, and on which they continued to construct their habitations for a long period, as the great size of many would prove. In the more sheltered portions smaller and more delicate forms, with the Crinoidea seem to have flourished; the latter in great perfection, judging from the size of the columns. The more exposed portions and the more fragile kinds were broken down as they came within the influence of the waves, and these materials were spread around the base, the coral reef extending in every direction as far as the material was transported, and there we now find the mass thinning out. There seems in this nothing more than we might expect, and probably only what is now accomplished in coral reefs which are near the surface of the ocean, and which may be alternately elevated above or depressed beneath it. The great amount of destruction here visible was not all accomplished at once, for we may find an overturned mass of coral covered with a fine deposit, and upon this another mass of coral, either overturned or in its natural position, the whole indicating a long continuation of the causes in operation. The simple fact of the succesive growths of coral upon deposits covering other corals, of itself proves a great lapse of time; for the growth of all these forms is exceedingly slow.

From the amount of exposure, it is impossible to ascertain whether these coral reefs were circular, or whether they formed more than a single line skirting the margin of the ocean. From the great amount of denudation on the north, and the east and west extent of these coral banks, we may infer that there was more than a single range; and if it can be proved that they existed far south of the present outcrop, we may rationally infer that they formed a series of circular reefs, probably much in the same manner that similar reefs and islands are formed in the present ocean.

The Onondaga limestone is scarcely anywhere developed in the same perfection as in the First and Third Districts, where it contains a greater number of fossils, and as a distinct mass is more persistent. As a quarry stone for building and other purposes, it rarely appears in the perfection which it assumes at Syracuse, Le Roy being the only known locality where this character is possessed in an equal degree; while in most other places where it is sufficiently compact for that purpose, the strata are very thin.

Localities. — The examination of a few points in the district, will suffice to acquire an acquaintance with this rock. The first locality of interest is at Vienna, where its connexion with the rocks above and below are clearly seen. Two miles northwest of the same point, it is better developed, and contains its peculiar fossils. Caledonia offers the next point of much interest, though the towns of Rush and Mendon, on the east side of the Genesee, are interesting in some degree. Le Roy, at the quarries before alluded to, offers the best exhibition of this rock in the district. In Clarence there is also a good exposure, a mile west of the village of Clarence Hollow. Near Williamsville, on the farm of Mr. Youngs, a large number of the corals and other fossils of the rock may be obtained; and this locality, with Clarence and Le Roy, are by far the best in the district.

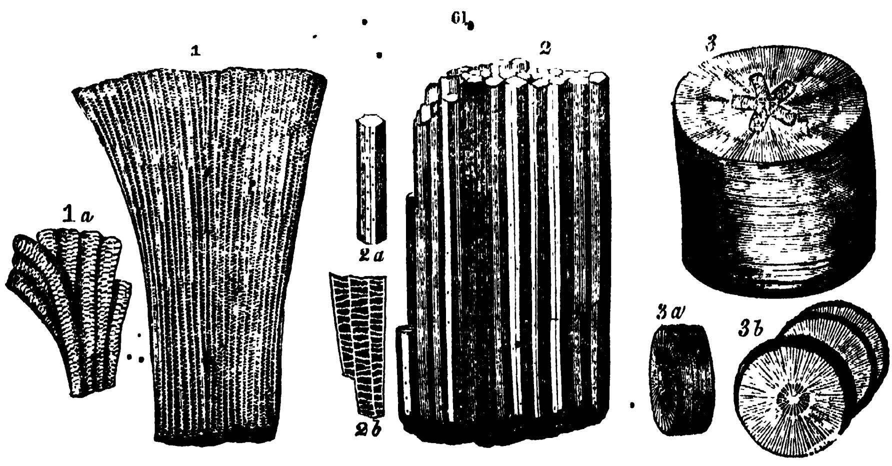
Thickness. — The thickness of this mass is very variable, being from one foot to twenty or even forty feet. At Black Rock, the stratum representing this rock is fourteen inches thick; in Newstead, Erie county, about the same; at Vienna, two feet. At Williamsville, as nearly as can be ascertained, it is twenty feet. This point and Le Roy, where the thickness was not ascertained, present the greatest development.

Mineral contents. — The only minerals noticed in this rock, are crystallized carbonate of lime, quartz in crystals lining cavities, chalcedony and hornstone, with iron pyrites in a few places. The Favosites are often silicified, and their cavities lined with small crystals of quartz. This rock is so intimately connected with the next in succession, and forms surfaces of so little extent, that its characters in agricultural respects can scarcely be considered, but will be noticed in connexion with the rock next in order.

Organic Remains of the Onondaga Limestone.

The organic forms of this rock are its most prominent marks, wherever the mass is well developed. In the Fourth District, Corals and Crinoidea were the predominating forms, the conditions under which it was deposited being apparently unfavorable to the existence of Testacea. A few univalve shells have sometimes been found, and more rarely some species of *Atrypa* and *Delthyris*.

Among the numerous forms of corals, those of the three following illustrations have been selected, as being the most common or most obvious among them. The number may be quadrupled, without exhausting the species of this rock.



Favosites
2, 2 *a* and 2 *b*. F. Gothlandica.

3, 3 *a* and 3 *b* Fragments of column and joints of unknown Crinoidea.

1. *Favosites alveolaris.** This specimen has a honeycomb structure; the transverse septa are interrupted. There are no pores visible, but from its analogy to others which are evidently of this species, there remains no doubt of identity.

1 *a*. A specimen with larger columns, presenting the pores upon the angles.

Localities—Williamsville, Erie county; Le Roy, Genesee county; and Caledonia, Livingston county.

2. *Favosites Gothlandica.*—A mass of solid columns, showing the pores upon the sides of the tubes.

2 *a*. A single tube magnified twice, and presenting a double row of pores upon the side.

2 *b*. A fragment from a honeycomb specimen, showing the transverse lamellæ.

Specimens from the mass from which these are figured, present the characters noticed by Mr. Lonsdale, of having a single and a double row of pores upon the same specimen, and upon the same column.

This is an exceedingly abundant coral, sometimes appearing with its tubes filled with calcareous matter as in fig. 2; and again with the cells in their original condition, presenting the appearance of honeycomb, by which name this and some other species are known. It is known to range from the Niagara to the Hamilton group inclusive, occurring in great perfection in nearly every rock.

Locality of specimen figured—Williamsville, Erie county. Found in the same rock at Caledonia, Le Roy, and numerous other places.

3. *Fragment of a crinoidal column.*—This is an abundant and characteristic fossil of this rock. Its great size and general smoothness, with the very thin plates of which it is composed, are sufficient to distinguish it.

3 *a*, shows the crenulated edges of the plates.

3 *b*, presents an appearance common on the surface of weathered slabs of this rock, where the column has been broken down, and the plates have slidden over each other, still remaining in contact.

This form seems referable to fig. 9, pl. 18, *Silurian Researches*. Fragments of these columns a foot or more in length are sometimes found, and there are others where the columns are composed of alternating larger and smaller plates.

Locality of specimens figured—Williamsville, Erie county. Found also at Caledonia, Le Roy and numerous other places.

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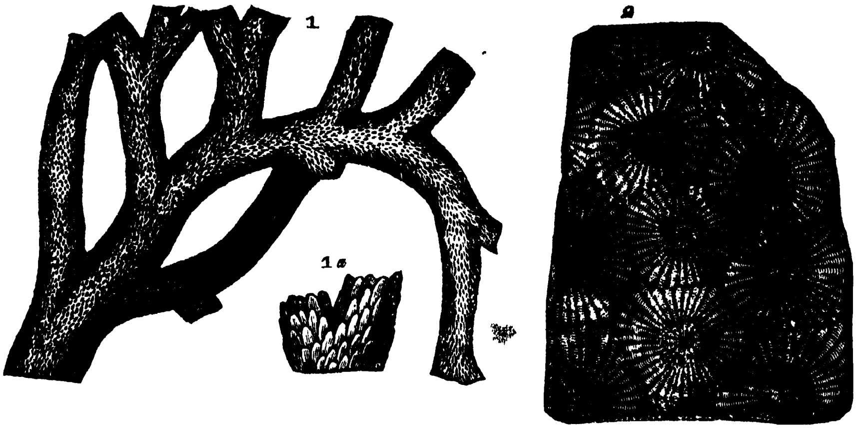
* For synonymes and references of the genus Favosites, see *Silurian Researches*, pp. 681, 682 and 683; also GOLDFUSS, *Petrefacta*, Genus *Calamopora*.

62.



1 and 1 *a*. Favosites fibrosa. 2. Astrea rugosa.

1. *Favosites fibrosa* (*Calamopora fibrosa*, Goldfuss, *Petrefacta*, pp. 82, 215, pl. xxviii, fig. 3 and 4, and pl. lxiv, fig. 9. *Silurian Researches*, p. 683, pl. 15 bis, fig. 6, 6 *a* to 6 *f*). The figure represents a specimen of the natural size, being a portion of the whole, showing the manner of its bifurcations. 1 *a*, is a portion magnified, but the transverse lamellæ are not visible.

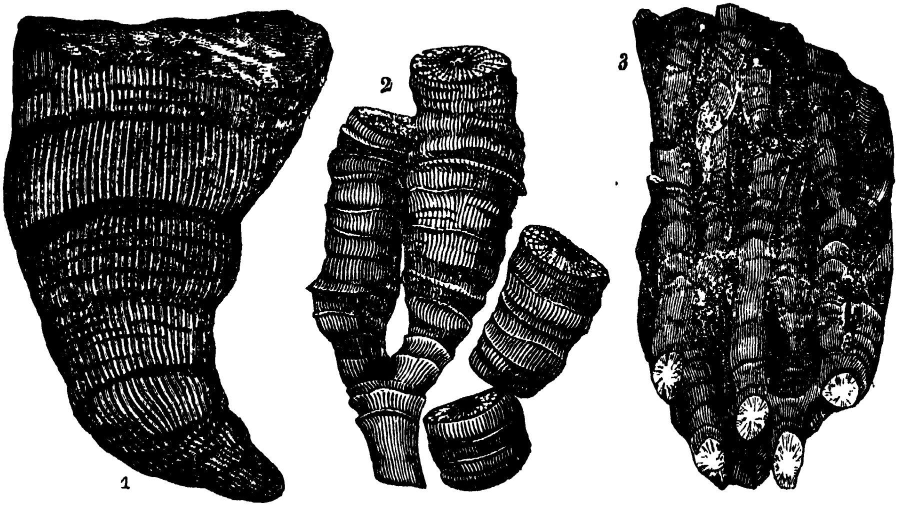
This fossil is abundant in many places upon the surface of the strata. It seems referable to this species of Goldfuss, though I have not been able to detect the connecting foramina; there are also some other varieties which I have no opportunity of examining. This species or a very similar one ranges from the Clinton group to the Hamilton.

Locality—Clarence, Erie county.

2. *Astrea rugosa*, n. s. The surface of this fossil consists of a series of circular or interrupted stars of about ⅜ of an inch in diameter, having an elevated disk in the centre of each, which is composed of 18 rays; these rays bifurcate on the outer margin of the disk, and form the 36 rays which compose the star. The rays are wrinkled, or crossed by concentric lamellæ, giving the surface a peculiar roughness, from which the name is derived; it differs from any of Goldfuss' figures in the number and character of the rays.

Locality—Le Roy, Genesee county.

63



1. Cyathophyllum. 2. Cyathophyllum dianthus. 3. Syringopora.

1. *Cyathophyllum?* It is impossible to pronounce with certainty whether this be a Cyathophyllum or Strombodes, as I have had no opportunity of examining its internal structure. It is one among the common and abundant forms of the Onondaga limestone occurring with C. flexuosum and C. ceratites.

2. *Cyathophyllum dianthus.* (Goldfuss, *Petref.* p. 54, pl. xv, fig. 13, and pl. xvi, fig. 1. *Silurian Researches,* p. 690, pl. 16, f. 12, 12*a* to 12*e*.) This coral usually appears in large groups, which, from their silicified condition, stand out in relief on the surface of the rock. The figure is a small portion from a mass of this kind, of the natural size.

Localities—Caledonia, Livingston county, Williamsville, Le Roy, &c.

3. *Syringopora.* This fossil often appears as in the specimen standing out in relief upon the surface; at other times the ends of the coral are seen projecting, showing their structure in the most perfect manner.

There are also two or three other species which are abundant in this rock. The one figured apparently differs from any species of Goldfuss.

The characteristic fossils of the Onondaga limestone in the Third District, figured by Mr. Vanuxem on page 132 of his Report, cannot be considered as typical of this rock in the Fourth District. The *Pentamerus elongatus* occurs at Vienna, but I have not seen it elsewhere in the district.

64.

22. CORNIFEROUS LIMESTONE.

Upper part of the Corniferous Limerock of EATON. *Seneca Limestone of the Annual Reports.*

This rock is one of the most persistent of any in the series, and at the same time maintains a uniformity in lithological character, and in the occurrence of certain fossils, scarcely possessed by any other. It is known to extend from the Helderberg mountains on the Hudson river, to the Niagara river, and thence far into Canada. This rock forms the terminating mass of the second limestone terrace to the south of lake Ontario, and with the Onondaga limestone and the upper part of the Salt group forms the whole height of the same in the Fourth District. It follows the same line of direction as noticed in the last described rock, and every where succeeds that mass, being always thicker and more prominent. By reference to the Geological Map, the limits of this and the next lower rock will be seen, occupying in the Fourth District a width of from two to four or five miles, dipping gradually to the south, and disappearing beneath the Marcellus Shale.

It has suffered a great amount of denudation at several points, as noticed under the preceding rock, the two being almost always in the same line of outcrop.

This rock has a prominent and well defined outline upon the north, and gives rise to a prominent feature in the topography of the country as well as to many interesting points in the scenery. All the smaller streams passing over it present rapids or cascades of more or less interest. The larger streams, and the lakes of Cayuga and Seneca which extend north beyond this rock, have excavated their channels deeply into it giving no evidence of its existence in their beds. It forms a slight barrier however at the outlet of lake Erie at Black Rock, producing a rapid current with considerable descent, and presenting a small island just above the water which is all that now remains to show that the rock was once continuous from the two shores.

Under the corniferous limerock of Prof. Eaton were included this rock and the Onondaga limestone of the Reports, the latter constituting his "*Ceratial rock*," so named from the abundance of Cyathophylli which it contains. The name corniferous is continued as being peculiarly applicable to this rock, though the other limestones contain the same mineral. This is the highest limestone of importance in the series, which continues throughout the district.

In lithological character this rock varies to a considerable degree in its range through the district, being at the eastern extremity a fine grained, compact limestone, scarcely presenting any crystalline grains. Its color varies from a light greyish blue, to dark blue or black, and it is sometimes even of a light grey or drab color. It contains numerous nodules of hornstone, and the strata are sometimes separated by irregular layers of the same. In other localities these layers of hornstone increase in number and thickness to the almost entire exclusion of calcareous matter, and they then present a very harsh outline. Where it possesses this character, the calcareous matter is soon dissolved out from weathering, leaving the hornstone in jagged and irregular projecting points, from which it receives the local name of "*chawed rock*." In the central part of the district the hornstone portions are largely developed, and the terminating mass in such situations is a light grey limestone, often of a sub-crystalline texture.

At the eastern end of the district the hornstone is intermingled and interstratified with the calcareous strata, the whole very dark colored. The same character prevails at the western extremity of the district, where the rock outcropping on the Niagara has, from its black color, given name to the village of Black Rock.

The rock for the greater part seems to have been composed of finely levigated calcareous mud, probably derived from the destruction of corals at distinct points, while at the same time siliceous matter often formed no inferior part in its production. The characters which distinguish the last rock, viz., the presence of corals and crinoidea are rare in this, and form no essential feature. Fossils are generally few, and for the most part consist of shells. Some portions it is true, though of small extent, appear as if they may have resulted from the destruction of corals.

This rock is usually distinguished from the limestone below, by its more compact structure, the presence of hornstone in layers or nodules, and the absence of Favosites, and crinoidal columns, which as before stated always mark the Onondaga limestone where well developed.

Where free from hornstone this rock furnishes a good building stone, and is readily dressed to a smooth face. The darker portions however give a sombre aspect to the structures, and the effect upon the eye and the mind is unfavorable. The lighter colored portions, usually of the upper part are more suitable for such purposes, and give a good appearance to buildings. That portion with much hornstone is only fit for rough walls, for if dressed smoothly, which is difficult, it weathers unequally and the moisture finds its way between the nodules of hornstone and the surrounding mass, and eventually produces mischief. The upper part of the mass is in many places so free from hornstone that it is extensively used for lime burning.

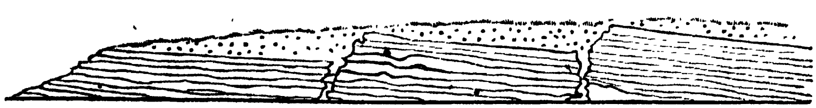
This rock is interesting to the geologist by its contrast with the preceding, both in color, general lithological character and organic contents. It reveals a period when a great change took place in the condition of the ocean, when from a sea teeming with organic forms like the corals and crinoidea, it became one in which few of these forms existed, and shells almost alone tenanted the deep. It appears to have been the commencement of a change by which the sea grew deeper, finally to the depth beyond which corals flourish, and these were all covered by the calcareous mud derived from previously existing masses.

This rock first appears in the district in the eastern part of Seneca county, having the same characters as in the quarries near Springport on the eastern side of Cayuga lake. The rock is exposed at numerous points, nearly all presenting the same characters; being in regular courses of from six to eighteen inches thick, usually separated by layers of hornstone, and sometimes embracing flattened nodules of the same, which have a striated surface, as if from the crystallization of some mineral in the space between the two rocks. A mile or two west of Waterloo it approaches the Seneca outlet, and is quarried on the margin of the stream; some of the upper strata are of a greyish blue color, weathering to a light grey or ashen, and containing some argillaceous matter. These strata are often marked by the presence of a *Cyrtoceras,* which often attains a large size. The greater part of the rock is fine grained, bluish in color, embracing an irregular strata of hornstone. In one quarry I noticed a separation of the higher and lower strata by a "*wayboard*," or seam of clay about four inches thick. This clay is exceedingly fine like the softest talc, and has a laminated structure and yellowish color; it differs greatly from the usual shaly matter separating the strata, and on this account is noticed. The rock at these quarries is readily worked, being crossed by vertical joints in two directions, which often separate the stone into blocks of convenient size, and leave a good back wall to the quarry.

The effect of these joints, and the manner of working the rock where they occur, is well illustrated in the view of a quarry south of Waterloo, which stands at the head of the section. The salient and reëntering angles, the lines of which bound the quarry, mark the two directions of these joints, one of which is nearly E. and W., and the other varying from N. 10° E. and S. 10° W. to N.E. and S.W.

About three miles south of Seneca-Falls village it comes to the surface in several places, and from always presenting the same strata above ground it appears to have been undermined, or from some other cause to have been broken into faults. The surface being level does not admit of an actual inspection of the condition of the rock, but judging from what is seen it holds the following position.

65.



This dislocation of the strata is probably caused by the removal of the soft gypseous rocks from beneath, allowing the higher strata to fall down. From that side next to Cayuga lake only presenting this appearance, it is probably due in some measure to the cause which excavated the lake, and which doubtless acted with greater effect upon the softer strata beneath the limestone. Upon the eastern shore of Cayuga lake, in the Third District, the influence of this agency is more distinctly visible.

From the quarries on the Seneca outlet, to the west of Waterloo, this rock does not again appear for several miles, having evidently been excavated in a direction north of Seneca lake, for about the same width as the lake. At Jones' quarry, where it first appears, in the town of Phelps, its eastern edge forms nearly a perpendicular escarpment, showing either a sinking down of the rock on the east, or its entire removal. The latter seems more probable, since there appears no evidence of causes to produce the former, and there are many reasons and facts for inferring that the valley of Seneca lake once extended much farther north than at present.

In Ontario county, at the place just mentioned, the rock is nearly of the same color and character as in Seneca county. Farther west it becomes of a lighter grey color, and often exhibits a tendency to crystalline structure. At the numerous points along this terrace westward where this rock appears, it presents a rounded outline of a light grey or almost ashen color, with projecting nodules or layers of hornstone, which, from weathering, have assumed a yellowish color, and are checkered by seams in all directions. Near Oakes' Corners, the course of the railroad has cut through its northeastern extremity; and along the south side of the railroad, for some distance, its northern outcrop is visible.

At Vienna, the whole rock is well exposed in the bed of the stream, extending from the lower to the higher village, and appearing still farther beyond.

The strata resting upon the Onondaga limestone are principally composed of hornstone; the calcareous matter has been dissolved from the same, and it presents the most rugged and irregular appearance conceivable. Where the stream passes over these beds, the calcareous portions are worn much deeper, while the hornstone stands up in projecting knobs. The lower part of the mass is developed in about twelve distinct strata or beds, of about one foot each, some of them varying from twelve to fourteen inches. The central portion of the mass at this place has a shaly structure, and is free from hornstone; it contains innumerable small fossils, which are scarcely distinguishable by the naked eye. This portion of the rock is blue, but weathers to an ashen color.

The shaly division is again succeeded by compact limestone with hornstone, and terminates upward in shaly calcareous, thinly laminated strata. Few fossils are found where the hornstone is abundant, but in other parts of the rock they are common.

Two miles west of Vienna, some strata of this rock, containing very little hornstone, are exposed over considerable surface. The rock is compact, of a light greyish blue color; it is readily quarried, and furnishes good building stone. The character exhibited in the bed and banks of Flint creek at Vienna, is the prevailing one along the outcrop of this rock westward.

In the bed and banks of Mud creek, above the village of Freedon, it presents nearly the same character, except that there is far less hornstone. The central portion is shaly, containing the same fossils as at Vienna, and in addition I obtained an Ichthyodorulite about six inches in length. Some part of the rock above this is very light colored, resembling the upper part of the Onondaga salt group. This portion, however, is marked by the presence of one of the most characteristic fossils of the rock, viz. *Odontocephalus selenurus.* The higher strata are thin-bedded, but with little intermixture of shaly matter.

The lower part of the rock above Freedon is a fine-grained, compact blue limestone, with a moderate proportion of hornstone. It contains some thin beds of coarser, greyish, subcrystalline limestone; and it is these which in some places become augmented in thickness, and furnish the fine quarries in this rock. At this place they distinctly alternate with the blue strata. This character is the same as that presented in the lower part of the rock in Seneca county, but it offers no sufficient reason for a subdivision.

Where best developed, the rock presents the threefold division visible on Flint creek and Mud creek. The same may also be seen in a few other places, but the distinctive characters are either not persistent, or they are not visible through the whole district. The very fine grain and light grey color seen in part of the mass on Mud creek, is also visible at one or two other places, but it is far from being a general or important character.

At Farwell's Mills, and at West-Mendon, the same general character of the rock is exhibited. The proportion of hornstone varies at almost every locality, but usually some of the strata consist in large proportion of that mineral. At Avon the higher strata of the rock have become a compact thick-bedded stone, and being entirely free from hornstone, are quarried in considerable quantities. The lower part of the mass has been exposed near the same place, and contains abundance of hornstone.

It is quite unnecessary to follow all these local variations in the character of the rock. From what is already said, it will be plainly seen that the nature and proportion of the component parts vary at different localities. In some places the hornstone predominates through more than half the mass, while in others it is in very subordinate proportions.

On the west side of the Genesee, its cherty characters are better developed than elsewhere. Between Caledonia and Le Roy, there are many acres, and I believe hundreds of acres, which are literally paved with hornstone in small angular fragments, or larger masses united by carbonate of lime. In consequence of this stony surface, this part of the town was for a long time considered almost useless for agricultural purposes, though originally it produced a good growth of timber, and more recently it has been discovered to be very productive, affording some of the finest crops. From the nature of the rock, the soil is necessarily highly calcareous; and from the abundance of stones, the surface is kept at a more equable temperature than in some other soils.

The manner of destruction produced by weathering is very obvious in this rock: the calcareous matter dissolves away; the hornstone, as it projects, shows little interstices or cracks, which are soon filled with water, which, on freezing, enlarges the space, and thus after a time the whole mass is broken down. This process is readily understood by an examination of the rock at any of its outcropping points. The roads over this portion of the rock are superior to the best macadamized roads; the loose arrangement of the fragments allowing the percolation of water, which is drained off by fissures below. The siliceous matter soon becomes pulverized, and offers no inconvenience from the size of particles. If man would take a hint from nature's operations, the more cherty parts of this rock would be used for improving the roads along the whole line of its outcrop. Still the only place where this mode of improvement has been adopted, is on the road from Buffalo to Williamsville.

The general characters of this rock are seen along the main road from Caledonia to Le Roy, and the country intervening this line and the northern margin of the terrace. Its rough and jagged surface everywhere marks its occurrence, and along this distance its development is greatly superior to that of the Onondaga limestone.

About two miles southeast of the village of Caledonia, on the land of Mr. Christie, the compact grey portion of this limestone is well devoloped, forming thicker strata than elsewhere in the district. It has been extensively quarried for the Genesee Valley canal. In appearance it much resembles the Onondaga stone; but the presence of large quantities of hornstone, and the occurrence of some fossils peculiar to the corniferous rock, are conclusive evidences.

In the bed of the stream below Le Roy village, the Corniferous rock prevails to the almost entire exclusion of the next mass below. The section along this creek gives between thirty and forty feet by actual measurement, which is composed almost entirely of limestone. This section in detail is as follows, beginning with the highest stratum of the rock, which is succeeded above by the Marcellus slates.

	FEET.	INCHES.
Two strata of grey limestone with numerous fissures, slaty, and compact at different points	1	8
Compact grey limestone—two strata	2	4
Hornstone with little limestone	0	8
Limestone	1	5
Hornstone	0	4
Limestone	0	10
Hornstone	0	14
Grey limestone	1	6
Hornstone	0	3
Limestone	0	9
Hornstone	0	3
Grey compact limestone	2	[illegible]
Thinly laminated limestone with fossils	2	0
Compact limestone with fossils	2	0
Limestone with nodules of hornstone	1	6
Limestone	0	6
Hornstone	0	4
Limestone in two courses	1	10
Limestone with nodules of hornstone, in two strata separated by hornstone	3	2
Limestone in courses of one foot each, separated by layers of hornstone	6	0

	FEET.	INCHES.
Limestone in two courses, with an irregular layer of hornstone between	2	2
Thin-bedded limestone with much hornstone in nodules and flattened masses, all containing abundance of coralline fossils	3	0
Limestone with a large proportion of hornstone intermixed; contains some coralline fossils	10	0
Limestone in two courses of ten inches each	1	8
From this point there is a fall of twenty or thirty feet in the stream, where the rock is indistinctly seen. From the point where it reappears, there are thin strata of hornstone with a small admixture of calcareous matter, the whole exceedingly rough and ragged	24	0

The last division contains in its upper part numerous coralline fossils usually replaced by silex, and in many instances they are even more durable than the mass of hornstone around them. The lower part of this mass is separated from the Salt group by six feet of light grey limestone, destitute of fossils, which, from its position, represents the Onondaga limestone.

There is no other point known in the district, where there is so great a development of the hornstone of this rock, it usually being a very subordinate part of the whole. From the vicinity of Le Roy, there appears to be a gradual diminution of the siliceous matter in a westerly direction, some points being nearly free from it. Within ten miles of the Niagara it again increases, constantly augmenting as far as Black Rock. In this intermediate space it occurs mostly as nodules embraced in the calcareous rock, and sometimes increasing so as to form a separation between the layers. The rock is usually of grey or greyish blue color; but when within ten miles of the Niagara, it again assumes the very dark, almost black color of the mass in Seneca county.

At Black Rock, where so well developed, the mass consists of calcareous matter in irregular wedge-form layers, separated by thin laminæ of shale. In some instances the siliceous portions are equal to the calcareous, and both are blended in the most heterogeneous manner. It is separated from the terminating rock of the Salt group, by a layer of grey limestone about fourteen inches thick.

It will be observed, that in all cases where this rock is highly developed, the Onondaga limestone, the next rock below, is but meagrely so. For all practical purposes, in the Fourth District, the two masses may be considered as one. They are intimately connected, forming together the Limestone Terrace, and there are few good localities where both are not to be seen. In lithological character, there is scarcely more difference between the Onondaga and the Corniferous, than in different parts and different localities of the latter rock.

The fossils of the two rocks in many instances blend together, or more properly the Favosites and other corals of the Onondaga occur in the central part of this rock. The upper part, however, is always distinguished by its organic contents, as will be seen under that head.

Localities. — The occurrence of this rock almost continuously through the district, offers numerous localities for its examination. A few of these may be indicated, as affording better exhibitions of the strata than others. The numerous quarries mentioned in Seneca county, are all interesting localities. The bed of Flint creek at Vienna, the outlet of Canandaigua lake, and the bed of Mud creek, all offer interesting points for examination. At the village of West-Mendon, the strata are well exhibited, though few fossils occur. To the south and west of the village of Caledonia, and the whole distance between this point and Le Roy, there is a fine exposure of the rock. The bed of Allen's creek at Le Roy, as far as the falls, affords perhaps the best exhibition of the strata in the district.. At Clarence Hollow, this rock contains a few fossils not elsewhere seen. In the vicinity of Williamsville, and at several points between this place and Buffalo, to the south of the turnpike, the upper part of this rock is well developed. It is peculiarly interesting from containing numerous fossils of the genera Strophomena, Delthyris, and Pleurorhyncus. At Black Rock, the lower part of the mass is very fully developed, and presents many interesting fossils.

The places enumerated will give a very perfect idea of the character of this rock; indeed, two or three of these localities are sufficient to present its most characteristic features.

Thickness. — The point of greatest thickness actually measured is on Allen's creek, where it is seventy-one and a half feet. At the eastern extremity of the district, the thickness cannot be more than half this, and at some points I have estimated it at thirty feet. At Black Rock there is about twenty-five feet laid open to view; but the higher part of the rock is not visible, and from the deep alluvion covering it farther east, it cannot be correctly estimated. The increased thickness in many instances seems due to the augmentation of the hornstone, which is exceedingly variable, often being collectively less than six feet, and again amounting to four or five times as much.

Mineral contents of the Corniferous limestone. — The mass presents few simple minerals, besides those which form an essential part of its composition. The hornstone sometimes passes into chalcedony, and crystallized quartz is rarely found. In the cavities in this rock at Black Rock, dogtooth spar sometimes occurs. Fluid bitumen, or petroleum, occurs in the same situation, usually filling the cells of the Favosites, from which, when broken, it often exudes in considerable quantity.

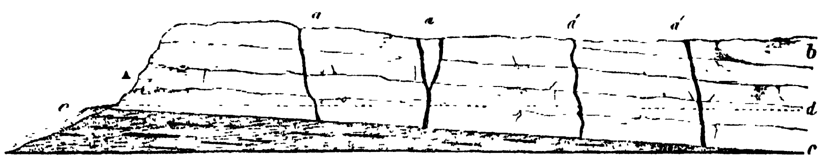
Springs.

This is one of the most interesting rocks in regard to the production of springs. As before described, the rock is crossed by vertical joints in two directions. The planes of these joints are usually separated several inches, and often several feet toward the northern margin of the rock; and by enlargement within, they sometimes form the entrance to a cavernous expansion. The soil above being usually thin, the water readily finds its way into these fissures, and passes off beneath. From this circumstance, it is often difficult, or nearly impossible, to obtain water by digging wells, unless the rock is blasted to great depth.

The water passes downward till it comes to an impervious stratum, where it is held up, and rising in the fissures till it can find some outlet, gushes out at the northern edge of the escarpment, in the form of numerous copious springs, which are among the most prominent, as they are often the most interesting and refreshing feature to the toil-worn geologist, as well as to the inhabitants of the place. The upper part of this outcropping edge often presents the most dry, barren, and uninviting appearance; while a few feet below, the surface is fresh and green, the soil moist, and little springs gushing out at every step.

The process by which these springs are produced, will be understood by the following diagram:

66.



The water passes down through the fissures *a*, *a*, to the impervious stratum *c*, where it accumulates till of sufficient height to flow over its northern edge at *c*, forming springs which are constantly supplied from the inexhaustible fountain in the fissures and cavities of the limestone. The water often accumulates in these fissures to a considerable height above the spring, particularly where the face of the cliff *A* is deeply covered with drift.

On the land of Mr. Stevens in the town of Clarence, Erie county, there is a broad fissure by which one can descend to a cavernous opening below. This in the spring, or during rainy seasons, is filled to within a few feet of the surface with water, which during the dry season of summer gradually subsides, as the discharge by the springs is greater than the supply from the surface. During the winter and spring, from the rains and dissolving snows, these fissures become quite filled, and frequently the water rises above the surface, forming little ponds in depressions half a mile south of the outcrop, in the position of *á*, *á*. At these seasons a greater quantity flows out by the springs and other openings on the north than usual, and the equilibrium is soon restored.

Where the soil is thin above the limestone, the course of these joints is indicated during the dry season by the freshness of the grass and herbage growing along their direction. The evaporation of the water below moistens the soil covering the joints, and consequently it retains the same freshness as where moistened from above, while the surrounding portions become dry and parched. Where the rock is thin and more deeply covered with soil, these features are not discernable.

In several instances streams flowing over this rock disappear in the fissures, and afterwards reäppear at some more northerly point. Allen's creek, at Le Roy, disappears in this manner a little north of the village, so that in summer and autumn the bed is entirely dry below. After thus disappearing, it evidently takes some other course, for it does not appear in the same channel below the falls for some distance. It is a favorite belief with many that this stream rises again in the Caledonia spring, seven miles distant; but the only facts advanced are the disappearance of the one, and the occurrence of the other with no apparent origin.

The Caledonia spring, from the great quantity of water it affords, is evidently the common outlet for a large area in its vicinity; but whether it is supplied from so great a distance as Le Roy, may be questionable. To the west and southwest of Caledonia the surface in wet seasons presents numerous small lakes or ponds, which drain off into the fissures below; and it is evident, from the nature of the rock, that there is a large reservoir constantly maintained.

The springs at Canoga, in Seneca county, owe their origin to the same cause, as also those at Springport, on the opposite side of the lake.

Agricultural characters.

The character of the soil covering this rock varies, to a considerable degree, according to its development. Where the rock is thin, as in the eastern part of the district, it scarcely produces any effect upon the surface; but where thicker, it has essentially modified the character of the soil. In Seneca county the soil covering the northern part of this rock is clayey, but becomes more loamy toward the southern part; in the western and central part of the county it is frequently covered with a loamy soil, but the characters appear entirely due to the accumulation of northern drift.

Where the rock becomes thicker and the quantity of hornstone greater, it has produced a coarse siliceous or silico-calcareous soil, from the destruction of the rock in the manner before described. The surface in such cases is often forbidding, from the great quantity of fragments of the "chawed rock," as it is termed; but where the larger of these are removed, the soil proves of the best quality. The constant destruction of the larger fragments by the action of frost and water liberates fresh calcareous matter, which must constantly act as a fertilizer.

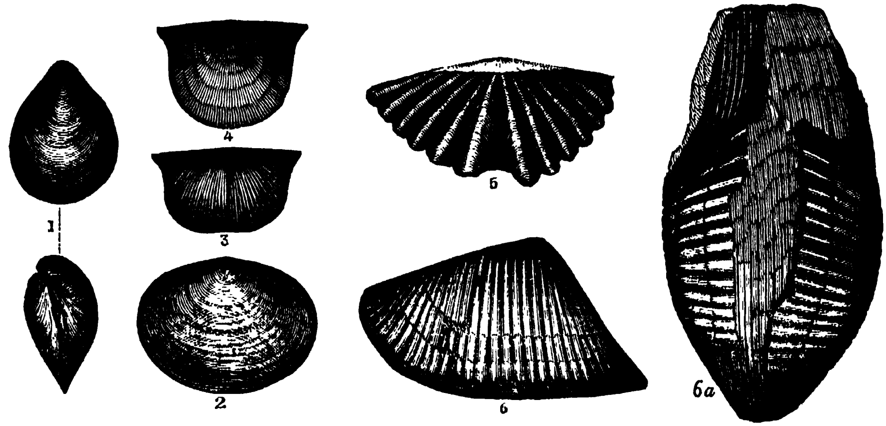
Organic Remains of the Corniferous Limestone.

The central and lower portions of this rock usually exhibit few forms which are peculiar to it, though they serve, from their association, to aid in the identification. In the higher portions, which are nearly or entirely free from hornstone, the fossils are peculiar, and serve at once to identify the rock, being known in no other. Among these fossils are two trilobites, the *Odontocephalus selenurus* of Green, and a *Calymene*. So abundant is the former of these at Schoharie and other places, that it alone is the fossil entirely relied on, and the rock is known as the "*Selenurus Rock*." The other trilobite is scarcely less characteristic. In many places in the Third District, and in Seneca county in the Fourth District, the *Strophomena lineata* of Conrad is the typical fossil, but it rarely occurs at any point west of the last named locality.

There are several species of the genus Cyrtoceras which are apparently confined to this rock, and in the eastern part of the State are common, while in the Fourth District they are but occasionally seen, other forms taking their place.

The following illustrations present some of the most common forms of this rock in western New-York, though there are many others which perhaps are equally abundant.

67.



1. Atrpya scitula.
2. Paracyclas elliptica.
3. Strophomena acutiradiata.
4. Strophomena crenistria.
5. Delthyris duodenaria.
6. Pleurorhyncus trigonalis.
6 *a*. Pleurorhyncus trigonalis.

1. *Atrypa scitula*, n. s. — Obovate, compressed towards the base; lower valve very convex, with a produced incurved beak; upper valve convex in the middle, with a small, rather prominent beak. The shell is very glabrous, with faintly perceptible concentric lines; it may be distinguished from any other in the rock, by the extension of the beak of the lower valve.

Locality—Williamsville, Erie county.

2. *Paracyclas elliptica*, n. s. — Shell broad oval; beaks scarcely prominent; surface marked by concentric lines; valves equally convex; very much elevated on the umbones. Shell the size of the figure, and larger; it is readily distinguished by the figure alone.

I am indebted to Dr. Everitt, of Batavia, for specimens of this fossil.

Generic name from its similarity to the *Cyclas*.

Locality—Le Roy, Genesee county.

3. *Strophomena acutiradiata*, n. s. — Lower valve convex, slightly impressed in front and on each side; hinge line extended beyond the width of the shell, and obtusely angulated at the extremities; surface covered with sharp striæ, which bifurcate toward the margin.

Locality—Five miles east of Buffalo. Very abundant in the higher strata of the rock.

4. *Strophomena crenistria*, n. s. — Semi-oval; lower valve slightly convex; upper one nearly flat; surface covered with fine diverging striæ, the spaces between which are crossed by concentric lines; upon the striæ, these lines produce elevated points or crenulations; hinge

line slightly arched, extending beyond the width of the shell, and obtusely angulated. The surface is marked by a few concentric lines of growth.

See also a figure of the same shell in the Hamilton Group.

Locality—Vienna, Ontario county.

5. *Delthyris duodenaria*, n. s. — General figure semicircular; valves nearly equally convex: mesial fold much elevated towards the front; ribs 12, gradually decreasing in size from the centre, rounded, and crossed by concentric undulating lines.

The specimen is imperfect, and though the fossil is abundant, I have never been able to obtain a perfect one. It is readily-known by the number of its ribs and the undulating lines. Resembles *D. raricosta* of Conrad, the *D. undulatus* of Vanuxem (Report, p. 132), but differs from that in form and in the number of ribs. Concentric lines often obsolete.

Locality—Five miles east of Buffalo, and at other points on the Macadam road.

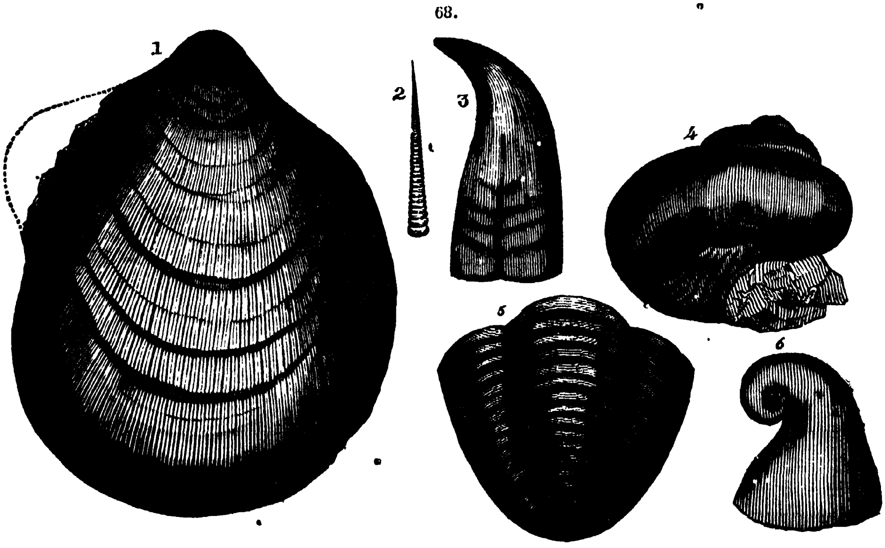
6. *Pleurorhyncus trigonalis*, n. s. — Sub-triangular; beaks little elevated; surface marked by about 20 ribs, some of which are divided; anterior surface broadly cordate; posteriorly slightly elevated and conoidal.

2 *a*. A view of the base, showing a portion of the shell remaining, which extends anteriorly beyond the cast, and is striated. This appears like a kind of sheath, which has apparently no opening upon the base.

This shell is certainly unlike the *P. cuneus* of the Schoharie grit.

Locality—Williamsville, Erie county.

68.



1 Pterinea cardiiformis. 3. Orthonychia. 5. Calymene crassimarginata.
2. Tentaculites scalaris. 4. Euomphalus? rotundus. 6. Acroculia erecta.

1. *Pterinea? cardiiformis*, n. s. — General figure cordiform; valves equal; posterior margin alate; cast of wing gibbous; surface marked by fine radiating striæ, and crossed by prominent lines of growth; beaks large and prominent. Wing imperfect in the specimen figured.

The shell is perfectly preserved upon the specimen figured, which is from the cabinet of Mrs. Ransem of Clarence Hollow. Several perfect casts were found in the same vicinity. It closely resembles a species of this genus in the Oriskany sandstone. It is with some hesitation that I refer this fossil to the genus *Pterinea*, being inclined to consider it distinct.

Localities—Clarence Hollow, and one mile west of this place.

2. *Tentaculites scalaris*, Schloth. (*Silurian Researches*, p. 643, pl. 19, f. 16.) — Subulate; composed of a series of truncated cones, with their bases towards the apex of the shell. Each higher joint appears to proceed from within the one below, "forming a set of steps rather than rings, like the sliding joints of an opera glass."

In England this fossil is abundant in the Caradoc sandstone, as it is in New-York in the Hudson river group; and Mr. Murchison remarks, that "it is not possible to distinguish this body from the *Tentaculites* of the Ludlow formation." The one figured holds a place more nearly equivalent to the latter formation.

Locality—Le Roy, Genesee county.

3. *Orthonychia*.* — Tapering, slightly curved above; obtusely angular, having the form of a claw or talon, as the generic name indicates.

There are several forms similar to this in the limestones of the Helderberg division.

Locality—Near Williamsville, Erie county.

4. *Euomphalus? rotundus*, n. s. — General form spheroidal; last whorl very much expanded; rapidly tapering to the summit, which is moderately elevated; umbilicus large.

The figure is from a cast. Shell striated.

Locality—Clarence, Erie county.

5. *Calymene crassimarginata*, n. s. — The abdomen and caudal portion of this fossil is of frequent occurrence in this rock. There are about sixteen articulations visible in the middle lobe, and two or three more on the lateral ones. It is distinguished by its great convexity, the prominence of the middle lobe, and the thick margin. The middle lobe is rather flat, and the articulations extend nearly straight across, bending more suddenly down at the sides. The articulations toward the extremity are often scarcely visible in the cast.

This fossil is one of those forms typical of this rock throughout Ohio, Indiana and Kentucky.

Localities—Near Williamsville, Clarence, Caledonia and Avon.

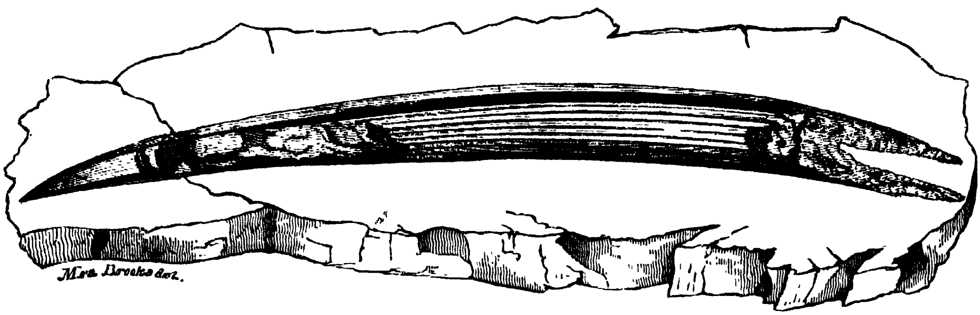
* A new genus, which I have adopted on the suggestion of my friend Mr. S. S. Haldeman, and which will include several forms analogous to this. See forthcoming Palæontology for description.

6. *Acroculia erecta*, n. s. — Erect; incurved at the beak, forming nearly two whorls; rapidly expanding below. The surface is sometimes crossed by undulating lines. This is by no means a rare fossil, though sometimes less incurved at the apex.

The form of the fossil is perfectly represented, though its more minute characters could not be, in consequence of the badness of the wood.

Localities—Five miles east of Buffalo, Williamsville, Le Roy and other places.

69.



Ichthyodorulite.

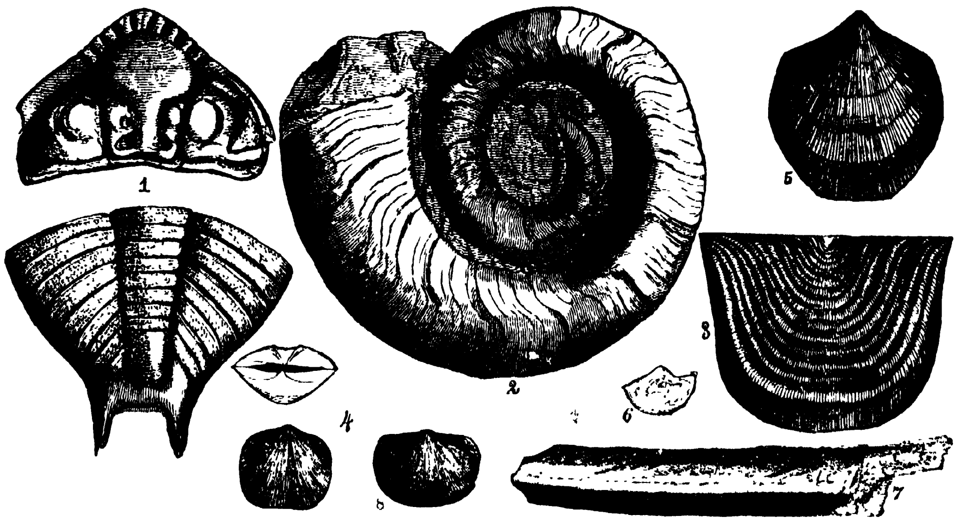
The illustration above is the most perfect specimen of this kind of fossil seen in the district. The specimen is slightly arched, and carinated upon the back; the surface is marked by parallel grooves and ridges, which extend nearly to the point; the latter is smooth, and finely finished. The specimen is 5½ inches in length.

Locality—Freedon, Ontario county.

There is a much larger specimen of a different species, in the cabinet of David Thomas of Aurora, which was obtained at the quarries near Waterloo. Mr. Skaats of Geneva informs me that he has seen a specimen from the Waterloo quarries, more than eight inches in length, and curved nearly into a semicircle. The surface was smooth, except an angular ridge along the centre.

The following woodcut is from the Report of Mr. Vanuxem, and exhibits the prevailing forms in this rock in the Third District:

70.



1. Odontocephalus selenurus.
2. Cyrtoceras undulatum.
3. Strophomena undulata.
4. Orthis lenticularis.
5. Atrypa prisca.
6 & 7. Ichthyodorulite.
8. Strophomena lineata.

1. *Odontocephalus selenurus.* — The post abdomen and caudal extremity are of frequent occurrence in the Fourth District.

2. *Cyrtoceras undulatum.* — Specimens of this genus have been seen at Waterloo, Caledonia and Le Roy.

3. *Strophomena undulata.* — This is a common fossil in many places, usually tinged of a reddish or bronze hue.

3. *Orthis lentiformis*, has not been seen in the district.

5. *Atrypa prisca*, is one of the most common and abundant fossils.

6 & 7. *Ichthyodorulite*, and section of the same. This has not been seen in the district.

8. *Strophomena lineata.* — This is an abundant fossil in Seneca county, but is very rare farther west.

Nos. 1, 3 and 8, may be considered as characteristic fossils in the Fourth District.

With the termination of the Corniferous limestone end all the important limestones of the New-York System. The calcareous deposits which occur in a higher position are, for the most part, thin and rarely persistent over a great extent. The constancy and wide extent of the beds just described renders them one of the best horizons of reference in the whole system. The subsequent deposits are of a nature quite different, and the organic contents are, for the most part, unlike those of the limestones. Over the whole area known to be occupied by the Corniferous limestone, there is an abrupt change from that rock to a black fissile argillaceous slate; while fossils, which have been abundant in the limestone, either cease entirely or are succeeded by others of a totally different character.

The Marcellus shale is the commencement of what may be considered as one great period of the New-York system, the materials of which are very unlike in different parts, or isolated portions; but viewed as a whole, present a general similarity in the products and their causes. The variation in lithological character is attended by a greater or less change in the character of the fossils; and though every successive division is strongly marked by its peculiar organic types, still some species of the lower divisions may always be found. The line of demarkation between these divisions is sometimes, and in some places, well defined, while at others there seems a gradual merging not only of the lithological products, but also of the fossils. The divisions heretofore enumerated in the Fourth District are sufficiently well marked throughout its extent, while at the east they are gradually less distinct, until at last in many places there is no distinguishable line of separation.

This arises both from the greater similarity of lithological products throughout, which the whole presents at the east, and also from the gradual ascent of some of the fossils which at the west are confined to lower divisions. This will be made more apparent under the description of the several subdivisions.

The whole series, from this point as far as the base of the Old Red Sandstone, seems to have been coeval and coëxtensive. All the members gradually diminish in thickness in a west and southwest direction, and the fossils of all seem to keep pace with this diminution, until at last the mass is nearly or quite non-fossiliferous. At their eastern commencement the lithological character is similar throughout the greater part of the mass, but as we progress westward we find a gradual separation, the more shaly portions with some calcareous matter taking the lower position, while the sandy and the alternations of shaly and sandy deposits hold a higher place. This character is maintained nearly the whole distance to the Mississippi river.

23. MARCELLUS SHALE.*

Lower part of the Pyritiferous rock (Third Graywacke) of EATON. *Marcellus Shale and Black Shale of the Annual Reports.*

(LOWER PART OF No. 8, PENNSYLVANIA SURVEY. BLACK SLATE OF THE OHIO REPORTS.)

[See Sections Plate 7 and Plate 13, No. 3 and 4; also woodcut, page 27.]

This rock admits of two divisions. The lower is very black, slaty and bituminous, and contains iron pyrites in great profusion; some portions are calcareous, and it is always marked by one or more courses of concretions or septaria, which are often very large. This division terminates upwards by a thin band of limestone, above which the shale is more fissile, and gradually passes from black to an olive or dark slate color.

In general characters the lower part resembles the Utica slate, and is not distinguishable from the Genesee slate in its general aspect; it is, therefore, more properly a slate than a shale, if the distinction is to be continued. For practical purposes, there is little advantage in separating the upper division of this shale from the Hamilton group. The line of separation is nowhere well marked, the change in lithological character being gradual, while some of the fossils continue from one to the other.

The finely levigated mud composing this rock indicates a period of great tranquillity in the waters, moved probably only by currents sufficient to transport the materials over the wide extent we find them. The nature and condition of the fossils also indicate a quiescent period; for their forms are among the most delicate, and their parts are usually preserved in the greatest perfection. In some instances, however, from their great numbers, they are packed closely together, and fracture on the separation of the laminæ.

This rock occupies the depression which extends along the southern border of the Corniferous limestone, and from two to three or four miles south of its outcrop. From its soft and destructible nature, it is only exposed in ravines and water courses, and from these situations we obtain a knowledge of its characters. The lower part, when long exposed, weathers to a brownish or iron rust color, partially from the presence and decomposition of iron pyrites, and partially from bituminous matter. In some situations it retains its purely black color, and scarcely separates into slaty laminæ after long exposure.

In many places, this rock contains so much bitumen as to give out flame when thrown into a fire of hot coals. From this character, and its black color, it has been considered an in-

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* In Ohio, Kentucky and Indiana, a rock possessing the same characters, and apparently holding the same place as this one, is known as the "Black Slate;" and this term seems more appropriate than Shale, since the rock is everywhere slaty in structure. In lithological aspect it is undistinguishable from the Genesee slate of New-York; but since the term Shale has been adopted, it is followed in this report.

dication of coal; and throughout the district, and even the whole length of the State, it has been bored or excavated in search for this mineral. This example affords an exemplification of the reasoning and practice in the absence of geological knowledge, and shows most clearly the benefits which may be derived from understanding the order among our rocks, and the true place of the coal-bearing strata.

This rock first appears in the district in Seneca county, where it succeeds the Corniferous limestone. There are one or two natural exposures of the same south of Waterloo village, and it approaches within a few feet of the surface entirely across the county. The portion most exposed is black and very fissile, separating into thin laminæ, from the presence of great numbers of a smooth Avicula, which is everywhere an abundant fossil of this rock. It is exceedingly thin and fragile, and usually appears in fragments upon the surface of the laminæ. Its form is obscure, though when perfect there is no doubt of its character.

In the excavation of wells a short distance south of the point where the limestone disappears, this shale is usually thrown out; and it can always be distinguished by the shell just mentioned, and flattened fragments of an Orthoceras, as well as by its peculiar black color.

The same rock appears about two miles south of Vienna, in the banks of Flint creek. The portion exposed is very fissile from weathering, and its color externally is somewhat greyish. The same thin stratum of limestone which holds a place in the shale in other places, appears at this locality. It contains a large number of Orthoceræ and a species of Euomphalus, but the interior is usually lined with crystalline matter, and the shell is very fragile. At this place I found a fragment of the *Dipleura Dekayi*, which is the lowest position in which I have seen this fossil. The shale also appears about two miles southeast of Vienna, and near the point where the limestone disappears beneath the surface.

The bed and banks of Flint creek in Bloomfield exhibit this rock in a good degree of perfection, and well marked by its peculiar fossils. The outlet of Conesus lake, a little west of the village of Avon, is one of the best exposures of the rock in the district. The lower part is black and fissile; about twenty feet higher, the mass is more compact, very black, and highly bituminous. It contains large accretions of siliceous limestone, which are sometimes quite pure, at others intermixed with shale. The stratum of limestone is compact, about a foot in thickness, and filled with fragments of fossils. The rock just below and above this limestone is very fissile, readily separating into broad slaty laminæ, the surfaces covered with organic remains.

On the west side of the Genesee river, it appears about two miles south of Caledonia village, where it has been bored in several places in search of coal. At this place, and a short distance farther north, it presents its usual characters both of compact and fissile structure.

At Le Roy village, this rock is well exposed to view in the bed of Allen's creek. The lower part of the shale is mostly compact, with little tendency to lamination, while the higher portions are very fissile. It contains a great abundance of concretions or Septaria, which are plentifully distributed through the mass at about the level of the creek, and below the fossiliferous portion of the rock. These concretions are of a siliceous limestone, apparently resulting from a small quantity of the material spread over the surface, which being too little to constitute a continuous stratum, assumed this form. The continuous stratum of limestone before noticed appears at this place, having the same character as elsewhere. The shale above it is very fissile, separating into thin laminæ, and abounding in fossils.

The lower part of the mass, on weathering, becomes iron-stained; but that portion above the limestone weathers to an ashen hue.

A little west of the village, the shale approaches the surface so nearly that it blackens the soil along the road.

West of Le Roy, there are few good points where this rock can be seen. The great depth of alluvion about the point of its junction with the Corniferous limestone has generally obscured the lower portion. At Alden and a few other points in Erie county, the upper part of the slate, abounding in Tentaculites, can be seen. The deep excavation along the valleys of Cayuga and Seneca creeks near Buffalo, and the depth of the drift and alluvion, effectually conceal this rock, though the Hamilton group above is well exposed.

Localities. — The two principal localities in the district, and those to which an observer should direct his attention, are the ravine of Conesus outlet, a little west of the village of Avon; and the bed and banks of Allen's creek, near Le Roy. At the former place, the absolute contact of the Marcellus shale with the limestone below is seen beneath a sawmill, where the rock is exposed. Its extent upwards is well exhibited, and its peculiar fossils can all be obtained. At Le Roy the same features are exhibited, and its connexion with the limestone is distinctly seen.

There are no other localities in the district, where the connexion with the lower rocks, and the characters of this, are so well exhibited.

Thickness. — The greatest thickness of this rock, where it can be measured accurately, does not amount to more than fifty feet; but as before stated, it gradually merges into the olive shales above. In the Third District, this shale is much thicker.

Minerals. — This rock contains no minerals of importance. Sulphuret of iron is everywhere found. Sulphate of baryta often occurs in the septaria, and crystallized carbonate of lime in the same situation, and lining the cavities of fossil bodies.

Springs. — From the presence of iron pyrites, the water flowing over, or rising from fissures in this rock, is often charged with sulphuretted hydrogen, though there are no copious springs.

Agricultural characters. — The shale alone, on decomposing, produces a clayey soil; but its width being small, and the accumulation of drift at this point being excessive, it rarely gives character to the surface soil for any considerable extent.

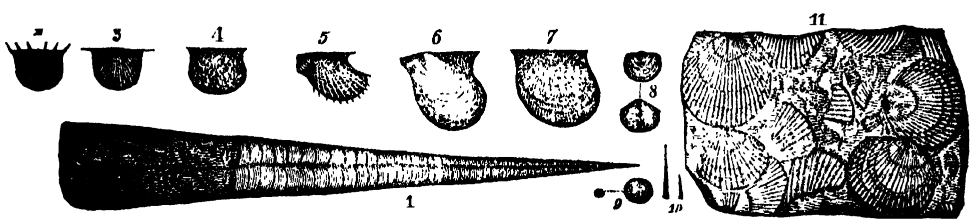
Organic Remains of the Marcellus Shale.

Nearly all the fossils are of small size and very delicate structure, indicating, as does the finely levigated mud in which they are imbedded, a quiet condition of the ocean in which they lived. These delicate forms are preserved in the greatest perfection, the most fragile shells being often as perfect as when living.

This character of small size of the fossils does not apply to the rock everywhere; for in the Third District it contains some goniatites, larger than in any other rock in the State.

The more common fossils met with, and those which are typical of the rock, are presented in the following illustration. So far as can be ascertained, these forms are all undescribed, with the exception of the last, which was named in the Report of the Third District. These occur at the two localities mentioned as the best points of observation, where they are very abundant, as well as many others not here figured.

71.



1. Orthoceras subulatum.
2. Strophomena setigera.
3. S. mucronata.
4. S. pustulosa.
5. Avicula muricata.
6. A. lævis.
7. A. equilatera.
8. Orthis nucleus.
9. Orbicula minuta.
10. Tentaculites fissurella.
11. Atrypa limitaris.

1. *Orthoceras subulatum*, n. s. — Shell tapering to an acute point, smooth; septa numerous, slightly arched on each side of an impressed line, which extends the whole length of the shell. There is usually about one-third of the shell where no marks of septa are visible.

This fossil is usually much flattened, and often replaced by iron pyrites, which from decomposition prevents the septa from being visible. It is apparently the only species in the rock.

Localities — Bloomfield, Le Roy, Avon, Seneca lake.

2. *Strophomena setigera*, n. s. — Shell semi-oval, marked by numerous fine radiating striæ, and a few concentric lines of growth; beak scarcely elevated; hinge line with six flexuous spines, which appear like bristles. The extent of the hinge line is proportionally much less than in *S. cornuta* of the Clinton group; the striæ are also coarser.

N. B. The spines are too short and rigid in the figure, but there has been no time to have it reengraved.

Locality — Avon.

3. *Strophomena mucronata*, n. s. — Shell semi-oval, with coarse striæ, which radiate from an imaginary point beyond the beak; beak of the lower valve elevated; hinge line extended into a kind of spine.

This shell is readily distinguished by its coarse striæ, which do not radiate from the beak, and the peculiar extension of the hinge line.

Localities — Avon, Indian reservation, Erie county.

4. *Strophomena pustulosa*, n. s. — Shell semi-oval, contracted beneath the hinge line; surface covered with wrinkles and pustules, without striæ; hinge extremities angulated.

The surface appears as if it may have been covered with spines, but I have not been so fortunate as to observe them. The shell when present is of a pearly hue, and readily separates, leaving a cast of the fossil. It is quite abundant.

Locality — Avon, Livingston county.

5. *Avicula muricata*, n. s. — Obliquely ovate; surface marked by elevated, radiating and concentric lines, giving a cancellated appearance; from the junction of these lines rises a short spine; posterior wing small, produced into a short acute spine; anterior wing obtuse, with an oblique fold.

The radiating lines are very faint on the posterior wing, and are not visible on the anterior wing. The small spines are usually broken off, except on the margin. This beautiful fossil will be readily identified from the figure.

Locality — Avon.

6. *Avicula lævis*, n. s. — Obliquely ovate, with the hinge line slightly deflected on the anterior side; beak convex, rather prominent; surface smooth, or marked with fine concentric lines of growth; posterior wing triangular, abruptly acute, extending nearly in line with the margin of the shell; anterior wing obtuse, with a slight plication.

This is a beautiful smooth shell, strongly contrasting in its surface with the last, both often being found together.

Localities — Avon and Bloomfield.

7. *Avicula equilatera*, n. s.— Obliquely semi-elliptical or sub-rhomboidal, nearly flat; hinge line straight, extending equally on each side of the beak; surface covered by radiating striæ, which are concentrically decussated by numerous elevated lines of growth.

The wings are less distinctly marked than is usual in species of this genus, which with the equilateral character readily distinguish it. The whole surface is regularly cancellated by the radiating striæ and elevated lines of growth.

Localities — Avon and Bloomfield.

8. *Orthis nucleus*, n. s. — Hemispherical; lower valve very convex, with a depression or sinus from beak to base; upper valve flat, marked with concentric lines of growth, and fine striæ; hinge extremities rounded.

This is a very abundant little shell, often forming thin courses, with scarcely the intervention of sufficient shale to make them cohere. It much resembles the *Spirifera unguiculus* (PHIL. *Paleozoic Fossils*, p. 69, fig. 119), and *Orthis umbonata* (CONRAD, *Jour. Acad. Nat. Sci.* Vol. viii, p. 264, pl. 14, fig. 4). The beak is much less prominent, the hinge line less extended, and the shell smaller than the last named shell.

9. *Orbicula minuta*, n. s. — Orbicular; surface marked by concentric lines.

This fossil is exceeding abundant, often nearly covering the shaly laminæ for several inches in thickness. They appear like small black specks or points. The larger figure is its maximum size. It is remarkably persistent in the district, being known at the most extreme localities.

Localities — Avon, Le Roy, Bloomfield and numerous other places.

10. *Tentaculites fissurella*, n. s. — Minute, almost microscopic; annulated above, and smooth near the base. When sufficiently magnified, a slit is perceived on one side, extending one-third or more of the whole length.

This fossil occurs in myriads, and, although so exceedingly minute, it forms layers several inches thick, extending many yards, and apparently many miles, it being equally abundant at distant localities. The layers which it forms are exceedingly fragile, and crumble on the least exposure to moisture.

Localities — Avon, Le Roy, Waterloo, Alden.

11. *Atrypa limitaris*. (*Orthis limitaris*, Geol. Report of Third District, p. 146, fig. 3.) Compressed, somewhat circular; surface covered with radiating ribs of nearly equal size.

This shell is exceedingly abundant in the upper part of the shale; the stratum, for considerable thickness, is completely charged with them, and they are often associated in great numbers with *Orbicula minuta*. The specimen figured is a fragment of this kind, which presents the fossil as it usually appears in the rock. It will be readily recognized.

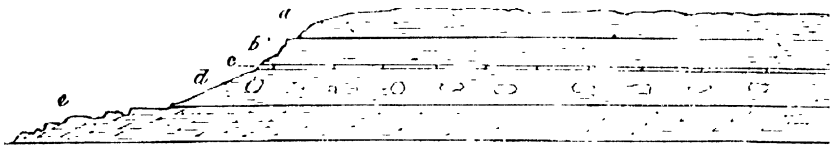
Localities — Waterloo, Vienna, Avon, Le Roy.

In addition to these fossils, there are two or three univalves which occur everywhere; one of these is a Goniatite, but from being replaced by iron pyrites which is in a decomposing state, it is impossible to define it. The large Goniatites figured in the Report of the Third District, page 146, as occurring in this rock, have not been seen in the Fourth District.

Localities of superposition.

The following woodcuts illustrate the relative position of this rock in the Fourth District :

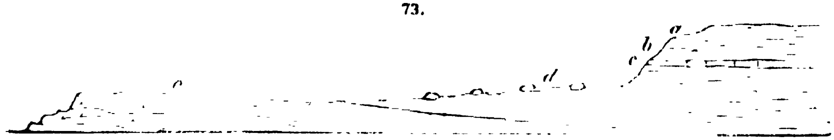
72.



Section on the outlet of Conesus lake, one mile west of West-Avon, Livingston county.

a. Shale of Hamilton group.
b. Black and olive shale of the Marcellus, gradually passing into that above.
c. Stratum of limestone with fossils. The shale above and below this limestone is highly fossiliferous.
d. Black bituminous shale with large septaria. *Atrypa limitaris* occurs in the lowest layers, resting on the limestone *c.*
e. Corniferous limestone.

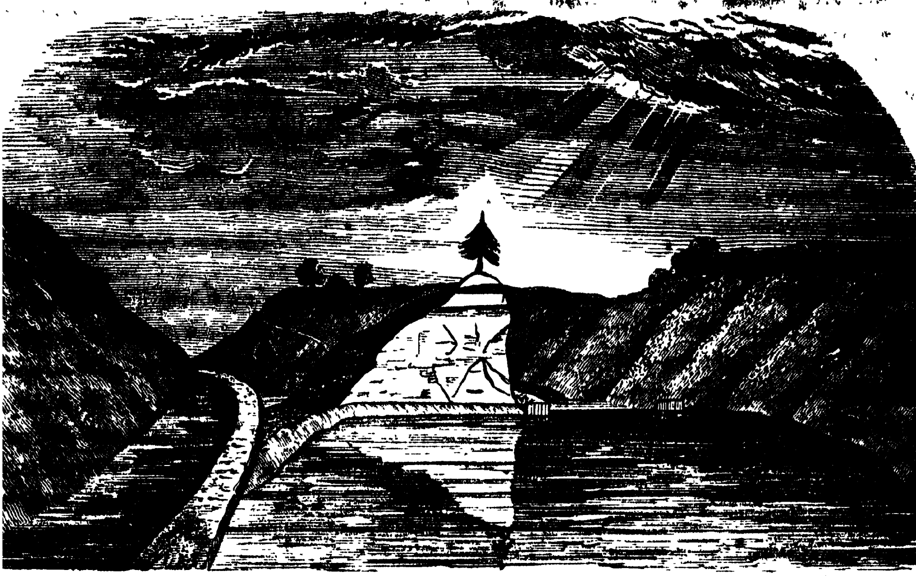
73.



Section of the bed and bank of Allen's creek, at Le Roy village.

a. Shale of Hamilton group.
b. Bluish and dark shales of the Marcellus.
c. Stratum of limestone, one foot thick.
d. Black slaty and compact shale with septaria. Bed of creek.
e. Corniferous limestone, forming the bed of creek as far as the falls.

74.



View of Sugarloaf Hill, at Hopeton, on the Crooked Lake Outlet. From a drawing by Mr. E. N. Horsford.

24. HAMILTON GROUP.

This group at present includes the *Pyritiferous rock* and *Third greywacke* of Eaton; *Ludlowville, Moscow* and *Skaneateles shales; Dark slaty fossiliferous shales, Compact calcareous blue shales, Olive shales, Shales near Apulia and Sherburne; Cazenovia group, Encrinal limestone, &c.* of the Annual Reports.

(Part of No. 8, Pennsylvania Survey.)

[See Coast Section of Lake Erie, Plate 5, and Section along Cayuga lake, Plate 7; also *O* of woodcut, page 27.]

This group consists of several members which may be considered distinct, but which, when viewed in connexion, present so many features in common, that they are all recognized as the products of one period, and thus constitute one great group. In the Fourth District, the only changes recognized in lithological products are from shaly to calcareous, with occasional thin beds of limestone, and more rarely of sandy shale.

The group, as a whole, presents an immense development of dull olive, or bluish grey calcareous shales, which, on weathering, assume a light grey or ashen tint; some portions become brownish on exposure, but these are of small thickness in this district. At a few points the shale becomes darker, or black, and exhibits a tendency to slaty structure; but as a general character, the cleavage is irregular, and oblique to the planes of stratification. On weathering, where the edges are exposed, there is manifested a slight tendency to slaty cleavage.

From the wide and even distribution of the materials of this group, it was evidently produced during a period of great tranquility, when the finely levigated mud was transported over wide areas by gentle oceanic currents. The great profusion and variety of organic forms proves also the quiescent condition of the ocean, which, together with the slightly calcareous nature of the mud, favored the growth and distribution of the Testacea.

The upper part of this group, in the Fourth District, bears a very close analogy in its lithological nature to the shale of the Niagara group; and in abundance of organic remains, it is even more prolific. The forms of the latter are, however, of entirely different species, though corals and shells of similar genera abound, and trilobites of the same and different genera.

Concretions or septaria, in well defined and often fantastic forms, are common in every part of this group. In many instances the calcareous matter has concreted around some organic body, or a nodule of iron pyrites seems to have been the centre of attraction. In such instances, we often find numerous fossils imbedded in them, or attached to their outer surface. The greater number, however, are well defined spheroidal masses, with or without seams of crystalline matter, and not containing any organic body. Others, and particularly in the lower part of the shale, are small, spherical or elongated, and with a small perforation through their centre, in the manner of the common nodules or other concretionary forms in recent clay beds.

Organic forms abound throughout the group, but they vary somewhat in the different parts. In the lower division, the most abundant are those of Orthis, Atrypa and Strophomena, with some spiral univalves; while above this portion, great numbers of Avicula, Cypricardia, Nucula, and other similar forms abound, with fewer of the genera Orthis, Delthyris, &c. In the next division, Delthyris, Strophomena and Atrypa abound, to the almost entire exclusion of the forms before mentioned. In the same situation with these we find numerous species of corals: Cyathophylli, Favosites and other forms, are abundant; while fragments of crinoidal columns are every where scattered through the mass, or spread evenly over the surface, form thin layers of themselves. Many of the species of this division are discontinued, and their place supplied by others of the same genera in the higher part of the group. The principal characteristic forms of each division will be found under the head of Organic remains of the group.

Although this group is so widely spread and evenly distributed, and of uniform character over the western part of the State, still at its eastern extremity the lithological character is widely different. The shales are more or less arenaceous, and some parts are well marked sandstone. The proportion of siliceous and argillaceous earth is nearly reversed from what it is in the same rocks farther west. The mass varies from sandy shale to shaly sandstone, and even tolerably pure sandstone. This character gradually changes to the westward, the sand diminishing and the clay increasing. The features presented by this group at its two extremes, and along its whole length, offer one of the most instructive exhibitions of the varying character of mechanical deposits. The facts prove the origin of the materials to have been at the east or southeast. The force of the current which drifted them into the ocean was sufficient only to carry onward the coarser particles to a certain distance, where they were deposited. The finely levigated mud was carried beyond this point, being floated by less force than the sand. Some portion of the clay was deposited with the sand toward the central part of the State, and but little of the latter extended beyond this point. Finally the current became more gentle, and the clay was deposited to a certain extent, beyond which the power of the current was insufficient to carry even this material, and the deposit consequently thinned out in that direction.

Nothing could be more analogous than this to the simple operation of a powerful stream conveying detritus into the ocean. The force of the stream is at once checked as it flows into the larger body of water, and the coarser materials are thrown down. From this point its force is gradually diminished as it progresses, and the coarser particles of the remaining matter are precipitated, until finally it loses its force entirely, and the materials before in suspension fall to the bottom. Matter like finely levigated clay, however, falls slowly to the bottom of a deep ocean, and in this way it may be carried on hundreds of miles, although the current be comparatively weak.

This is not an isolated example; for the same character is observed in all our mechanical deposits, which are vastly thicker in one place than another, showing that the ancient ocean had a limit, and that these materials were brought in like the common detritus of rivers, and spread over the bottom, gradually diminishing as the force of the current was neutralized by the greater body of surrounding water.

This change in the nature of the materials is accompanied by an equally marked change in the fossils imbedded in the different parts of the group. In the eastern part of the State, Avicula and Cypricardia with Nucula, &c. prevail in immense numbers; while at the extreme western margin, though in precisely the same position, they are of the rarest occurrence, while numerous forms of Delthyris and Atrypa abound. In the present state of our knowledge of the limits of this ancient sea, it is impossible to say positively what influence proximity to land or shallow water may have had upon these forms; but it seems, nevertheless, true that the kind of *bottom* or bed of the ocean had much to do in modifying the character of the testacea inhabiting it. Or, perhaps we should say that the different kinds of bottom were more favorable to the growth of certain species and genera than to others, and that as the kind of deposit changed, so also did the organic beings inhabiting it.* Of this fact we shall find sufficient proof as we investigate this formation.

* In the present sea we know that its littoral inhabitants, at least, congregate in certain situations and upon certain bottoms, and that forms abundant in some situations are rare in others, though different species are abundant. Even the fishes that approach the shore frequent different kinds of bottom, doubtless in search of their food; and different portions of our Atlantic bays are known as "haddock ground," and "cod ground," the former always being caught on sandy bottom, while the cod frequent stony and rocky bottoms. These facts may very well explain why one part of a geological formation may abound in certain forms, while another, varying somewhat in character, may contain a very different congregation of fossils.

The lithological character of rocks, therefore, is an element to be taken into consideration when we undertake to identify strata by their contained fossils.

The valleys of Seneca and Cayuga lakes are both excavated, for more than half their length, in the shales of this group; and the banks of these lakes, with the lateral ravines, afford the best facilities for examination. The group appears also to be better developed in this part of the State than farther west, there being in that direction a gradual thinning of the different masses.

Along the banks of these lakes I have been able to trace the following subdivisions, which hold good over considerable areas, but which cannot be relied on in every instance; for toward the western extremity of the State some portions are lost or merge into others, so that the same lines of subdivision cannot be recognized. These divisions, which have been enumerated in the annual reports, are the following:

1. *Dark, slaty fossiliferous shale*, which rests directly upon the Marcellus shale, there being, as before remarked, no very well defined line of separation between the two. This part of the group is not very abundant in fossils; it may be seen in the towns of Varick and Fayette in Seneca county, and on Flint creek and Mud creek in Ontario county.

2. *A compact calcareous blue shale*, often passing into an impure limestone. The mass is quite thin, and worthy of notice only from being somewhat persistent, and marking the point of separation between two more important shaly masses. This is visible on the banks of Cayuga and Seneca lakes, on Flint creek, and was traced as far as the west side of the Genesee river.

3. *An olive, or often bluish fissile shale* rests upon the last named mass. It is marked by small concretions, and contains a few Cyathophylli and some other fossils. Toward the upper part, this shale becomes very fissile and of an olive color, often stained by oxide of manganese. It can be seen on the shores of both the lakes just mentioned.

4. *Ludlowville shales.* The latter mass passes by insensible gradation to a more compact rock, which contains an admixture of sand, and often separates in large masses which resist the action of the weather for a long time. Above this part the rock is a soft bluish grey shale, which is more calcareous and fissile, and contains a different association of fossils. These two kinds, with the next below and the two above, appear at and near the village of Ludlowville, in Cayuga county; and since these rocks are of the same age as those of the Ludlow formation of England, described by Mr. Murchison, this is a desirable locality to perpetuate the name.

5. *Encrinal limestone.* This rock is a thin bed, usually of impure limestone, with a great abundance of crinoidal columns. Sometimes the mass is a compact shale, held together by columns of great size and length. It is a persistent mass, holding only one position in the group, and continuous as far as Lake Erie. It is a convenient point of reference, and will be frequently mentioned in the description. It rests upon the last named shale, separating it from the Moscow shale.

6. *Moscow shale.* This mass succeeds the encrinal limestone, and is a well defined and persistent mass throughout the district. It is of a greyish blue color, and scarcely laminated; it separates into irregular fragments, which are rarely slaty. It is slightly calcareous, and abounds with fossils, many of them unlike those below.

With this mass terminates both the peculiar shales of which the group is composed, and also the greater part of those fossils typical of the same, so far as regards the Fourth District. The divisions here enumerated may be found of service to the careful observer, and they afford some interesting facts regarding changes in fossils; still they cannot all be described as distinct, neither is it of practical importance that they should be.

From the fact that the position of the last is well marked, being embraced between the Encrinal limestone below and the Tully limestone above, and also containing a peculiar association of fossils, it is everywhere recognizable, and as a subdivision is more important than some of the others.

The subdivisons here enumerated can all be seen on the eastern shore of Cayuga lake, between Springport and Ludlowville; the latter place also presents the two next higher rocks of the system.* The eastern shore of Seneca lake exhibits the same between its outlet and Lodi, in Seneca county. The same rocks appear, but not so well exposed, on the western shores of both lakes. This fact is of interest, as showing the influence of the prevalent westerly winds, which, from the constant action of the water driving against the eastern shores, has undermined the mass, and a perpendicular cliff is thus constantly kept exposed.

The operation of the same cause has produced a fine exhibition of the rocks of this group upon the shores of Lake Erie.

This group of rocks occupies a belt of country from five to eight miles wide, extending through the counties of Seneca, Ontario, Livingston, Genesee and Erie.

In the county of Seneca it occupies the southern part of Fayette, the whole of Varick, nearly the whole of Romulus, and that portion of Ovid bordering the shores of both lakes. The superior rocks have been greatly denuded, and the surface of the group is greater than in any part of the country westward. Its southern limit, which is just north of the village of Ovid, is several miles farther south than any other point before coming to Lake Erie. The two lakes, Seneca and Cayuga, seem to have been the great outlet of northern waters, and along their channels the great excavating and transporting force seems to have operated with peculiar energy.

On the eastern side of Seneca lake the group is well exposed in the outlet of Crooked lake, which in its passage to Seneca lake has excavated a channel from rocks of the Portage group, through the Genesee slate, the Tully limestone and Moscow shale, exposing the two latter to great advantage, and presenting localities where great numbers of the finest fossils can be obtained. The illustration at the head of this group presents a conical hill of the Moscow shale, succeeded near the top by the Tully limestone, and above this a thin band of Genesee slate, upon which is a covering of alluvium. The sloping hills on either side are indented by numerous ravines which expose the rocks of the same group. It also occupies the eastern margins of the towns of Benton and Milo in Yates county.

In Ontario the group occupies nearly the whole of the town of Seneca, the southwestern part of Phelps, the northern part of Gorham, nearly all of Hopewell, the whole of Canandaigua, East and West-Bloomfield and Lima.

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* See Section, Plate VII.

In these towns there are numerous good exposures of the group, the best of which are along Canandaigua lake and in the ravines upon either side. The banks of Flint creek also afford a good opportunity of examining the whole series, and the several subdivisions as enumerated may be found between Vienna and the village of Bethel, where the Tully limestone and Genesee slate succeed this group. On the north of the turnpike from Geneva to Canandaigua, there are several ravines which disclose these shales in great perfection. The parts of the group here exhibited are principally the encrinal limestone and the shales below, which abound in fossils. The upper part of the division, denominated *Ludlowville shales*, is well marked by great numbers of *Delthyris mucronatus* and *Atrypa concentrica*, with one or two species of Strophomena; the lower part contains large numbers of Cypricardia and Avicula, and is more sandy in character than that above. The same portion of the mass is also well developed on Canandaigua lake, where its fossils are numerous. The lower part of the group is also seen, as well as the *Moscow shale* above.

In Livingston county this formation occupies nearly the whole of the towns of Avon and York, a part of Geneseo, Leicester and Caledonia. The deep valley of the Genesee, with numerous lateral ravines and water courses, renders this county one of the most desirable localities for examining the rocks of this group. The *Moscow shale* receives its name from the beautiful development of the same on Beard's creek, on the land of Mr. Horsford; and it contains at this locality more than fifty species of fossils, many of which do not occur in any part of the group below. The rock at this place is a pure calcareous mudstone, of a bluish color on first exposure, but weathering to a whitish ashen. Its decomposition is hastened by the diffusion of iron pyrites, which sometimes replaces the fossil bodies. At this locality the Genesee slate succeeds, without the intervention of any other rock. Several miles north of this point, on the land of the Hon. G. W. Patterson, the shale is well developed in a small ravine, and also at one or two other places in the immediate neighborhood.

About three fourths of a mile west of York centre, there is a fine development of the shale immediately below the encrinal limestone. The latter also appears here in the form of a shaly limestone, with numerous crinoidal stems and other fossils. The shale is completely charged with Cyathophylli of different species, Favosites and other corals, with some trilobites and shells. In following down this ravine towards the river, the lower divisions of the shale are but obscurely seen, till we arrive at the thin division, before mentioned as the *calcareous blue shale* (or shaly limestone), which at this place is compact, and a tolerably pure limestone.

On the east side of the river, at Jacock's run, the Moscow shale, Encrinal limestone, and the higher part of the Ludlowville shales, are well exposed, and offer an abundance of fine fossils, among which are several beautiful corals of the genus Retepora or Fenestella. By following this ravine towards the river, the lower division of the group may be seen. At another ravine a mile or two farther south, the same shales are exhibited in a good degree of perfection.

The Moscow shale is seen near the base of the fall on Fall brook, south of Geneseo village. The same is also seen near the Conesus outlet, and along that stream the lower divisions of the group are well exposed at several places.

The lower divisions of the group are seen in Allen's creek, south of Le Roy; and the higher portions, with the Moscow shale, at Pavilion and Bethany. A little distance to the east and south of Batavia, the lower part of the group is well exposed, and in Alexandria the higher divisions of the same.

In the town of Darien, a little west of the Centre, there is a good exposure of the upper part of the Ludlowville division and the Encrinal limestone; the latter is a compact mass about three feet thick, and its upper part strongly stained from decomposing iron pyrites. The shale abounds with *Atrypa affinis*, *A. concentrica*, *Delthyris mucronatus*, and other species of these genera. *Cyathophylli*, *Strombodes*, *Favosites*, and other corals are almost as abundant as at York in Livingston county. The Moscow shale is tolerably well exposed at this place, though its decomposition upon the surface has obscured its characters, and it presents the appearance of an ordinary clay bank.

On the road westward from the last named place, the rocks of the group are exposed in several places. On a small stream crossing the road near Alden, the shales are well exposed; and a little south of this, the encrinal limestone is quarried. It is here highly fossiliferous; containing, in addition to the usual abundance of crinoidal columns, *Delthyris*, *Pleurotomaria*, and *Calymene bufo*. At this and many other localities, this thin calcareous mass appears to be a common depository of many or all the species of the shale below, with several others which are peculiar to itself. It was of course produced during a cessation of the mud deposit; and the forms living on the bed of the latter would consequently be inclosed in this deposition, with others produced on the calcareous bottom, some of which are different.

Along the Cayuga creek, on the Indian reservation, these shales can be traced from near their base, throughout, to their connexion with the higher rocks. And here I should not omit to state what has appeared, only more indistinctly, at other localities. The division noticed as the olive shale, and the band of blue calcareous shale, with the sandy part of the Ludlowville division, have, almost or entirely, disappeared, apparently from a gradual diminution in the quantity of matter. The gradual thinning becomes very apparent at all the localities west of the Genesee river. At the same time all those portions which are persistent, except the encrinal limestone, have diminished in the same direction; and although few localities offer good exposures, it is, nevertheless, very evident that such is the fact.

This becomes more palpable when we arrive at the shore of Lake Erie, which offers the best continuous exposure west of Seneca lake. It is here quite evident that the rocks have diminished to less than one half the thickness which they have on Seneca lake. At the same time, however, many of the fossils have maintained their position, and some species seem even to be more abundant than eastward. The *Cypricardia*, *Avicula*, *Nucula*, *Bellerophon*, and a few others appear to have diminished in numbers according to the diminution of the sandy calcareous shale in which they so abound at the east.

To show, however, how fixed are their habits and place of residence, there is a stratum of this kind on Lake Erie, which is indicated by the letter *a*, in the section Plate 5, in which *Cypricardia*, *Turbo*, *Bellerophon* and *Orthoceras* occur to the almost entire exclusion of every thing else. This stratum, too, holds the place which the thick mass of similar character does further east; and directly above it we find bluish calcareous shales, with *Delthyris mucronata*, *Atrypa concentrica* and *A. affinis*, being the characteristics of the upper part of the Ludlowville division of this group.

This fact is sufficient to show that there were distinct periods of formation, and that the thick mass of sandy shale so abounding in the *conchiferous mollusca* in the eastern part of the State, and which in the central part is still in great force, extended westward entirely to lake Erie. It is there recognized by the same lithological characters, the same or a similar association of fossils, and holds the identical place in the strata.

The section of this group on Lake Erie (see Plate 5) commences with the shale immediately above the Marcellus, and from thence the continuation is nearly unbroken throughout. The characters of the lower and higher divisions are more nearly alike than farther east, the whole being a soft bluish shale, readily crumbling on exposure to the atmosphere, and decomposing to a tenacious mud. The sandy portion is scarcely noticed, and thin beds of black slaty shale, so common on Seneca lake and other localities in the central part of the State, have entirely ceased. The peculiar fossils of these portions are likewise wanting, showing the association of certain forms with products of similar nature. The fossils here alluded to are a species of *Orbicula*, the *Atrypa congregata* of Conrad, and some others.

Notwithstanding that fossils are exceedingly numerous in this exposure along Lake Erie, it must be acknowledged that there is a manifest decrease in the number of species. Scarcely any new ones are noticed, and many which have been common at the east are rare or wanting. There are several species which abound in immense numbers, and which in this respect fully compensate in number of individuals for the absence of a larger number of species. This fact of the gradual disappearance of fossils is equally obvious with the decreasing thickness of rocks which is observed as we progress westward. Whether this was caused by increased depth of water, distance from shore, or by the thinning of the deposit alone, it may be interesting to inquire; probably, however, all these causes operated in some degree to produce the result.

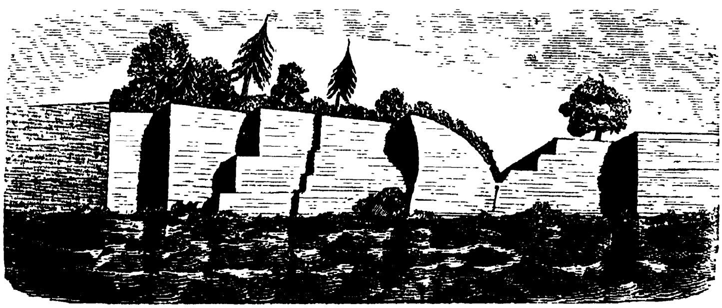
The lower divisions of this group on Lake Erie, or that part below the stratum marked *a* in the section, are nearly destitute of fossils, and the forms which seem peculiar to this part on Seneca and Cayuga lakes are not found here. The three upper divisions are here the only ones which are interesting from their organic contents.

Throughout the whole period of this deposition, there appears no evidence of any disturbances. The character of the materials, the condition of the fossils, all show the absence of violent currents or of powerful waves. The deposit was probably made at a depth below water, beyond the reach of the waves which may have agitated the surface; and there appear to have been no oscillations by which one portion of its extent was elevated, while another was depressed. It was emphatically a long period of repose.

Joints or Vertical Cleavage.

The rocks of this group, where exposed in cliffs or in the banks of ravines, are traversed by numerous joints, usually vertical to the planes of stratification, but sometimes slightly oblique, and again more or less curved. These will be more fully described in the chapter relating to that subject alone. The following sketch exhibits the appearance of a natural section of the Moscow shale on the banks of Cayuga lake.

75.



Jointed structure of the Cliffs on Cayuga lake. From a sketch by Mr. E. N. HORSFORD.

It will be seen that these joints do not all continue through the part of the mass exposed, but the blocks exhibit a series of steps which limit the depth to which these divisional planes extend. This structure is very favorable to the rapid abrasion and undermining of the cliffs along the lake shore. The water finds access to the slightly opened fissures, which, in the colder seasons, are enlarged by the freezing of the same, and in summer the waves dash into them, constantly widening the breach. A slight undermining causes a separation by the joints in the opposite direction, and the waves in time leave them standing in isolated blocks, which are gradually undermined, and fall into the lake. Examples of this kind are frequently seen, not only in this group, but in those next succeeding, and more especially the Portage group, where they are illustrated.

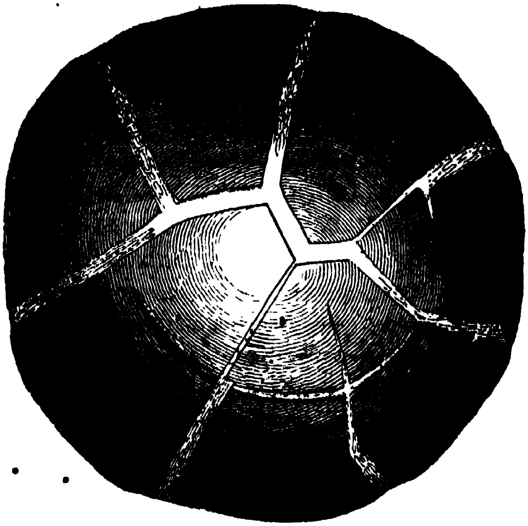
Concretions or Septaria.—These bodies, presenting various fantastic forms, are of frequent occurrence in this group, though not so abundant as in the shales below and above. Many of them, as before noticed, are calcareous concretions, which appear to have aggregated around a fossil body or a small nodule of iron pyrites. In the latter case the mass usually contains pyrites, and it is probably owing to the attractive force of this substance that they were produced. Fossil shells are frequently found in the centre of these bodies, and the outer surface is often covered with them.

76.

Nodules of iron pyrites, often embracing a fossil in the centre, are of frequent occurrence; they are usually uninteresting, except as showing the incipient stages of this process. The small figure in the margin represents one of these aggregated around a *Loxonema*, a portion of which projects above.

... septaria are spherical, flattened or oblong, and crossed by numerous seams of calcareous spar, and in the centre is frequently a cavity lined with crystals and partially filled with fluid bitumen. The figure below represents a small specimen of this kind from the shore of Lake Erie. It is figured for the purpose of illustrating the general appearance of these bodies, which are frequently taken for some fossil.* The calcareous concretion is first formed, and afterwards cracks, and the spaces become filled with crystalline matter from segregation or infiltration. Sometimes there are no cracks in them, and at others these are filled with clay or shale.

77.



Localities — The description of this group has necessarily led to the mention of many localities; but as the object of this head is to direct observers to the most important points, I may mention the banks of Cayuga and Seneca lakes, the ravines on the Genesee river, in Avon,

* The common belief is that these bodies are petrified tortoises or turtles, and that the seams are the divisions of the plates of the shell. So firm is this belief with many persons that they are kept as an evidence of former living animals, while the multitudes of shells in the same rock are entirely overlooked.

York and Leicester, and the shore of Lake Erie at Eighteen-mile creek, as the most important and interesting points, and which will give all the desired information of this group in the Fourth District.

Thickness. — The thickness of this group on the eastern limit of the district cannot be less than 1000 feet. There are a few undulations in the strata which may mislead in the estimation, to a small extent. Each of the members noticed thins gradually toward the west, until on Lake Erie it is less than half that amount. The whole thickness visible at this point is about one hundred feet. The Moscow shale, which in the eastern part of the district is fifty or sixty feet thick, is on Lake Erie 15 feet thick, and the lower members have diminished in equal proportion; the shale of Ludlowville, known by the great numbers of *Avicula*, *Cypricardia*, &c. is scarcely a foot thick in the west.

Mineral contents of the rock. — From the nature of the rock, and the absence of all disturbances and intrusive rocks, it will be presumed that there are few simple minerals. Those which do occur are usually in the concretions; crystallized carbonate of lime and baryta, and sometimes blende and galena occur in these bodies. Iron pyrites occurs in all situations, and from its decomposition result sulphate of alumina and sulphate of iron.

The presence of blende, galena and other minerals proves that, under more favorable circumstances, these rocks might have been somewhat metalliferous; but being, in its present state, an unaltered mechanical deposit, the substances of this kind which it contains are disseminated through the mass, and the quantity is so minute as to be unappreciable while so diffused.

Springs. — From the generally impervious nature of the rocks composing this group, it gives origin to numerous springs which rise to the surface in all situations. Wherever the soil is thin above the rock, the place is manifested by a wet or damp soil; and though there are few prominent and important springs, yet the water is carried to the surface, and oozes out over large spaces. Water is easily procured by digging wells in all situations where this rock underlies the surface, unless it be too deeply covered with alluvion. This is the condition in some parts of Bloomfield, Ontario county, where the rock has been deeply excavated, and the space afterwards filled with an immense deposit of northern drift, which rises into innumerable hills and long ridges. From the great number of low conical hills clustered together in these situations, they are known by the name of the "*Hopper hills.*"

Agricultural characters of the group.

The soil resulting from the decomposition of these rocks, when unmixed with foreign materials, varies from a tolerably pure marly clay to clayey loam; but the prevalence of northern drift over a large part of the surface occupied by this group, has essentially modified the characters of the soil covering it. The sandy calcareous portion of the shale has given origin to a clayey loam, which, in some places in the eastern part of the district, remains nearly unmixed with foreign materials. The soil varies, however, from a stiff clay to sandy or gravelly; and sometimes these divisions are arranged over considerable areas, apparently without reference to the rocks beneath.

As an example, we find, in passing over this group from Seneca lake westward, that there are alternations of sandy, gravelly and clayey soils, as far as the valley of Flint creek; passing this, the soil is for the most part sandy and gravelly, passing into a gravelly clay, till we reach the summit between Flint creek and Canandaigua lake; and descending from this point to the outlet of the lake, the soil is almost wholly clay. Again, on the west of this lake the soil is clay or clayey gravel, till we arrive in Bloomfield, where it varies from a light sandy loam to gravel and gravelly loam, with but little clay except in the low grounds.

Farther west, and particularly in the valleys, the soil is more clayey where this group extends. Approaching Lake Erie, the northern drift has accumulated above these rocks, and the soil presents a gravelly and loamy character, with occasional tracts of clay in low grounds, or in places where the rock approaches the surface. Along the shore of Lake Erie, where this group extends, there being no considerable proportion of drift, the soil is extremely clayey, as any one may recollect who has travelled the road southwest from Buffalo in the wet season.

Whatever kind of soil prevails, however, it is always highly calcareous, and over the whole extent of the group is of unequalled fertility. A large proportion of the famous "Genesee country" lies upon this group, and the fertility of this soil is well known. The materials derived from the destruction of the rocks of this group are largely intermingled with the soils to the south of their southern boundary, and contribute largely to the fertility of the slopes underlaid by rocks of the Portage group, and the broad valleys which extend southward nearly to the Pennsylvania line.

Organic Remains of the Hamilton Group.

The contrast in the prevailing fossils of this group with those of the last is as great as in the lithological products of the two formations. We sometimes indeed meet with a species which occurs in the limestone below, but except in a few instances these recognitions are rare. Some of the more abundant corals are identical, but the great number of new forms renders them of less importance, and in all instances they are too few in number to produce any doubt or difficulty in identification of strata.

Shells both of the Brachiopoda and Dimyaira have immensely increased, and in many single localities from twenty to fifty species of fossils may be obtained. The great abundance and perfection of these fossils offer strong inducements for the study of this branch, and perhaps no other department of Natural History, except Botany, will yield so rich a harvest from limited areas as Palæontology. If their occurrence in the lower rocks, as represented in this volume, is interesting, their great number and exquisite perfection in the Hamilton group will certainly delight the mind of every lover of Nature. Here it seems, that instead of extracting them from the solid rock, we are culling them from the dried ocean mud, which a late retiring sea has left above its reach, so much do these soft shales resemble the mud deposits on the bays and creeks along the sea shore.

The following woodcuts are illustrations of the prevailing forms in different parts of the group. Those from the lowest portions are omitted.

78.

1. Bellerophon patulus.
2. Microdon bellastriata.
3. Cucullea opima.
4. Nucula oblonga.
5. Nucula lineata.
6. Tellina? ovata.
7. Nucula bellatula.
8. Cypricardia truncata.
9. Modiola concentrica.

1. *Bellerophon patulus*, n. s. — Sides slightly umbilicated, aperture suddenly and broadly dilated, nearly smooth, or with faint undulating striæ, which become stronger and slightly arched in receding from the margin.

The striæ become very strong and sharply arched upon the first volution.

Locality — Cayuga lake shore.

2. *Microdon bellastriata* (Conrad, *Jour. Acad. Nat. Sci.* Vol. 8, p. 247, pl. 13, fig. 12).— Compressed, broadly oval and somewhat truncated posteriorly; marked by numerous equal concentric striæ.

This is a beautiful and easily recognized shell. It is often abundant in the harder shales, but in the western part of the district is exceedingly rare. It is one of those fossils having a wide geographical range, being known in the middle and southwestern parts of Virginia.

The young of this shell closely resembles the figure of *Venus parallela* (Phil. *Geol. Yorkshire*, Part ii, pl. 5, fig. 8).

Locality — Banks of Seneca and Cayuga lake; Crooked lake outlet; more rarely in the Genesee valley.

3. *Cucullea opima*, n. s. — Ovate, very convex; beaks near the anterior extremity, very prominent; surface marked by strong concentric lines; cast nearly smooth; impression of the internal laminæ oblique.

When compressed, this fossil has the appearance of a *Nucula;* but the impressions of the internal laminæ seem sufficient to warrant its reference to *Cucullea.*

Locality—Ovid, Seneca county.

4. *Nucula? oblonga.* — Oblong, elliptical, very inequilateral, very finely and concentrically striated; an impressed line extends from the hinge, just forward of the beak, half way to the base.

This is a very common form in the eastern part of the district.

Localities—Cayuga and Seneca lake; Outlet of Crooked lake; Genesee valley.

5. *Nucula lineata?* (PHILLIPS, *Paleozoic Fossils*, p. 39, fig. 64). — Sub-triangular, convex; beaks much elevated; surface covered with coarse concentric striæ.

This shell is not very uncommon in the ravines about Seneca and Cayuga lakes, though the specimens usually seen are much compressed and distorted.

Locality—Seneca lake shore; Shelldrake point on Cayuga lake.

6. *Tellina? ovata*, n. s. — General form ovate, produced posteriorly, and apparently slightly gaping at the extremity; posterior slope angulated; surface covered by minute concentric striæ, which become more prominent near the margin.

Since no teeth are visible in the hinge line, and the external form is so analogous to *Tellina*, it is referred to that genus.

Locality—Cayuga lake.

7. *Nucula bellatula*, n. s. — Ovate, somewhat contracted near the posterior extremity; surface covered with regular, fine concentric striæ; teeth in the hinge margin very distinct. There is a slight depression extending along the posterior slope, giving a contracted appearance to this part of the shell.

This beautiful little shell is often seen in the harder shales of the group.

Localities—Cayuga and Seneca lakes.

8. *Cypricardia truncata*. (*Cypricardites truncata*, CONRAD, *Jour. Acad. Nat. Sci.* Vol. 8, p. 244, pl. 12, fig. 17.) — Trapezoidal; surface covered with concentric wrinkles; posterior slope sharply carinated. The wrinkles upon the posterior slope are parallel to the truncated margin, and nearly at right angles with those upon the side of the shell.

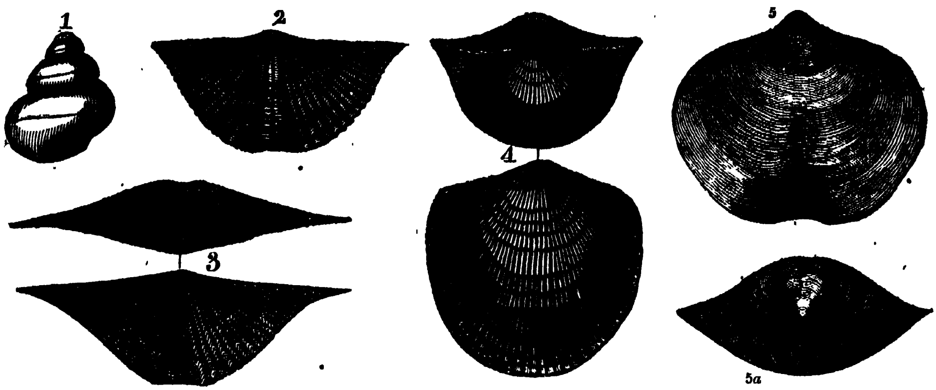
Compare *Cucullea arguta* (PHIL. *Geol. Yorkshire*, Part ii, pl. 5, fig. 20).

Locality—Cayuga lake.

9. *Modiola concentrica.* — Oblong-ovate, very inequilateral; surface covered with regular, equal concentric striæ, which become confluent towards the base; hinge line curved; anterior side short, with a longitudinal impression directly below the beaks.

This is a very abundant fossil, being found in the coarser shales over all the eastern part of the district. It resembles the figure of *Modiola? semisulcata* (*Silurian Researches*, pl. 8, fig. 6).

Localities—Cayuga and Seneca lakes; Outlet of Crooked lake; Ontario and Livingston counties.



1. Turbo lineatus. 2 and 3. Delthyris mucronata. 4. Atrypa prisca. 5. Atrypa concentrica.

1. *Turbo lineatus*, n. s. — Turbinate, obtuse; surface marked by several sharp spiral lines, all which, except the central one, are not visible on the cast; longitudinally striated; last whorl of the shell rapidly expanding; aperture orbicular; umbilicus moderate.

This fossil occurs generally as a cast, and in some places is abundant, frequently invested with a coral.

Locality—Ovid, Seneca lake shore.

2 and 3. *Delthyris mucronata* (*Annual Reports of the New-York Geological Survey*, 1841, p. 54). — Varying in form from semicircular to triangular, with the hinge line greatly extended; surface marked by 24 to 30 rounded ribs, which are crossed by crowded undulating elevated lamellæ, giving a squamous appearance to the shell; hinge area very narrow; aperture small. Figure 2 is the nearly semicircular form; fig. 3 shows the hinge line more extended; and fig. 3 of Illustration 84, presents a still more extended hinge line, from the shaly sandstone of the Third District.

This is a very ornamental shell, and its numerous varieties in form are very interesting. In the soft calcareous shales of western New-York, it is shorter and more rotund; while in the sandy shales and shaly sandstones of the middle and eastern part of the State, it is greatly extended, and its extremities very acute. Occurs in all localities of the upper middle portion of the group.

4. *Atrypa prisca.* (*Terebratula affinis,* Min. Con.; *T. prisca,* Von Buch; *T. reticularis,* Bronn, *Lethea Geog.*; *Atrypa reticularis,* Dalman; *A. affinis, Silurian Researches.*)—Oblong, often nearly circular; lower valve least convex, with the beak scarcely prominent, and pressed close to the beak of the upper valve; upper valve very convex; front margin often advanced and a little depressed; surface radiated with numerous round striæ, which bifurcate at irregular intervals.

The specimens vary in size, and very frequently are flattened from compression, so that they do not present the rotund form of the figure. This is an abundant and widely distributed fossil, appearing throughout the Hamilton and Chemung groups. It is more abundant in the Hamilton group just below the Encrinal limestone, associated with the preceding and succeeding forms. It also occurs in the Moscow shale in great numbers.

Localities—Seneca lake; Hopeton; Moscow; York; Darien; Eighteen-mile creek, &c.

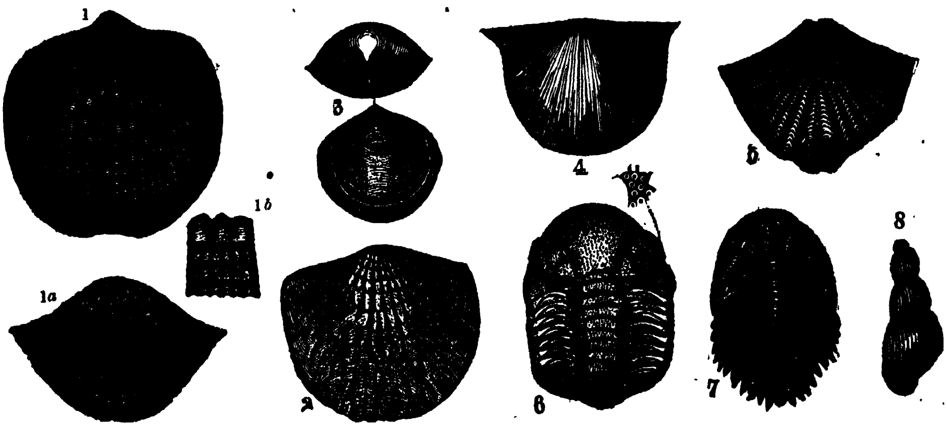
5. *Atrypa concentrica* (Bronn, *Lethea Geog.*).—Spheroidal, flattened or rotund, impressed in front; upper valve very convex in the middle, slightly elevated in front and depressed at the sides; beak scarcely prominent, and closely pressed to the beak of the lower valve; lower valve convex, with a prominent, slightly incurved beak, and a mesial sinus extending two-thirds the length of the shell, elevating the front; surface marked by numerous concentric striæ, which in young specimens are projecting lamellæ, giving the shell a squamose appearance.

This is an exceedingly abundant fossil in many places, and appears in the greatest numbers just below the Encrinal limestone. Sometimes it occurs in the shale above this stratum, associated with *Orthis umbonata.* It will be readily recognized from its general smoothness and numerous concentric lines.

Localities—Seneca and Cayuga lakes; Hopewell; Conesus outlet; Darien; and in greater numbers and perfection at Eighteen-mile creek on Lake Erie.

The following illustration presents some of the typical fossils of the Moscow shale. Several of these have not been seen in the group below while others do occur in lower situations.

80.



1, 1 *a*, 1 *b*, 2. Atrypa spinosa.
3. Atrypa concinna.
4. Strophomena inequistriata.
5. Delthyris zigzag.
6. Calymene bufo.
7. Cryphæus calliteles.
8. Loxonema sinuosa.

1 & 2. *Atrypa spinosa*, n. s.—Sub-orbicular, often flattened, producing an angle at the extremities of the hinge; beak of the lower valve slightly prominent, incurved; surface with about twenty rounded radii, which bifurcate often very regularly at less than half the distance from beak to base; radii crossed by numerous elevated lamellæ, which upon each rib are folded and extended into a spine of one-fourth to one half an inch in length; surface between the lamellæ concentrically striated.

The shell more commonly appears without the spines, or with them partially worn off. When destitute of spines, it resembles the figure of *A. squamosa* (Sowerby, *Geol. Trans.* 2d series, Vol. 5, pl. 57, fig. 1).

Fig. 1 is of a specimen from Eighteen-mile creek, where the spines are always absent. Fig. 2 is of a specimen from Moscow, where the spines are more or less perfect, being encased around the margin in soft shale, and worn off on the prominent part of the shell.

This fossil is frequently confounded with *Atrypa prisca*.

Localities—Moscow, Eighteen-mile creek.

3. *Atrypa concinna*, n. s.—Lenticular, nearly smooth, or with a few distant elevated lines of growth; lower valve most convex, with a faintly impressed line extending from beak to base; beak of the upper valve scarcely prominent, and closely pressed within the lower one; beak of lower valve prominent, small, acute, incurved.

This is a very glabrous shell, with a prominent line of growth near the beaks, and one or two more near the margin, leaving the greater part of its area entirely plain.

Localities—Moscow, Eighteen-mile creek.

4. *Strophomena inequistriata* (CONRAD, *Jour. Acad. Nat. Sci.* Vol. 8, p. 254, pl. 14, fig. 2). — Somewhat semicircular; lower valve very convex; surface covered with radiating striæ, every fourth or fifth of which is more prominent than the rest; striæ increasing in number towards the margin; hinge extremities angulated.

There seems to me very good reason for considering this form and the *S. mucronata* (CONRAD, *Jour. Acad. Nat. Sci.* Vol. 8, pl. 14, fig. 10), as identical, and that both are identical with *Orthis interstrialis* (PHIL. *Palæozoic Fossils*, p. 61, pl. 25, fig. 103, *a*, *b*, *c*, *d*).

In the calcareous shales of the Hamilton group, its form is often better defined and more rotund, though the striæ are less sharp; while in the Chemung rocks, it is usually compressed, and very frequently the shell is partially or entirely removed.

Locality—Seneca lake; Moscow.

5. *Delthyris zigzag*, n. s. — Upper valve semicircular, moderately convex; surface marked by 16 to twenty rounded ribs, which are crossed by very prominent undulating or zigzag laminæ; mesial fold of the upper valve somewhat duplicate, of the lower valve deeply impressed and elevated in front.

So far as known, this fossil is confined to the Moscow shale. It is readily distinguished by the prominent zigzag laminæ.

6. *Calymene bufo* (GREEN, *Monograph*, p. 41). — Head semicircular; middle lobe very large, obtuse in front; surface covered with numerous depressed pimples; articulations of the body 10, of the tail 8; articulations of the middle lobe apparently double, those of the lateral lobe deeply grooved near their junction with the central lobe.

The fossil from which the drawing is taken is partially coiled, so that the tail is not visible. It is one of the most abundant fossils of the group, occurring either perfect or in fragments at nearly every locality.

Localities—Moscow; Seneca lake, and Eighteen-mile creek.

7. *Cryphæus calliteles*, GREEN. — Head lunate, with the posterior angles of the buckler extended to the fifth rib of the body. Articulations of the abdomen 10; of the tail, 10 in the middle, and 6 in the lateral lobes. Articulations of the lateral lobes free at the margin, and forming a beautiful punctulated fringe. Structure of the head and eyes like the *Asaphus*. Surface pimpled, and, apparently from the removal of these, punctulated.

Localities—Moscow; Pavilion; Eighteen-mile creek.

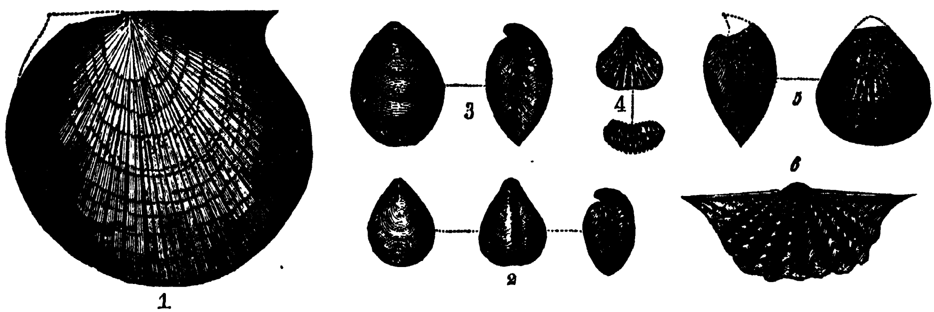
8. *Loxonema nexilis* (PHIL. *Palæozoic Fossils*, p. 99, pl. 38, fig. 183. *Terebra nexilis*, SOWERBY, *Geol. Trans.* 2d Series, Vol. v, pl. 54, fig. 17.) — Elongated, subulate; volutions convex, with alternating longitudinal arched furrows and raised lines, retiring from and advancing toward the sutural lines. (The specimen figured is imperfect.)

The raised lines are less arched than in *L. sinuosa* (*Terebra sinuosa*, Silurian Researches, pl. 8, fig. 15), which also occurs in this group, and are almost straight on some of the higher whorls.

Locality—Seneca lake; Moscow.

The specimens figured in the following illustrations appear to be confined to the thin band of Encrinal limestone below the Moscow shale.

81.



1. Avicula orbiculata. 2. Atiypa rostrata. 3. Atrypa. 4. Atrypa. 5. Atrypa. 6. Delthyris.

1. *Avicula orbiculata*, n. s.—Roundish, auriculated; slightly oblique hinge line shorter than the width of the shell; posterior wing extending nearly in a line with the margin of the shell. Surface covered with rounded radiating ribs, which become fainter upon the upper lateral margins; these are crossed by rounded concentric lines, which are less prominent than the others.

The nearly round figure of this shell forms a prominent feature of its distinctive character.

Locality—Eighteen-mile creek.

2. *Atrypa rostrata*, n. s.—Obovate; valves nearly equally convex, lower one with a longitudinal depression from beak to base; beak of the upper valve scarcely prominent, of the lower valve very prominent, produced and incurved over the upper one.

This is a very neat little shell, marked by a few concentric lines of growth.

Locality—Eighteen-mile creek.

3. *Atrypa* ——, n. s.—Elliptical, slightly elongated at the beak; valves nearly equally convex, smooth, or with faint concentric lines of growth; beak of the lower valve prominent, rather small, and slightly incurved.

This shell is larger than the last, the beak smaller proportionally, and less incurved, and there is no depression on the lower valve.

Locality—Eighteen-mile creek.

4. *Atrypa* ——. — Obtusely cuneate; valves equally convex, with about 16 plicæ on each, three of which are raised in front; beak of the lower valve prominent, small, that of the upper closely pressed to the lower.

This shell often varies in size from the figure.

Locality—Eighteen-mile creek.

5. *Atrypa* ——, n. s. — Broadly obovate, tapering abruptly to the beak, and rounded below; lower valve most convex; beak of the lower valve large, very slightly incurved; that of the upper valve small, rather prominent, and closely pressed to the lower valve.

This shell is distinguished from figs. 2 and 3, by its broadly rounded base, the large, prominent, nearly straight beak of the lower valve, and the slight radiating elevated lines which are visible in the cast.

Locality—Eighteen-mile creek.

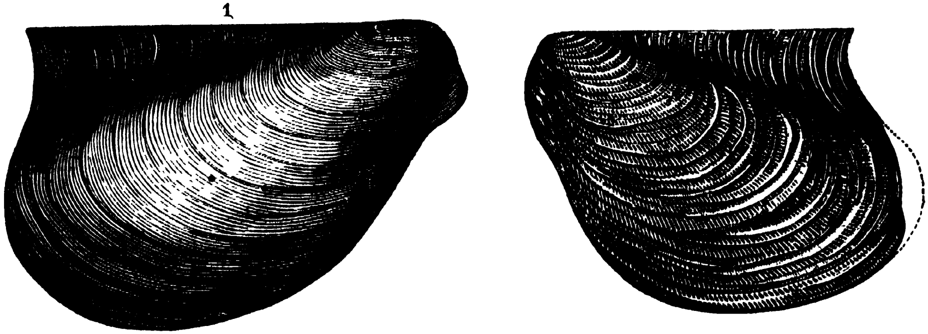
6. *Delthyris sculptilis*, n. s. — Semicircular, somewhat auriculate; surface marked with eight prominent ribs, which are crossed by strong elevated laminæ of growth, the spaces between which appear as if grooved; the mesial elevation of the upper valve scarcely larger than the ribs.

At first view this fossil appears much like the *D. zigzag*, but there are fewer ribs, and the laminæ are more deeply sculptured. So far as known, this fossil is confined to the Encrinal limestone.

Locality—Eighteen-mile creek.

The following species of *Avicula* is associated with the Encrinal limestone of this group throughout the district.

82.



1 and 2. Avicula decussata.

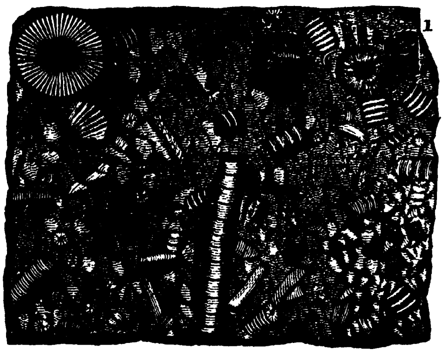
1 and 2. *Avicula decussata*, n. s. — Obliquely ovate or sub-rhomboidal; surface marked by numerous fine radiating lines, which are decussated by irregular concentric lines of growth: the concentric lines are rather like wrinkles, and stronger than the radiating lines.

Fig. 1 is a cast in limestone, in which only the concentric lines are visible. In fig. 2, the shell is still retained, and presents the two series of lines. This is from the limestone where largely intermixed with shale.

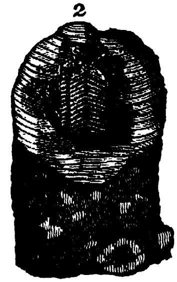
Localities—York; Darien; Alden; Eighteen-mile creek; Seneca lake; Outlet of Crooked lake.

83.

1



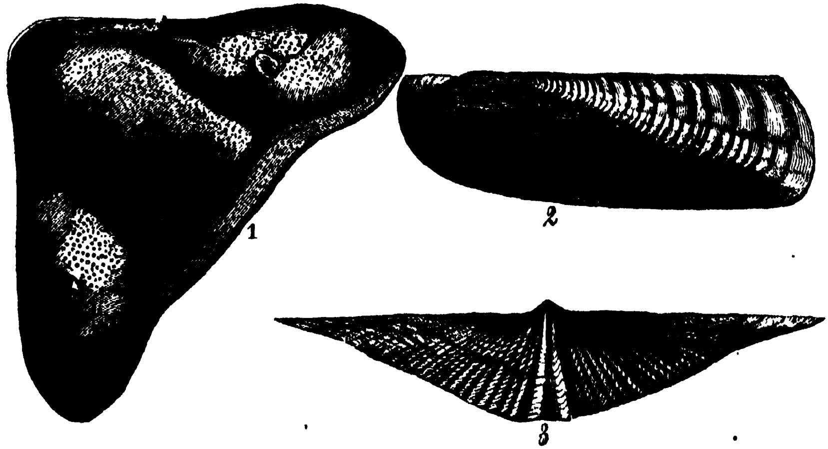
2



The character of the Encrinal limestone of this group is well illustrated in the above woodcut. Fig. 1 is a small portion of the surface of a specimen of this limestone from Eighteen-mile creek. From being slightly weathered, the fragments of crinoidal columns, corals and shells, stand out in relief. These fragments are sometimes invested with a coral, showing that after their destruction they remained long enough upon the bottom for the coral to grow and cover them. There are fragments of the columns of several species, of which no perfect specimens have ever been found. Fig. 2 is a fragment of a large column, from the shaly limestone in Livingston county. The pentapetalous canal has been filled with siliceous matter, and the column around has decayed, leaving the former projecting for half an inch. Columns of this size and larger are often found, of one or two feet in length; they are usually furnished with branches, and these being broken off, they appear like knotty sticks.

The following illustration, from the Report of the Third District, presents some of the characteristic fossils of this group in that part of the State, where it will be seen from previous remarks that the lithological nature of the strata is somewhat different.

84.



1. Dipleura Dekayi. 2. Orthonata undulata. 3. Delthyris mucronata.

1. Head of *Dipleura Dekayi* (Green, *Monograph*, p. 79).— This portion of the fossil, as well as the caudal extremity, are usually found detached, and in the sandy shales of the Third District are abundant. In the softer shales of the Fourth District it is comparatively rare, though I have seen it in many places.

It ranges from the Marcellus shale throughout the group, and I have found the caudal extremity of a trilobite in the rocks of the Chemung group, apparently referable to the same species.

2. *Orthonata undulata* (Conrad, *Annual Reports*).— This fossil is not unfrequent on the eastern margin of the district, but far from presenting the perfectly delineated forms which it does farther east. It entirely disappears before reaching the Genesee valley.

This and the last named fossil, which are typical of the group in the eastern part of the State, cannot be so considered throughout that portion west of Seneca lake.

3. *Delthyris mucronata* (Conrad, *Annual Reports*).— This is the common form of this fossil in the sandy shales and shaly sandstones of the Third District; while, as we progress westward into the soft calcareous mudstones of the group, its hinge line becomes less extended, and the general form more rotund (see illustration, page 198 of this Report). It is one of the most numerous forms, and appears almost equally abundant throughout the length of the State, its maximum in the Fourth District being on the shore of Lake Erie.

The other forms figured on page 152 in the Report of the Third District, viz. *Orthoceras constrictum*, *Cypricardia recurva*, *Avicula flabella* and *Orbicula grandis*, have all been seen in the Fourth District, but they are not considered among the typical fossils of this group.

In addition to the fossils already presented from this group, we might introduce many more, perhaps equally characteristic in different localities. The following among the *Delthyris*, may serve to illustrate the prevailing forms of this genus.

1. *Delthyris granulifera.* — View of upper valve, presenting the duplicate mesial fold and the granulated surface.

1 *a.* End view of the same, showing the curved beak of the lower valve, and the spiral coil within the shell.

1 *b.* A specimen with a more extended hinge line.

1 *c*, and 1 *d.* Two views of a smaller specimen of the same fossil.

This is by no means an uncommon fossil, though it is usually much compressed and distorted, and the delicate points or granulations upon its surface are worn off. The specimen fig. 1 is very free from compression, and presents the parts in true proportion to each other. In fig. 1 *b*, the area is narrowed, from the upper valve having been pressed backward. The fossil is very variable in the proportionate extension of the hinge line, sometimes being produced at the extremities into a point.

This specimen is from Moscow, Livingston county. In the smaller figure, the concentric laminæ are numerous and sharp, as is the fact in many species of this genus.

2. *Delthyris congesta.* — View of the upper valve, showing the broad mesial fold, and broad plain ribs.

2 *a.* Front view, showing the elevation of the lower valve into a linguiform extension, and the deep mesial sinus.

This is a remarkably rotund fossil when pressed, but when compressed, often much resembles the last, and is frequently mistaken for it. The mesial fold, however, is plain, and the surface free from granulations; the ribs are likewise fewer in number.

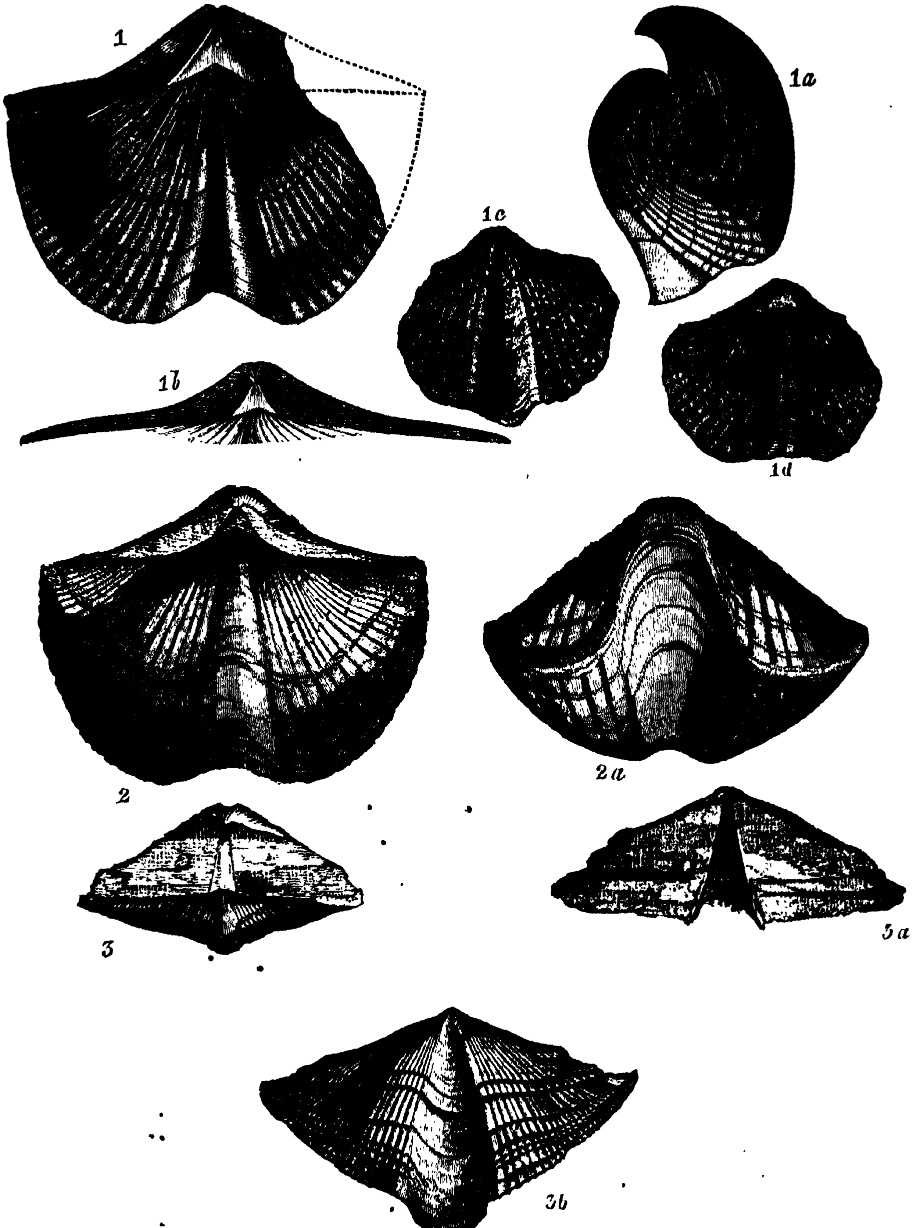
3. *Delthyris macronota.* — View of hinge, showing the broad area and narrow aperture.

3 *a.* View of the area of the lower valve.

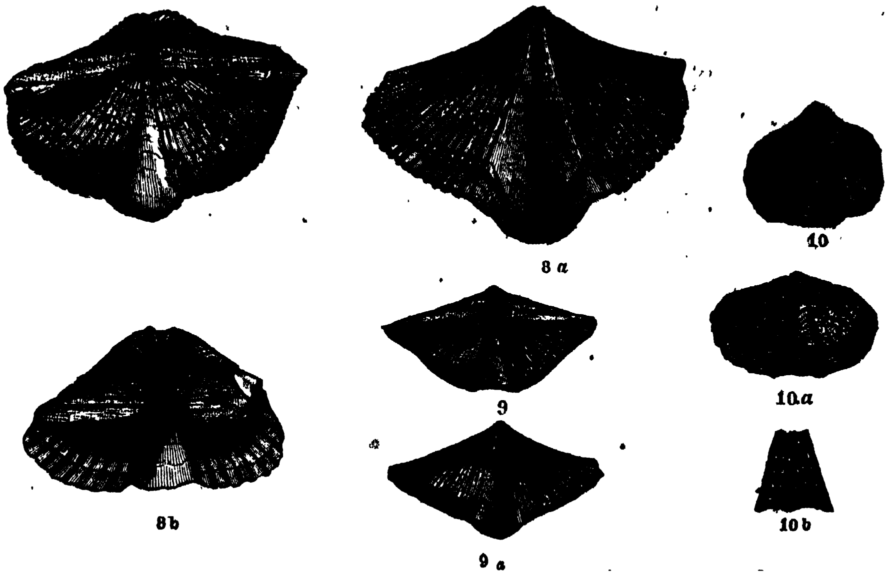
3 *b.* Lower valve.

This fossil is always readily distinguished by the broad area, the narrow aperture, and the numerous small plain ribs and strong concentric laminæ of growth. It is more abundant at Moscow than in any other part of the district; though it is of frequent occurrence on the shores of Seneca lake, and in other places.

85.



86.



8. *Delthyris medialis.* — View of upper valve and hinge area, with the deltoid aperture.

8 *a*. Lower valve of the same, showing the broad expanding mesial sinus.

8 *b*. View of the interior of the lower valve.

9, and 9 *a*. Two views of a young shell of the same species??

Upper valve semicircular, much elevated in the middle; lower valve very convex, beak prominent; surface marked by 32 to 40 rounded ribs, which are crossed by numerous laminæ of growth. These lines of growth are slightly arched upon the rib, and there is frequently a depressed line extending along the centre of each, half way from base to beak. The area is large, curved, and striated transversely.

I find this shell in the State Collection, labelled by Mr. Conrad, *D. audacula;* but it does not correspond with the fossil described by him under that name (*Jour. Acad. Nat. Sci.* Vol. 8, p. 262). This fossil is the most abundant of the *Delthyrides* after *D. mucronata.*

Localities—Moscow; Seneca lake; Pavilion; Lake Erie.

10. *Delthyris fimbriata* (Conrad, *Jour. Acad. Nat. Sci.* Vol. 8, p. 263). — Lower valve.

10 *a*. Cast of the upper valve of the same.

10 *b*. A small portion of the shell magnified.

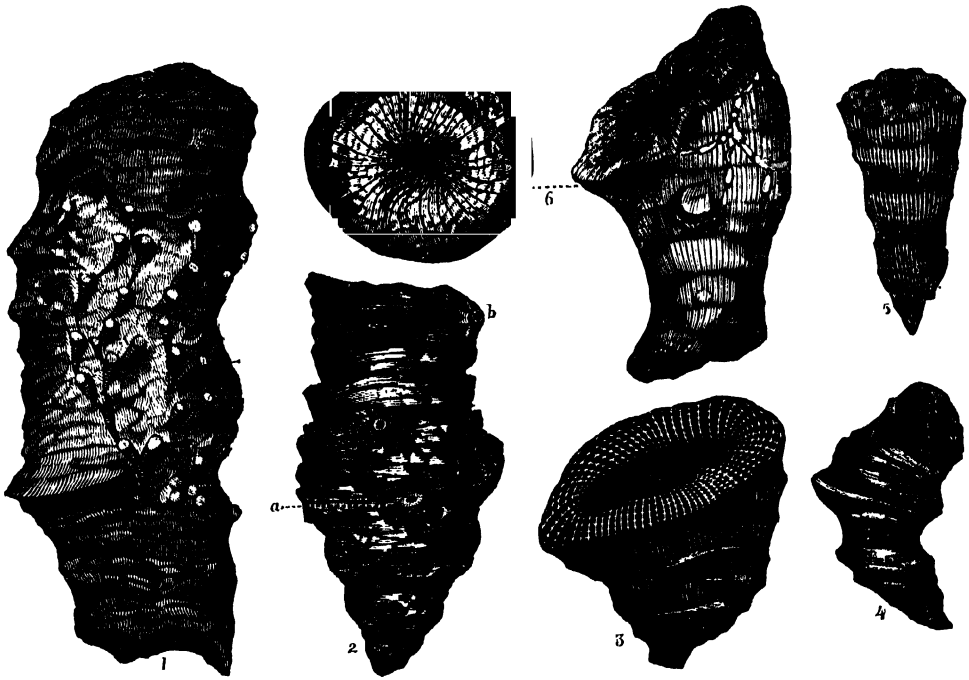
Upper valve sub-elliptical; lower valve nearly circular; surface marked by about twelve rounded ribs, which are crossed by concentric fimbriated lamellæ; beak very prominent.

The shell of this fossil appears very fragile, and the cast is more commonly met with.

Localities—Seneca lake; Moscow; York.

Among the numerous corals, the following have been selected as presenting some of the more common forms.

87.



1. Cystiphyllum cylindricum. 3. Strombodes helianthoides? 4. Strombodes distortus. 5. Strombodes? rectus 6. Strombodes simplex.

1 and 2. *Cystiphyllum cylindricum.* (LONSDALE in *Silurian Researches*, p. 691, pl. 16 *bis*, f. 3, 3 *a* and 3 *b*.) — Cylindrical; straight or curved; externally very rugose and striated; internally wholly vesicular.

Fig. 1 with *Aulopora tubæformis* attached; the same is figured with this coral attached, in *Silurian Researches*, from the Wenlock limestone.

Fig. 2, a smaller specimen, with the bases of crinoidal columns attached. Of these, the one at *a* evidently fixed itself while the coral was standing in an upright position; the one at *b*, and an intermediate one, evidently began their growth after the coral was thrown down, as their direction is at right angles to its axis.

Localities—Moscow; York; Eighteen-mile creek.

3. *Strombodes helianthoides?* (PHIL. *Palæozoic Fossils*, p. 11, pl. 5, f. 13. *Cyathophyllum helianthoidum*, GOLDFUSS, pl. 20, f. 2). — Turbinate, straight or slightly curved near

the base; surface striated and distantly wrinkled; disk expanded, and sub-reflexed at the margin; cup deep in the centre; lamellæ denticulated. The vertical lamellæ proceed from the centre, and there are no transverse laminæ as in *Cyathophyllum.*

Localities—Moscow; York; Seneca lake.

4. *Strombodes distortus,* n. s.? — Irregularly cylindrical, contracted and expanded by strong concentric rugæ; more or less abruptly curved. The laminæ are spirally contorted in specimens which have been examined.

Localities—York; Moscow; Eighteen-mile creek.

5. *Strombodes? rectus,* n. s. — General form turbinate, elongated, gradually expanding from the base; straight; surface marked by longitudinal lines, which indicate the internal laminæ.

This is an abundant fossil, sometimes appearing in pairs, but never joined together. It usually tapers gradually to a very small point at the base. The cup is very deep, and the margins thin, being usually flattened.

Localities—Moscow; Seneca lake; York; Eighteen-mile creek.

6. *Strombodes simplex,* n. s. — Turbinate, curved near the base; disk expanded; thin on the edge, sometimes sub-reflexed; laminæ simple, much contorted in the centre, and irregularly bifurcating toward the margin, (about 40 in number;) surface marked by longitudinal striæ.

The simple prominent laminæ, and shallow cup, at once distinguish this species. It resembles the *S. plicatum,* which occurs in the Corniferous limestone.

Locality—Moscow.

Several other species of these genera occur in the Hamilton group, some of which have been figured, as well as many other fossils which will hereafter be published, either at the end of the volume or in the report on palæontology.

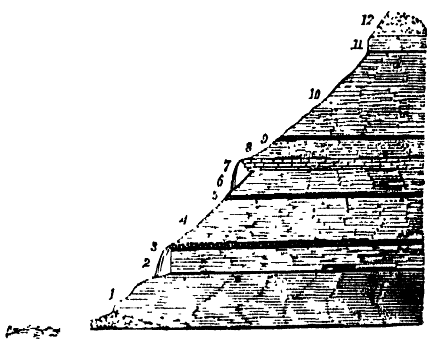
Localities of Superposition in the Hamilton Group.

[See Section along Cayuga lake, Pl. VII.; and Coast Section of Lake Erie, Pl. V.]

The section along Cayuga lake presents this group, succeeded by the Tully limestone, which is followed by the Genesee slate. The section on Lake Erie presents these two slates in contact, with merely the intervention of a calcareous band of two or three inches thick. These points are the two extremes of the district, and between them the Tully limestone has thinned out, or is only represented by a thin calcareous layer. Notwithstanding this, however, we find, in all localities examined, that the Moscow and Genesee shales are entirely distinct, never mingling in any degree.

The following section on the bank of Cayuga lake, at Kidder's ferry, presents the succession of these rocks.

88.



1. Olive shale, with Pterinea, Cypricardia, Strophomena, &c. 80 feet.
2. Coarse-grained shale, with large numbers of Fucoides.... 40 feet.
3. A harder calcareous stratum, producing a cascade.
4, 5 and 6. Bluish and greyish blue, very fissile shales, with large numbers of Atrypa, Orthis, Delthyris & Strophomena, 90 feet.
7. Tully limestone .... 11 ft. 8 in.
8, 10 and 11. Genesee slate, embracing a heavy course of septaria, 9; the portion at 11 is highly fossiliferous. Whole thickness .... 150 ft.
12. Slaty sandstone, irregularly laminated.

The following is a section of the conical hill on the Crooked lake outlet, being the same shown in the sketch at the head of the group.

89.

4. Genesee slate .... 7 feet.
3. Tully limestone .... 13 "
2. A thin band of black slate.
1. Bluish, fissile, and compact shale of the Hamilton group .. 60 "

90.

25. TULLY LIMESTONE.

This rock marks in a most prominent manner the termination of the fossiliferous shales of the Hamilton group, and is succeeded by shales of a widely different character. It first appears within the district on the western shore of Cayuga lake, extending for many miles, and is readily traced across the county of Seneca to the Seneca lake, where it is exposed upon both shores, and in the outlet of Crooked lake.

It receives its name from the village of Tully, in Onondaga county, where it is better developed than elsewhere, and better marked by its peculiar fossils. From this point westerly it becomes gradually thinner, until it is scarcely recognized.

The rock is usually thick-bedded, but often divides by numerous irregular seams into small fragments. Sometimes, however, it is in courses of six inches or a foot thick, and quite close-grained and compact. In other situations I have noticed it, where the surface was completely checkered by seams; and on breaking the mass, the whole crumbles into small angular fragments, much in the same manner as the shales containing pyrites. The rock is often an intimate mixture of shaly and calcareous matter, the latter greatly predominating. Again it is almost purely calcareous, with shale in thin seams, separating the rock into wedge-form and irregular laminæ. Its color, on first exposure, is blue, or often nearly black, but weathers to an ashen hue. From resisting the weather more firmly than the shales, it usually stands out in the face of the cliffs as a prominent band. It sometimes exhibits a tendency to a concretionary structure, but this is not usual.

On the shores of Cayuga and Seneca lakes, its relations to the overlying and underlying rocks are distinctly seen along a distance of many miles. From where it first appears on the north, it soon dips to the level of the lake, and again rises to the southward, presenting several undulations, which continue the mass above the water much longer than otherwise. These undulations are recognized in the section, Plate VII; and they are even more distinctly marked on the western side of the lake, and upon Seneca lake.

The illustration at the head of the preceding page is from a sketch on the shore of Seneca lake, south of Hathaway's landing, where the Tully limestone is seen to dip from the north, and pass beneath the level of the lake; and again a few rods farther on, it rises from beneath the water and ascends southward, disappearing from the shore. About six miles farther south, it again comes to the level of the lake, and disappears beneath it for the last time.

These undulations appear upon the west side also, and here it makes another ascent from the lake after its second disappearance beneath it. This place is a short distance south of Bigstream point, in Yates county. It is merely the top of the arch which appears above the water, presenting its whole thickness with a few feet of the shale below, and curving gradually downwards in either direction. (See woodcut 91.)

On the eastern shore of Seneca lake, where this rock rises considerably above the water level, the action of the waves has undermined the softer shale beneath, and leaves the limestone projecting. This process has evidently gone on for a long period, as the shore is skirted by an irregular wall of the fallen fragments. Thousands of tons of these fragments have been removed for burning to lime, and those now remaining are mostly beneath water. The practice of removing these fragments, or of allowing them to be taken away, is of doubtful economy; for while they remain, they form a barrier which protects the shore from farther encroachments by the water; but their removal admits a renewed action of the water upon the cliffs, which undermines the limestone, bringing it down with all the mass above it.

Along the western shores of the lakes this feature is not perceptible, from the short duration of easterly winds, which have little influence upon the shales. The high perpendicular cliffs are consequently less common on this side, and the limestone less exposed.

This limestone appears in the banks of the outlet of Crooked lake, being visible almost continuously from Seneca lake as far as the fall at Wait's mill on the outlet, where it disappears beneath the superincumbent black slate.

After leaving this place and the western shore of Seneca lake, this limestone appears but at few points farther west. In the bed of Flint creek, at the village of Bethel, it is visible, and at another point about four miles northwest of this place, in the bed of a small stream. At the latter point, it is but three feet thick.

A few miles farther west, on Canandaigua lake, it is represented by a few inches of impure calcareous matter, but the character of the shales above and below contrast as strongly as where the limestone has its greatest thickness. In all localities west of this point, where the junction of the shales can be examined, we find a few inches of hard impure limestone, which would scarcely be noticed but for the contrast in the shales, which bear the same characters as farther east.

So far, therefore, as it can be described, this rock is virtually absent at all places west of Canandaigua lake; still its place is equally marked, and affords a point of reference in all localities. Its origin was evidently at the east, and from the small quantity of the product, it has spread over only a small portion of the State. Were it not for the great contrast in the shale above, and the extinction of the greater part of the organic remains at this point, it might be united with the last group, being in fact less persistent than the Encrinal limestone which separates the Moscow shale from that below it. Several of the fossils of this rock are peculiar to it, being unknown elsewhere. The same is true also of the fossils of the Encrinal limestone, before spoken of in the Hamilton group.

Concretionary Structure of the Tully Limestone.

Near Big-stream point, on Seneca lake, where this limestone rises above the level of the water, the lower strata exhibit a concretionary structure, and some portions are actually separated into regular spherical concretions. The sketch below is a section at this place.

91.

This structure seems to be owing to a meagre supply of the material, which when spread over the bottom was insufficient to form a continuous stratum, and collected into these spherical and concretionary masses. Similar effects seem to have occurred in other cases, particularly in some of the shales where a small portion of calcareous matter has aggregated itself into spherical forms, presenting a continous course of these, which hold the same position in the strata as if a thin layer, once continuous, had been rolled up into spheroids.

Localities.—A few localities will suffice for acquiring a knowledge of this rock in the Fourth District. The western shore of Cayuga lake south of Ovid, and the eastern shore of Seneca lakç, from Hathaway's landing southwards, will give good opportunities of examination. The western shore of Seneca lake and the outlet of Crooked lake are also equally good localities.

At the village of Bellona, in Ontario county, it is well exposed in the bed of a small stream, and contains more of its fossils than at any other locality. There are some other points of minor interest, but they afford the observer nothing new, or of different interest from those enumerated.

Thickness. — The greatest thickness of this rock within the district is but sixteen feet, and in most of the localities it is less than ten feet thick. It gradually diminishes westward, and from Canandaigua lake westward its place is occupied by a calcareous band of three or four inches thick.

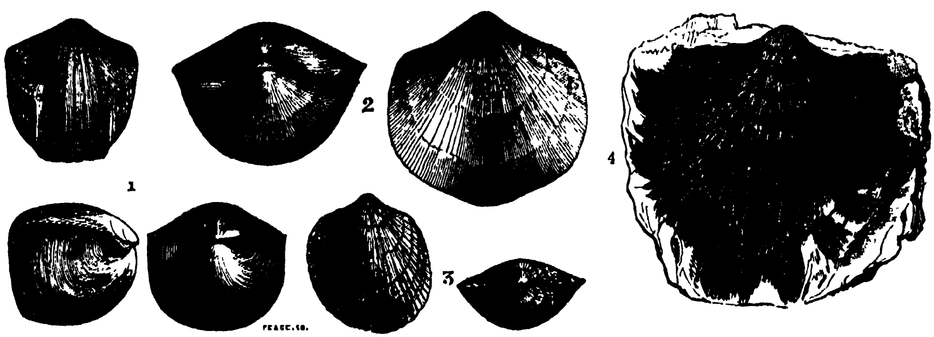
Mineral contents. — The rock contains no mineral of interest. The cavities of fossils are often lined with calcareous spar, and in a few cases some small crystals of sulphate of baryta have been obtained in similar situations.

The mass is too thin to be of importance in its effects upon springs or upon the character of the soil. It is the most southern limestone in the State from which lime is burned, and in this respect is important to the inhabitants of the district along which it extends. Being from six to eight or ten miles south of any other point where limestone is quarried, it becomes of great value, both for burning to lime and as a rough building stone.

Organic Remains of the Tully Limestone.

As a general fact, organic remains are rare in this rock within the district. In the Third District, however, they are more common, but they are of the same forms in both. Besides those figured below, there is a species of Cyathophyllum, which is abundant at Bellona in some thin shaly layers in the upper part of the rock. In many localities fragments of fossils are found, though perfect ones are not met with. This seems more extremely so towards its western termination.

92.



1. Atrypa cuboides? 2. Orthis resupinata. 3. Atrypa lentiformis. 4. Atrypa affinis.

1. *Atrypa cuboides?* (Reference, Sowerby, *Geol. Trans.* 2d series, Vol. 5, pl. 56, f. 21. Phillips, *Palæozoic Fossils*, page 84, pl. 34, f. 150.) — Sub-globose or cuboidal; front margin of the lower valve extremely elevated, occupying a deep sinus, with nearly parallel sides in the upper valve; lower valve, with the exception of this process, nearly flat; beak small.

This fossil is readily known by the square sinus of the upper valve, the strongly ribbed process which fills it, and the sharp edges of the shell at the junction of the valves. It seems scarcely possible that this shell can be different from the English specimens, though both Sowerby and Phillips describe the *A. cuboides* as having fifteen ribs on the mesial sinus, while ours has but from six to eight. In other respects there is a precise correspondence. The ribs on the process of the lower valve, and on the elevated portion of the upper valve, are much stronger than elsewhere on the shell.

Locality—Bellona, Ontario county.

2. *Orthis resupinata* (PHILLIPS, *Palæozoic Fossils*, p. 67, pl. 27, f. 115. *Spirifera resupinata* of same author, *Geol. of Yorkshire*. *Terebratula resupinata*, Sow. *Min. Conch.* tab. 325. *Anomites resupinatus*, MARTIN. *Orthis Tulliensis*, *Report of Third District*, page 163.) — Transversely elliptical; lower valve very convex, slightly flattened in the centre; upper valve convex near the beak, and depressed in front; surface finely radiated.

When the shell is partially or entirely removed, the surface appears covered with minute punctulations. From comparison of specimens, Mr. Conrad says this fossil is identical with those sent from England under the name of *Anomites resupinatus*. It occurs in the mountain limestone of England, and in rocks of the same age as the higher shales and sandstones of the New-York system.

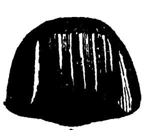
3. *Atrypa lentiformis* (VANUXEM, *Geol. Report*, page 163). — I am not able to discover that this fossil differs from the *Atrypa affinis* in some of its various appearances. It is usually smaller in this rock than that fossil generally is; but in the next figure is another form, apparently of the same fossil, from this rock.

4. *Atrypa affinis*. (For synonymes and authorities, see page 198.) — The valves of the shell are much compressed at the margins, giving it the appearance of being surrounded with a fringe. The specimens, as commonly obtained, are only that part of the figure which appears more prominent.

I am indebted to Dr. H. P. Sartwell, of Penn-Yan, for the specimen from which this figure is taken; and also for specimens of the *Atrypa cuboides?*

Locality—Bellona, Ontario county.

93.



1

The figure in the margin is a front view of *Atrypa cuboides?* the others not being quite satisfactory in regard to the form and appearance of the ribs on the mesial sinus The elevated portion of the lower valve is not quite as great as in Mr. Phillips's figure. I have not the means of referring to Mr. Sowerby's figure at this time, but that is the one by which I had identified this fossil as I then supposed.

For localities of superposition of the Tully limestone, see that head under the Hamilton group.

REMARKS, PRELIMINARY TO THE FOLLOWING ROCKS AND GROUPS.

In the Fourth District, the Tully limestone terminates all those deposits in which calcareous matter forms an essential part. In all the higher rocks, this material, when existing, is the result of the destruction of organic bodies; and in the few instances where it appears, the origin is unquestionable, for the fossils still retain so much of their original form as to be readily recognized. This rock forms a strong line of demarcation not only in this respect, but also as regards fossils, very few forms which are known below continuing into the rocks above. The lithological character of the products above this rock are throughout more or less similar, while they differ from those below; and with a single exception, lithological character is a sufficient guide for distinguishing the different strata.

This contrast of character is more marked towards the western extremity of the district, than it is farther east; and finally, on its eastern extreme, there is a greater similarity in the lithological features. This change is likewise attended with the occurrence of some of the fossils of the lower group in the rocks of the higher, the nature of the two being very similar, although the Tully limestone is in its greatest force; while at the west, where it does not exist, no such mingling of the fossils is known.

At Ithaca, for example, where we are far above the Tully limestone, and where the rocks are well marked by an abundance of fossils peculiar to themselves, still we find the *Microdon bellastriata*, the *Modiola concentrica* and some others, and I have even detected the *Calymene bufo* and *Dipleura Dekayi* in the same association. Still farther east, there is a greater mingling of species of the lower rocks with the upper, and a nearer approach constantly in materials of composition. These circumstances, in the eastern portion of the State, render it difficult to point out the line of demarcation between the lower and higher rocks of this division.

At the eastern extremity of the State, also, the Tully limestone does not exist, and therefore that guide to the line of division between the lower and higher groups is wanting. The absence of this rock, and the similarity of lithological products as well as the mingling of the organic remains of the lower rocks, renders it impossible to make a distinction in groups with the same degree of satisfaction as farther west. By reference to the section along the Genesee river (Plate 13), it will be seen that the Genesee slate, a black carbonaceous mass, is succeeded by shale of a deep green color, and well defined above. This is succeeded by flagstones, which alternate with shale of a less deep green color, and often with black shale. These again are followed by a greater proportion of sandstone, often thick-bedded, and presenting far less of the characters of those below.

These rocks are well exposed on the Genesee river, and there can be no possible room for error in their examination. The whole thickness here exposed is scarcely less than one thousand feet; and throughout this thickness, there is as yet no fossil known which occurs in the Chemung group to the south and above these rocks. These circumstances led to the separation of this portion of the system, and the adoption of Portage or Nunda as the locality designating the group. Farther east the green shale (Cashaqua shale) is often darker in color, and more sandy, becoming largely interstratified with flagstones which have much the character of those which lie above it on the Genesee, except in the absence of a peculiar species of *Fucoides*. At the same time, the small *Avicula*, which is so abundant in the Genesee slate, is almost equally abundant in the green shale and flagstones at Penn-Yan.

Again, when we go westward as far as Lake Erie, we find, that instead of the flagstones succeeding the green shale as on the Genesee, a black shale is the first mass above. This soon gives place to green shale; and we have alternations of green and black shale for many hundred feet, before coming to the thin-bedded sandstones.

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26. GENESEE SLATE.

Upper Black slate, and *Black shale and slate*, of the Annual Reports

(Part of No. 8? Pennsylvania Survey.)

[Lower part of P. woodcut, page 27. See also Sections, Plates V. and VII., and County Sections.]

Superimposed upon the Tully limestone, or, in its absence, resting upon the Moscow shale, we find a great development of argillaceous, fissile, black slate. Where its edges only are exposed, it withstands the weather for a great length of time, and often presents mural banks in the ravines, river courses, and upon the shores of lakes. Where the surface of the strata are exposed, it rapidly exfoliates in thin even laminæ. On disintegration, it is often stained with iron, owing to decomposition of pyrites; but in many instances, and the greater number of localities, it retains its deep black color. In this it is distinguished from some beds of black slate in higher situations, which always become stained with hydrate of iron on their edges, and upon the surface of the laminæ.

In color and general characters it greatly resembles the Marcellus shale; and aside from position, it would be difficult to distinguish the two in the absence of fossils.

Constituting a part of the great series of shales, with flagstones and thin-bedded sandstones, which occupy all the southern range of counties, it forms no conspicuous feature in the scenery or topography upon the general surface. In ravines and river banks, it is usually seen in connection with the rocks below or above, or with both, and forms only an element in the deep escarpments. Its greatest development in the district, and a point where it appears more prominently alone, is at the opening of the gorge of the Genesee river at Mount Morris.*

* From the circumstance that other shales above this appear in the same gorge, it would have been desirable to give another name, but no locality is known, which is not more objectionable than this. Since it is very probable, also, that this

The mass decomposes much less rapidly than the soft calcareous shales below it, and the thin slaty laminæ resist atmospheric action for a long time. On the Genesee it presents two regular courses of concretions or septaria, with numerous single ones scattered through it without order. These are often divided by seams of crystalline matter; but many of them are without these seams, the inside being entirely composed of crystalline carbonate of lime of a deep resinous color, from its strong impregnation with bitumen, which often flows from the small cavities when the mass is broken.

In lithological character this rock is entirely uniform throughout the district, presenting itself upon the margin of Cayuga lake and upon Lake Erie, having the same deep black color and laminated slaty structure. Neither is there any change in its organic remains; the same forms, and many of them almost equally abundant, are found throughout its entire extent. The greater portion of this rock is destitute of fossil remains, and it is only toward the upper part that they occur.

The position of this formation on the map is at the junction of the purple and brown colors: it being too thin a mass, and occupying too little surface, to be represented by itself. In the Fourth District this rock borders the margins of Cayuga and Seneca lakes, and is visible in all the deep ravines, forming high cliffs above the Tully limestone, which latter always projects boldly, forming a cliff, or a cascade on all the small streams. It crosses Seneca county in a curve, its extreme northern limit being some distance north of the village of Ovid, while its final disappearance to the south on the lake shore is ten or twelve miles distant. This circumstance is owing to the great height of the central part of the county above the lake, the highest part of which is between 400 and 500 feet above the level of the water of Seneca, and more than 500 above Cayuga lake. On the western side of Seneca county, this rock extends as far south as the town of Starkey in Yates county; and from thence it sweeps around in a northwest direction through the towns of Benton, Seneca and Gorham, and stretches southward along Canandaigua lake, to within a few miles of its southern extremity. From this place westward its outline is extremely irregular; and in the western part of Ontario county, it forms some small outliers in the towns of Bristol and Richmond. From the outlet of Conesus lake in Livingston county, its direction is southwesterly, till it comes to the level of the Genesee valley in Groveland and Mount-Morris. From the western side of this valley, its course is northwesterly to the south part of the town of York, whence it continues westward to Allen's creek. Beyond this point it extends northwesterly into Bethany, and thence by an irregular west and southwest direction to Lake Erie.

The outline and direction of this rock is interesting, as showing the southern limit and extent of the Hamilton group. The irregularities in outline, and the great southern depres-

rock will in future be considered only as a member of the Portage group, its local name will be the more appropriate. The aboriginal name of this place was *Squakie Hoh;* and the gorge at its outlet received the name of *Squakie Hondah*, which signifies a gorge with a river opening into a plain, which is beautifully applicable to this spot, where the river, after pursuing a meandering course for twenty miles through a deep gorge, and over three successive cascades descending more than five hundred feet, flows out into the beautiful broad and fertile valley of the Genesee. These aboriginal names have been furnished me by E. N. HORSFORD, Esq.

sions, are owing to deep valleys, as those of the lakes and the Genesee river. As it approaches Lake Erie, it takes a broad sweep to the southwest, and disappears beneath the surface of the lake in the town of Evans in Chautauque county.*

The uniformity in lithological character of this mass throughout, and its finely levigated particles, indicate a quiescent period, and the operation of an ocean moved only by gentle currents. There is no great accumulation in one part over another, and the deposition appears only to have been affected by the common law of gravitation. At the time of its deposition it possessed the character of a soft, black, carbonaceous mud, with scarcely an admixture of siliceous matter in any part.

Concretions. — The well defined concretions or septaria have been noticed, and these are all that occur throughout the mass to interrupt its sameness. These bodies are often without any apparent seams; at other times they are crossed in various directions by seams of crystalline carbonate of lime, etc., which apparently fill cracks previously formed by the desiccation of the mass. These concretions are interesting as showing the occurrence of calcareous matter at one or two positions in the rock, which, though small in quantity, spread over a large extent of surface.

These bodies vary from the diameter of a few inches to two or three feet, and are usually pretty purely calcareous and nearly spherical.

Localities. — A few points will suffice to give the observer a knowledge of this rock. In Seneca county it can be examined in nearly all the gorges which communicate with the lake, in the towns of Ovid, Lodi and Covert. Below the Lodi falls it abounds in fossils peculiar to it, though of few species, Orbicula and Lingula being the most abundant. About two miles south of Big-stream point, in Yates county, it is well exposed on the lake shore, and contains its usual fossils. Along the outlet of Crooked lake it is well developed, and also in the ravines on the south side of this place. There are several good points for examination on the banks of Canandaigua lake, and in the ravines leading to the same.

The gorge of the Genesee river at Mount-Morris affords, probably, the best exposition of this rock, where it is laid open in the perpendicular cliffs on either side, for more than a mile in length. The principal fossil at this place is a species of Avicula with a very fragile shell, which will be seen figured in illustration No. 94. The shale is well exposed in a ravine, and at a fall on a small stream about two miles northwest of the village of Moscow, in Livingston county.

From this place to Lake Erie it may be examined in nearly every ravine which extends southward, and in the lateral ones joining the north and south valleys. Its constant fossil is the little Avicula just referred to, and in nearly every locality it abounds, frequently covering the surface of the slaty laminæ, through several inches in thickness, and more sparingly scattered through a greater extent.

* It will be recollected that the surface of Lake Erie is about 120 feet higher than Seneca lake, and consequently this rock disappears beneath its surface four or five miles farther north than if it were at the same level.

On the shore of Lake Erie it may be examined in numerous places, but the best locality is at Eighteen-mile creek and along the banks of the creek a mile from the lake. It is here, if possible, more strongly marked by the Aviculæ, and they are so crowded together that often, for many feet in extent, it is nearly impossible to distinguish their forms.

Thickness. — On the shores of Seneca lake and in Ontario county the thickness of this rock is about 150 feet, as estimated by careful measurements along the descent of streams and in perpendicular banks, though there is no single point where the whole thickness is shown at once. After passing the Genesee river in a westerly direction, it soon becomes evident that the rock has diminished in thickness, though there are no points where good measurements can be obtained. On the shore of Lake Erie, however, the whole rock is well exposed, in connection with the lower and higher masses, in the perpendicular cliff at the mouth of Eighteen-mile creek (See section, Plate 5.) At this place its thickness is but twenty-three feet seven inches, or less than one-sixth of its thickness at the eastern limit of the district. This thinning is due to the cause before mentioned, viz. the diminishing power of the currents which transported the materials, and the consequent precipitation of a greater portion of the matter near the origin of the same. It bears no evidence of denudation, and, from the even surface of the rock below, this great diminution is not local, but has evidently been gradual and uniform through the extent of one hundred and fifty miles.

Minerals of the Genesee Slate.

The only minerals, except iron pyrites, which occur in this rock are found in the cavities of the concretions. These are crystallized carbonate of lime, in the common rhombic forms, and in hexahedral prisms with trihedral summits; sulphate of baryta; quartz crystals, with more rarely galena, or sulphuret of lead. Fluid bitumen is of common occurrence, and with it a bright blue fluid and a substance like spermaceti, but softer. These are volatile, and it has been impossible to preserve any of them. The fluid bitumen and the blue fluid have likewise been noticed in septaria in the Marcellus slate.

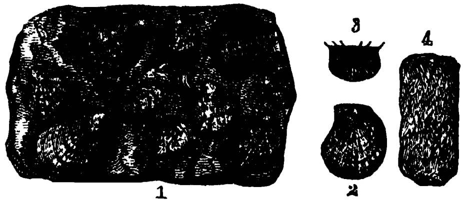
This shale is so intimately blended with the rocks that follow, that alone it has exercised no influence on the soil or springs which is not common to the rocks above it, and are only such as will be subsequently noticed under the next group.

Organic Remains of the Genesee Slate.

The only constant fossil of this rock is the *Avicula fragilis*, figured below. The greater part of the mass is destitute of any organic remains, and it is only in the higher portion that we find them in very considerable numbers. The forms figured in the woodcut (No. 95) are usually found in the upper strata, and I do not recollect having ever seen any of them more than twelve or fifteen feet below its termination. In several localties on Cayuga and Seneca lakes, these forms are all found associated together, and in great numbers; but farther west they are more rarely found, and finally do not appear at all. The *Aviculæ*, on the other hand, appear to increase in numbers in a westerly direction, and on Lake Erie are more numerous than at any other point.

With the termination of the Moscow shale, seem to have perished the immense number of organic forms which every where mark the presence of that rock. For a long period, as is evident from the character of this shale, the ocean bed was not inhabited by living things; and with the exception of the few species in the Tully limestone, where that rock occurs, it is not until we arrive at nearly the termination of this slate, that vitality again assumes its place among the laws of nature, to go on increasing, till in the upper part of the Chemung group the ocean literally swarmed with living things.

94.



1 and 2. Avicula fragilis. 3. Strophomena setigera. 4. Tentaculites fissurella.

1 and 2. *Avicula fragilis*, n. s. — Shell ovate, (hinge line being usually concealed,) very thin; surface marked by concentric lines, and a few faint radiating striæ; hinge line shorter than the width of the shell.

Fig. 1 is a small fragment of the shale, with these shells covering the surface.

Fig. 2, a single shell, showing the perfect form.

It is an extremely abundant fossil, but from being mutilated, and often partially concealed, its generic relations are not always readily detected. It occurs in the Marcellus shale.

Localities—Seneca county; Geneseo; Leicester; Mount-Morris; Eighteen-mile creek.

3. *Strophomena setigera* (see page 180 of this Report). This fossil is also common to the Marcellus shale.

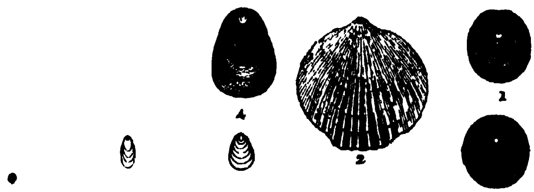
Locality—Outlet of Crooked lake.

4. *Tentaculites fissurella*. A fragment of the shale covered with the fossil (see page 180 of this Report). Occurs likewise in the Marcellus shale.

The three species here figured are all common to this rock and the Marcellus shale, the lithological character of the two being precisely similar. Neither of them have been noticed in the intervening rocks of the Hamilton group, though the *Avicula* passes upwards into the Cashaqua shale of the Portage group. This is an interesting example of the recurrence of the same species of fossils in rocks widely separated from each other. This identity in fossils, and similarity in lithological characters, has been the cause of frequent mistakes in identifying the two.

The following species, figured in the Report of the Third District, page 168, are quite abundant in this rock in the eastern part of the district, but are far less common farther west, and disappear altogether before reaching Lake Erie.

95.



1. Orbicula Lodensis. 2. Atrypa (Orthis) quadricostata. 3. Lingula spatulata. 4. Lingula concentrica.

1. *Orbicula Lodensis.*—The shell is concentrically striated, and marked by a few radiating lines. It differs from one in the Hamilton group, in being much smoother.

Localities—Lodi in Seneca county, below the Falls; Big-stream point.

2. *Atrypa quadricostata.*—Mesial portion of the shell marked by four or five strong radiating ribs; sides nearly plain.

Occurs with the last.

3. *Lingula spatulata.*—This is an abundant little fossil in the localities named above, and is readily distinguished by its small size and spatulate form.

4. *Lingula concentrica.*—This fossil is peculiar for its great proportional breadth at the beak, and the extent of the margin beyond. Some specimens seem scarcely referable to the genus.

Occurs with the preceding species at Lodi, and near Bigstream point.

For localities of superposition of this rock, see that head under Hamilton group.

96.

Upper and Middle Falls of Portage. From a sketch by Mrs. Hall.

27. PORTAGE OR NUNDA GROUP.

Sherburne flagstones and shale, Cashaqua shale, Gardeau and Portage groups, of the Annual Reports.

(Part of No. 9, Pennsylvania Survey.)

[See P of woodcut, page 27, and section of Genesee river, Pl. XIII; also section of Lake Erie shore, Pl. VII.]

This group presents an extensive development of shale, shales and flagstones, and finally some thick-bedded sandstone towards its upper part. Like all the other mechanical deposits of the system, as they appear in New-York, it is extremely variable in character at different and distant points. From its general similarity, and from the difficulty also of separating it from the higher rocks on its southern limits, it is colored the same tint on the map, being the northern part of the light umber tint.

From its superior development along the banks of the Genesee river in the district formerly included in the town of Nunda, now Portage, it has received that name to distinguish it from the higher rocks, which possess some differences in lithological characters, but a more striking dissimilarity in organic remains.

This group rises sometimes in a gentle slope, and at other times abruptly from the softer shales below. The enduring sandstones of the upper part have enabled it to withstand denuding action to a considerable degree, and these often extend far northward on the elevated grounds between the deep north and south valleys, presenting a gentle northern slope to the shales of the Hamilton group; while on the sides of the same hills the slope is abrupt, and the surface being but little covered with northern drift, the valleys are bounded on either side by steep hills. This character is well illustrated along the southern part of the Genesee valley towards Dansville, and in the valleys of Allen's creek, the Tonawanda, and the different branches of the Seneca and Cayuga creeks. The same is also seen in the valleys of Mud creek, Flint creek, Canandaigua lake, and to a greater or less degree along all the valleys and streams which extend into this group.

The change in the external appearance of the country indicates the commencement of these rocks, although they are not seen. The valleys just spoken of, in their course through the shales of the Hamilton group, present gently sloping sides, and the country rarely rises far above the level of the valley bottom or bed of the stream. On approaching the northern margin of the Portage group, the observer finds a gradually increasing elevation of the hills on either side, and an abruptness in their slope; and in a short time he finds himself in a deep valley, bounded on either side by hills rising four or five hundred feet, and in some instances even eight hundred feet above the bed of the stream. These elevations often extend several miles unbroken, except partially by the deep ravines which indent their sides, and which have originated in recent or ancient water courses which took their rise upon the summits of these hills.

The higher sandstones of the group, and in many instances some of the intermediate ones, produce falls in the streams which pass over them, and some of the most beautiful cascades in the State are found among the rocks of this group. The highest perpendicular fall of water in the State is produced by the rocks of this group, and in none others do we meet with more grand and striking scenery. The pedestrian often finds his course impeded by a gorge of several hundred feet in depth; and in the very bottom of this, and scarcely perceptible, is the winding stream, the only representative of the once powerful torrent that has excavated the deep channel. Farther on, above or below, he may see the little stream dashed over a precipice, and almost disappearing in spray before it reaches the bottom; here, however, it gathers itself in a deep pool, from which it flows on quietly as before, or gurgling and dashing through the fragments of the fallen cliffs, it finds its way into the gently sloping valley of the softer shales.

So numerous are these falls in the district, that to present even an enumeration of them would fill a page. Among these have been selected for illustrations, either from their beauty and interest, or from being accessible places, the following: Portage Middle and Upper Falls, Portage Lower Falls, Taghannuck Falls,* Hector Falls, and Lodi Falls. The first of these, the illustration at the head of the preceding page, is the locality giving name to the group. The river in view is precipitated over two falls of 66 and 110 feet respectively; and below the last, the rocks rise in perpendicular cliffs of 350 feet in height.

* This is the aboriginal name; the place is usually known as Goodwin Falls.

On the Genesee river, which affords the best development in the district, this group admits of the several subdivisions shown in woodcut 97 at the foot of the page.*

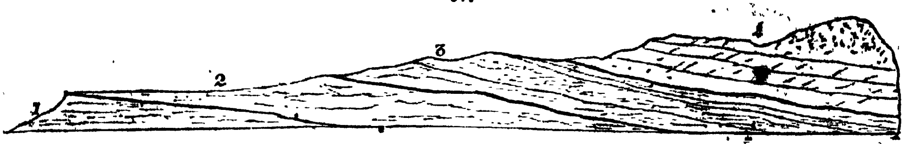
98.

View on Cashaqua creek. From a sketch by Mrs. HALL.

1. CASHAQUA SHALE.

This rock, in lithological and fossil characters, differs sufficiently from those above to be considered under a separate name. From its perfect development upon the Cashaqua creek, that name was applied to it before the examinations of the higher rocks had been completed.

* 97.



1. Genesee slate. 2. Cashaqua shale. 3. Gardeau shale and flagstones. 4. Portage sandstones.

The lowest rock here represented rests on the Genesee slate, and about eight feet from its base is marked with a band of black shale, similar to the Genesee in every respect. The three divisions of this group, as given in the woodcut, are plainly recognizable on the Genesee river, and to a great extent over the whole district. As we go east from this point, however, there is a constant increase of arenaceous matter, and in a westerly direction an increase of mud or shale. The whole can be better described under the three divisions above noticed.

The mass at this place is a soft argillaceous rock of a green color, rapidly crumbling on exposure, and forming a tenacious clay. From the influence of atmospheric agency, it is very difficult to procure good specimens; and fossils not being abundant, they might be easily overlooked. It is, however, marked by certain species of shells which have not been seen in any other rock, and these have been found to hold the same position over an extent of 150 miles.

On the Cashaqua, and in other places in the same neighborhood, it contains some flattened concretions of impure limestone, and sometimes of sandstone, but of these it presents no continuous layers. It is deeply excavated, presenting high and abruptly sloping banks, which project into the valley on one side and recede on the other, as the stream winds along its course below. In looking down the stream, as represented in the woodcut at the head of the page, the slopes of these cliffs are free from vegetation, while on the opposite side they are entirely covered, often with large trees. This effect is produced by the action of the meandering stream, which flows in its channel from one side of the gorge to the other, continually undermining the rock which crumbles down from above, thus constantly presenting a fresh surface.

At the eastern extremity of the district, and on the shores of Seneca lake at Penn-Yan and other places, this rock consists of a green shale with thin flagstones, and interlaminated sandy shale. It contains the same fossils; and holding the same position as on the Genesee, it can be regarded only as the same rock, the intercalation of sandy strata being due to its proximity to the place of origin. Farther east it is not recognized as a shale at all, the mass consisting of thinly laminated shaly sandstone. At Penn-Yan it often manifests a concretionary structure, and the sandy strata are irregular in thickness and continuance.

On tracing it west of the Genesee, it constantly presents the same features as on the Cashaqua creek, though the lower part is occasionally dark colored, and separated from the Genesee slate by a thin calcareous band. It is exposed in numerous streams and ravines, the most important of which are those in the hills bordering on Allen's creek, Tonawanda creek, and the branches of Seneca and Cayuga creeks. It appears at the village of Wyoming, in Wyoming county, and in numerous other points in the same neighborhood. On the shore of Lake Erie its whole thickness is seen in the high perpendicular cliff, having thinned from 110 feet on the Genesee to 33 feet at Eighteen-mile creek. At this place it retains all the characters which are peculiar to it on the Genesee, having changed only in thickness.

2. Gardeau Shale and Flagstones.

Along the Genesee river, above the last described rock, we find a great development of green and black slaty and sandy shales, with thin layers of sandstone, which form beautiful and durable flagstones; these are quarried from the same situation in many places in the district. The rocks of this part of the group form high, almost perpendicular banks on the Genesee, only indented by the incipient ravines caused by slides and the action of running water. From their great exposure along the Gardeau reservation, that name was adopted in the annual reports, to distinguish this part of the formation; and since this is a good point for investigation, it is described as a subordinate part of the Portage group.

In the lower part of this subdivision the shales consist of alternations of green slaty and sandy shale with black slaty shale, one or two thin courses of sandstone occurring in the space of four or five feet. As we ascend, the arenaceous matter increases in quantity, the layers are thicker and more numerous, and the shale forms distinct alternations of black and green, often many times in succession, within the space of fifty feet. Towards the upper part the courses of sandstone become too thick for flagstones, and the shale is in thicker masses than below.

These characters, however, which are sufficiently obvious in the gorge of the Genesee, are not constant for any great distance in either direction. Toward the east the arenaceous strata augment in a great degree, to the exclusion of the shales; while in a westerly direction the sandstones are constantly disappearing, and the proportion of shale constantly increasing. At the western limit of the State, along the shores of Lake Erie, the Cashaqua shale is succeeded by a thick mass of black shale, and this is again succeeded by alternations of green and black shales for several hundred feet upwards, the flagstones having entirely disappeared from nearly the whole thickness. With the absence of sandy strata and the augmentation of shale, a few fossils, which were rather sparingly seen along the Genesee and in the eastern part of the district, become more numerous, and form a distinguishing feature of the rock.

3. Portage Sandstones.

The thick-bedded sandstones at Portage form the terminal rocks of the group. These are well exposed in the deep gorge below Portageville, where the perpendicular cliffs rise to the height of three hundred and fifty feet. The upper part consists of thick-bedded sandstone, with little shale; while below, the sandy layers become thinner, with more frequent alternations of shale. The thick-bedded character of the sandstones, and the presence of fucoids passing vertically through the strata, induced the separation from the rocks below, where the characteristic species of the same genus lies horizontally upon the surface of the strata. The lithological character of the sandstone, and the presence of the vertical fucoid, hold uniform over a considerable extent; and the presence of the latter alone is often sufficient to decide the position of the rock, where it is but slightly exposed.

Toward Cayuga lake, the increase of arenaceous strata below has rendered a distinction between the two of little importance; and farther west, where the Gardeau division has become very shaly, the higher division has taken the character which the former one has on the Genesee, being composed of alternating thin-bedded sandstone or flagstones and shale.

Along the western limit of the State there are but few points where the thick-bedded sandstone, like that at Portage, can be seen. One of these is at Laona, and another, which is the terminating mass of the group, is at Shumla. Along the lake shore it appears at several places; and in the excavation for the New-York and Erie railroad, west of Fredonia, the same rocks are exposed.

The description of these three divisions will furnish a correct idea of the lithological character of the group. At the eastern end of the district the whole series consists of shales and shaly sandstones, with some thick-bedded sandstones, corresponding more nearly with those above them than the same do farther west. Still it must be acknowledged that in lithological characters there is no abrupt change, or evidence of very different conditions in the ocean from which they were deposited, from the termination of the Tully limestone, to the final deposition of the Chemung group. Shales and sandstones, differing in some degree, it is true, compose the whole assemblage. In the lower part these are more intermingled, and the sand is finer; while in the higher part of this series, the sand is often coarser, and generally less intermixed with shale. The Portage group forms the lower member of this great division, the sandstones and shales being less separated than above; the arenaceous strata are finer grained, and always more argillaceous than in the Chemung group.

When we apply the test of organic remains, we find an equally, or even more strongly marked difference in the two groups, and upon this alone a distinction between the two should be made. Throughout the whole thickness of the Portage group, which is not less than 1000 feet, there are but two forms which can be referred to the Brachiopoda; one of these is a *Delthyris*, and the other apparently an *Orthis*, and both are quite unlike any others which have been seen in the rocks above or below. In both the Hamilton and Chemung groups, shells of this family are the predominating forms, and they are at least ten times more numerous than any others. In the Portage group the principal forms are *Goniatites* (fragments of several species being known), *Bellerophon*, and bivalve shells allied to *Pterinea?* with a small *Avicula* everywhere characteristic, and known in no other rock.

Considering these facts, it seems desirable to separate these lower rocks, that we may have an opportunity of investigating them separately, and of comparing their fossils before we unite them with the higher group, which has a very great development, and in which I have never seen one of the fossils of the Portage group.

The higher mass of sandstone of the Portage group, before mentioned, is very persistent, being known in Ohio as the Waverly sandstone; and there, as well as in New-York, it forms a line of demarcation between the almost non-fossiliferous shales and sandstones below, and the highly fossiliferous sandstones and shales above, which latter are a continuation of the Chemung group. From the circumstance that but few of the strata in the Portage group contain fossils, they have usually been overlooked, and the rocks on a hasty examination would be pronounced non-fossiliferous.

Along the shore of Lake Erie, the rocks of this group hold a conspicuous place, having traced them continuously from near Eighteen-mile creek in Erie county, to Erie in Pennsylvania; and beyond this they appear at numerous points, apparently being continuous as far as Cleaveland in Ohio. Fossils, with the exception of fucoids, are rare throughout this whole distance, and it is mainly from lithological characters that the strata are recognized. In Ohio, and to the southwest, there is a much greater similarity in the lithological characters of the Portage and Chemung groups than in New-York, and there they are not separated by those who have described them.

Diagonal lamination.—This structure, which indicates the mechanical process of deposition, is of frequent occurrence. In many of the flagstones these lines of deposition are marked by thin laminæ of shale, and again the layer thins entirely out. The process is readily understood to be that where the sand is carried on and spread over the surface, sloping off towards one side farthest from its origin. The next deposition covers this sloping side necessarily in the same manner, producing the oblique lines which are often seen in these flagstones.

Ripple marks are abundant in the sandy shale, or where the shale becomes interstratified with sandstone, but it is often difficult or impossible to obtain good specimens. They are irregular or unequal generally, but in some instances are well preserved. Many of them have the appearance of having been produced by a "chopped sea," or that where a current opposed the direction of the wind. The same effect is often visible on sandy beaches where the tide has ebbed; the surface being broken into short, interrupted and irregular ripples, produced either by the tidal current opposing the wind, or some other similar cause, always readily understood. That such circumstances operated at the time of this deposition, and that the sea was alternately shallow and again deeper, is proved at every step among these strata. The deposits of dark and green argillaceous shales bear no evidence of ripples or diagonal lamination, and from their homogeneous nature were probably deposited in deep water, while all the sandy shales and alternations of shale and sandstone bear evidence of a shallow sea. It is true that the homogeneous mud would not retain ripple marks or lines of deposition, but from its nature and the attendant circumstances we infer that it was deposited in deeper water and under a more quiet condition than the sandy strata.

Casts of Shrinkage cracks.—These have been described under the Medina sandstone, and in the Portage group we again meet with them, though not so prominent or so large as in the former.

These marks are upon the under surface of an argillaceous sandstone which rests directly upon a soft black shale. The shale became cracked by exposure above water, and the sandy matter subsequently deposited filled the fissures.

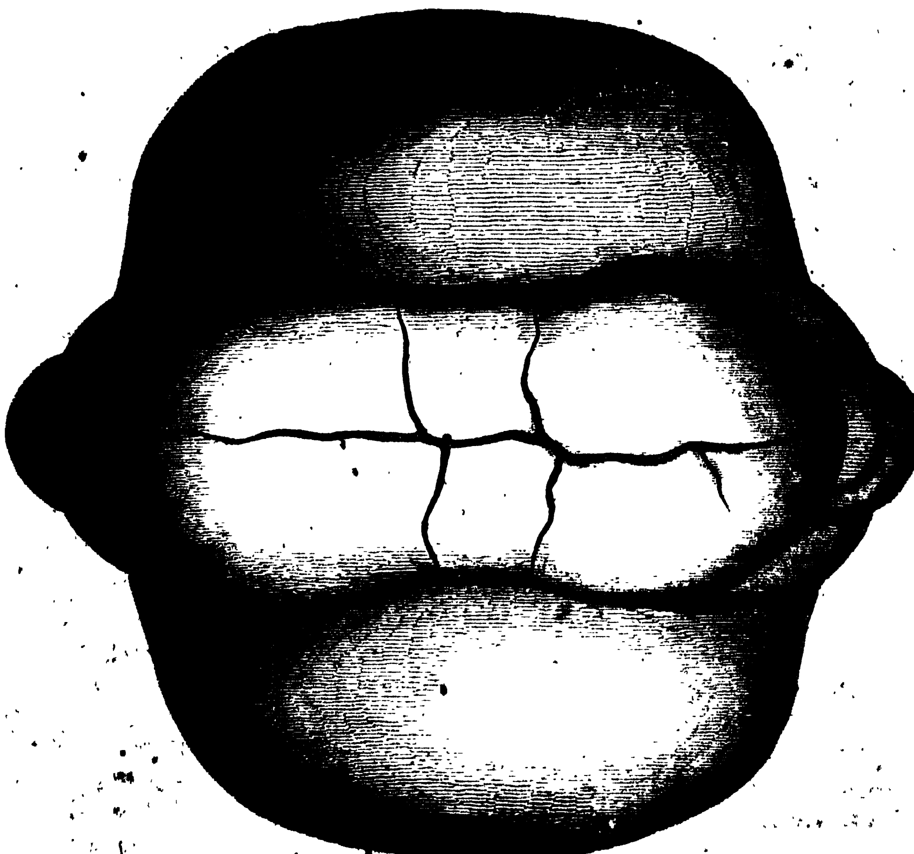
Concretions.—This group throughout presents a great variety of concretionary forms. The strata, however, are all uniform, and rarely give any appearance of concretionary structure in themselves. The concretions are more or less calcareous in the different parts of the group and in different shales. The more perfectly spherical with seams of crystalline matter are found in the black shale, while the forms varying from this to the very flat or lenticular ones are found in the shales varying from blackish to greenish black and green. The black varieties of shale are always more or less slaty, while the green varieties are not slaty, but present the marly or indurated mud-like characters, and instead of separating into laminæ, crumble into irregular fragments.

The more spherical forms are due to a higher degree of crystallization which results from a larger proportion of carbonate of lime, while the flattened forms are less crystalline, and consequently less spherical from the larger amount of argillaceous matter.

These forms are too well known to require description, but they often assume some fantastic shape which causes them to be mistaken for an organic body. This arises from the seams on the surface, which are fancied to resemble the lines of suture in the shells of the tortoise or turtle, and by this name they are frequently known in the neighborhood where they occur plentifully. From the great number of these in some parts of this group, they frequently join each other, and assume many of the singular forms which we meet with in "clay-balls," or concretions in ordinary clay, which, however, rarely attain more than a few inches in diameter.

The following form is so unique that it seems worthy of illustration, as showing the imitative power of concretionary force.

99.



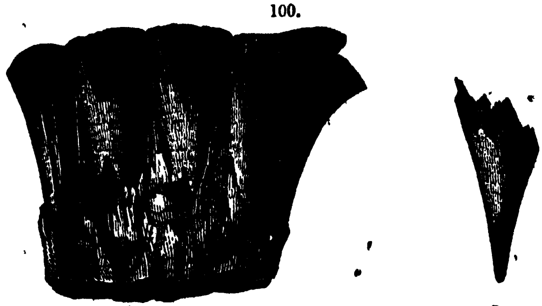
Concretion or Septaria, one third the natural size.

The specimen is from the shore of Lake Erie, where hundreds are annually thrown down upon the beach by the undermining action of the waves. The usual form of these bodies where this one was obtained, is that of a flattened spheroid. Great numbers of these are burned for hydraulic cement between Dunkirk and Portland harbor, and they produce a very good material for this purpose. At the locality alluded to, they are frequently two or three feet in diameter, and not more than half a foot thick. There are several of these in the State Collection, showing the varying forms and different sizes.

In the black shale near Sturgeon point, I saw one of these concretions, almost spherical in form and six feet in diameter.

On the Genesee river these concretions are often of the size and form of common loaves of bread, and many of them present the structure of "cone in cone." This structure occupies from one to two inches on the outer surface of the concretions. The same structure is also found in some wedge-form layers in the same situation, both on the Genesee river and on Lake Erie shore, and it is well known along nearly the whole distance from Chautauque county, New-York, to Cleveland, Ohio. I have not had an opportunity of ascertaining whether it holds precisely the same position throughout, but in the western part of the State, its position is the same for more than one hundred miles in extent. Many beautiful specimens have been obtained from Erie, Pensylvania, and other places in that neighborhood.

100.



1. 2.

Cone in Cone.

The woodcut illustrates the usual appearance of this curious structure. The mass is of a peculiar kind of clay, and the cones are often composed of concretive laminæ, presenting a transversely striated or wrinkled surface; they are also striated longitudinally.

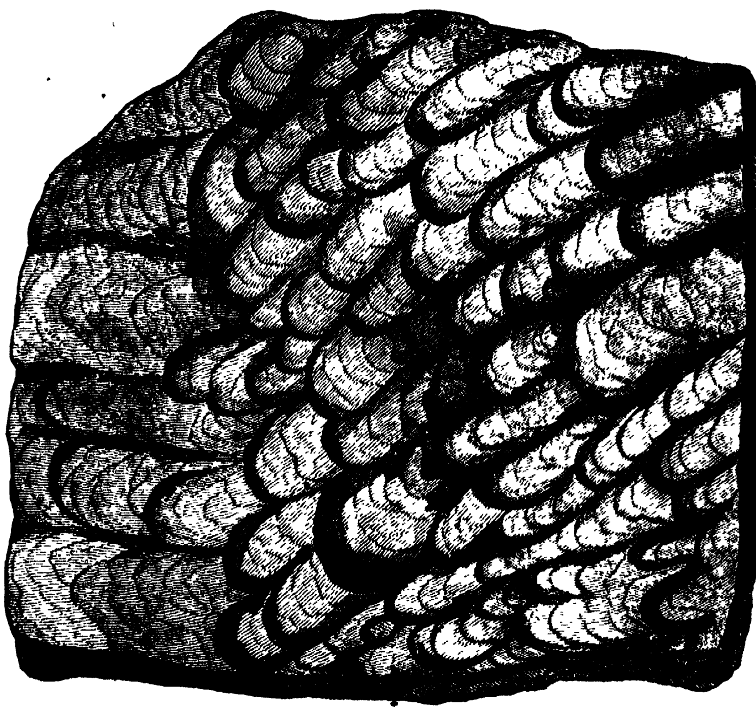
Fig. 1, represents the common structure of the mass. Fig. 2, is a single cone detached from the others.

Casts of flowing mud.

The phenomena presented in these bear some analogy to a concretionary structure, but from numerous examples it seems to be demonstrated otherwise. The appearances are similar to those presented by a semifluid mud, or any viscid body flowing over a slightly descending surface, or impelled along by some other force. A very analogous appearance is often presented when a small stream or rivulet, oozing from a cliff or descending a steep hill, becomes suddenly frozen. The surface of the ice presents all the inequalities of the flowing water, and occasionally little streams have broken through, and flowing a short distance have become frozen. Another analogous appearance is to be seen in the cooled cinder from iron furnaces, which presents all the inequalities of the first and the congealed streamlets which have flowed for a few inches over the surface.

The woodcut below is a *fac simile* of a layer of shaly sandstone taken from the bank of the Genesee near Portage. There is a thin coating of shaly matter upon the surface, and the whole appears to have been moved along while in a semifluid state, either from some force applied, or from the inclination of the bed of the ocean. There seems at least no other mode of explaining these phenomena.

101.



Cast of flowing mud, Portage, N. Y.

There are several other similar appearances, all varying in some degree; and as we would naturally expect, no two localities present precisely the same form of surface. Many of them appear to have been casts in previous depressions, as if the fluid mud had filled inequalities hollowed out by the action of flowing shallow water over a muddy bottom. The ripple-marks and mud-cracks both indicate a shallow sea, and these surfaces often offer equal evidences of the same. It frequently happens also that in the same layer presenting these casts of flowing mud there are diagonal lines of lamination, indicating the power and action of currents upon the transported matter, being another fact in proof of the shallowness of the sea.

Many other illustrations might be given presenting the same general character, and in none of them is there any appearance like the ordinary concretionary structure. From numerous examinations of this kind, I have been led to the conclusion that these are due to the cause here assigned. Having seen no description of any thing of this kind, I have been under the necessity of attributing them to some cause; and if this be not the true one, I shall be glad to embrace any other view which will more readily and naturally explain them.

Casts of Mud-furrows and Striæ.

I have applied this term to certain appearances upon the under side of the strata of sandstone, or flagstones, which are numerous and extensive in the Fourth District, as well as elsewhere in this group; having from my own observation detected them in other parts of New-York, in Pennsylvania, Ohio, and even to some extent in Indiana.

These casts are elevated lines or ridges upon the surface of the stone, varying from the size of the usual scratches upon the present surface of the strata to the diameter of half an inch, and even one, two and three inches, and in one case I have seen a specimen six inches in diameter.

The only assignable cause for these ridges is the action of a current flowing over the surface of the strata, sometimes transporting sand and at other times coarser materials, which furrowed the surface upon which the subsequent deposits were made. They are, in all cases, preserved upon the under surfaces of sandstone or shaly sandstone layers, which rest upon soft shale, so that the furrows or scratches must have been made in this mud. They are not all confined to one position, but appear at different depths in the group; showing that the cause, be it what it may, operated through a long period, and in a pretty uniform manner. The ridges are never curved or bent on one side; and though two systems are sometimes observed crossing each other, they are still as well defined and their course as unbroken as in the glacial or alluvial scratches upon the surface of the present rocky strata.

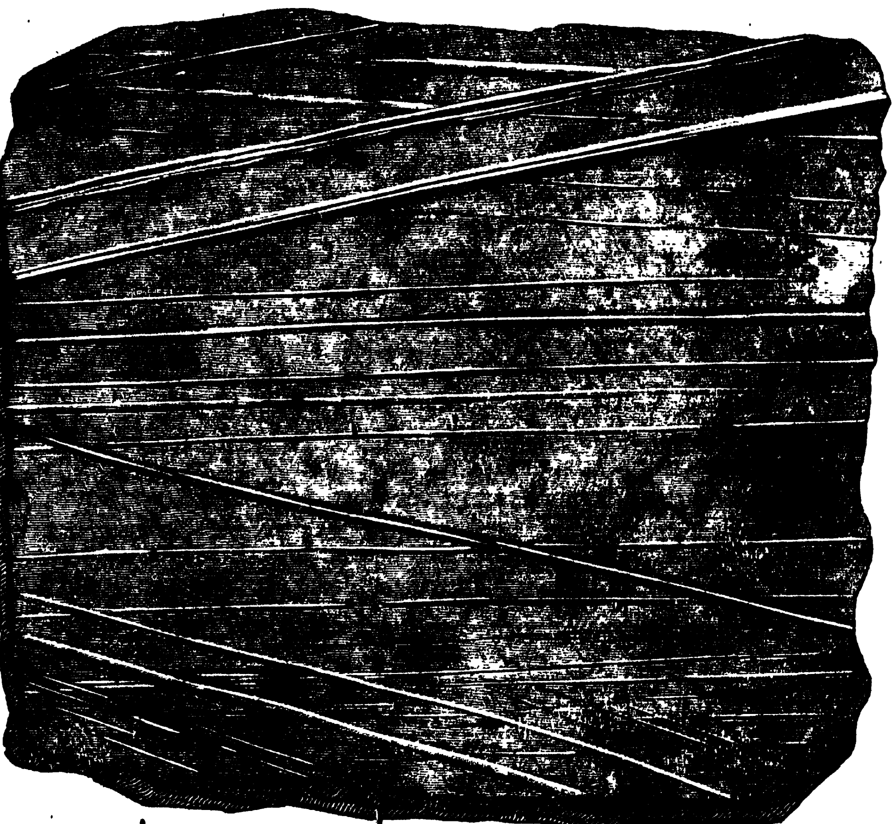
From the frequent occurrence of these, and their continuation through a great thickness of strata, we can hardly suppose the furrows to have been made upon hard surfaces; and if we suppose the mud in which they were made to have been soft, it seems almost impossible to conceive how they should be preserved. Still the numerous similar facts in other rocks prove that even the most delicate markings are preserved, under even more unfavorable circumstances. The tracks of birds and reptiles in the new red sandstone, with the impression of rain drops, is equally difficult to comprehend, were it not demonstrated beyond all question. Again it has been shown that in the Medina sandstone* the delicate wave lines and the minute

* Pages 52 and 54 of this volume.

ridges of sand, piled up before some little obstacle in the current, are preserved with the same integrity as they appear upon a sandy beach just left dry by the receding tide. In the same manner, the evidence of these slight scratches and deeper furrows in the mud of the Portage group have been preserved in the casts formed by the succeeding depositions. Nothing can be more clear and convincing than the proofs, and nothing more beautifully illustrative of the effects of oceanic currents upon the bottom. We have little space here to describe these phenomena, and they should be seen to be fully appreciated. This fact, however, may be added to the number, if we have not already sufficient, to prove the condition of the sea in these remote periods.

The following woodcut represents a surface where three systems of ridges appear, or where the grooves were made in three directions.

102.



Casts of Striæ — natural size.

This specimen is from Erie county, not far from the lake shore, and in the same locality numerous others were observed at different heights in the strata; some of them were much larger than those here represented. In two instances where I carefully noted the direction of these ridges, it was nearly E. and W. This is subject to a few degrees variation, but I have found the same general direction to prevail over wide areas.* In some instances the furrow appears to have been made in mud which was partially indurated, and the cast presents the same appearance of a tremulous motion in the body making the furrow, which is sometimes observed in the alluvial grooves. In many of these casts the angles are sharp, as if the grooves were made with a pointed or angular body; in others they are round, as if the body were smooth, or the mud partially flowed together before the period of the succeeding deposition.

In many instances the striæ are not coarser than those of common alluvial or glacial origin. In Seneca county these striæ occur upon the surface of a dark colored argillaceous sandstone, which rests upon a sandy shale of a blackish color. The shale is so friable that nothing is preserved in it, but the surface of the rock above is thus striated. This case is peculiar, and I think I have detected the same stratum similarly marked, at the distance of twenty miles. It appears in the ravine at Goodwin's falls, on the eastern side of Seneca county, and on the western side of the county near the head of the lake is a similar stratum. The position of the two is almost or precisely the same, while in lithological character and the markings no one can distinguish the difference. Thus it appears that, whatever may have been the cause, it operated very uniformly over large surfaces.†

It will be recollected that there are no uplifts or disturbances which could refer these markings to the sliding of one stratum on another; and besides, they are always found at the junction of argillaceous with more arenaceous strata, the former of which could not make an impression in the harder stone. Many of them are so large, and their direction so uniform, that this cause could not have produced them, even allowing evidence of its operation, which does not exist.

In some instances these ridges can be traced for a few feet in extent only, one end being large, and gradually disappearing as if the furrow was made by some heavy body striking the bottom for a short distance, and then lifted above it. Sometimes the furrows appear to have remained unfilled for a length of time, from the fact that they are then partially filled with drifted shells, of which the following is an example:

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* Some ridges of this kind have since been examined on Cayuga lake, which had a direction N.W. and S.E. It is often extremely difficult to ascertain with accuracy their direction; for being on the lower side of the strata, it is only where we can find an overhanging rock that they can be examined, and we cannot always be sure that it may not have been slightly moved in its bed.

† In this instance, although large surfaces were examined, the striæ have all a single uniform direction.

103.

Cast of Mud-furrow, with Shells.*—Natural size.

This cast has upon its surface the marks of numerous shells, all of single valves, which appear to have been quietly floated along over the even surface, till they lodged in the depression from which they could not be removed. The succeeding deposition covered them, and they became attached to it, and it now appears as a cast in relief. Upon the lower surface of the layer from which the ridge rises, there are no shells, though they are quite numerous on the ridge.

Many other interesting illustrations of similar kinds could be given, but these appear sufficient for the occasion, and to show their origin, which proves at least some interesting facts in relation to this period.

Localities.—Almost every ravine and stream upon the elevation which rises to the south from the Hamilton group, exposes the rocks of the Portage group in greater or less perfection. Along the banks of Cayuga and Seneca lakes, towards the southern extremity, these rocks form cliffs, often of considerable height, which, from the alternating hard and soft layers and the numerous vertical joints, present the appearance of solid walls of masonry in distinct and regular courses. Isolated masses, like some huge column, are often seen standing out in bold relief from the line of the cliff, being the remains of a previously exposed surface which has crumbled away.

* It must be borne in mind that the upper surface, as represented, is the lower in nature.

At Penn-Yan, in the outlet of Crooked lake, and in the ravines of the neighborhood, the shales and shaly sandstones of the group are well exposed. The Cashaqua shale here embraces thin courses of sandstone, and contains numerous fossils. Along the shores of Crooked lake, and in the ravines entering it, and at Hammondsport, its southern extremity, the rocks of the middle and higher part of the group are well exposed. They are everywhere known by the thin flagstones, covered upon their under surfaces by the short rigid stems of *Fucoides graphica* (see woodcut, page 241). At the southern extremity of Canandaigua lake, and in the deep ravines which extend from the valley of the same in the vicinity of Naples, the whole group is fully exposed, and these places offer good points of examination. The small lakes to the west of the Canandaigua, viz. the Honeoye, Hemlock and Canadice, with the ravines extending from them on either side, are all good points of examination.

The Caneseraga creek, and its branches in the vicinity of Dansville, offer good exposures of the rocks of this group.

The small streams flowing in the Genesee valley between Dansville and Mount-Morris, on both sides, afford good opportunities of investigation. The Cashaqua creek (see illustration, page 226), is the best of these.

The Genesee, as before noticed, in its passage from Portage to Mount-Morris, exposes the whole series of rocks in fine mural escarpments which rise from 50 to 350 feet high. The examination of this gorge throughout its whole length, will give a most perfect and connected view of all the subdivisions of this group.

West of the Genesee, the valley of Allen's creek, of the Tonawanda creek, and the lateral ravines of the same, expose these rocks in a very perfect manner. The branches of Cayuga and Seneca creeks in Erie county give an exposure of the group throughout.

The shores of Lake Erie, from Eighteen-mile creek to the State line, are composed of rocks of this group, presenting themselves in cliffs of 20 to 100 feet high. The streams and ravines, particularly the Canadawa, the Chautauque and the Twenty-mile creek, also give good exposures of this group. The deep gorge of the Chautauque creek not only exposes the rocks of this group, but their connection with the Chemung group, as well as the rocks of the latter through several hundred feet in thickness.

Finally, scarcely any stream or ravine which flows over this group can be examined, without finding a good exposure of some portion of the strata.

Thickness. — The thickness of this group on the Genesee cannot be less than one thousand feet. The fall in the river from the head of the falls to the base of the group near Mount-Morris, is nearly six hundred feet.* The rocks rise about two hundred feet higher; and the dip in this distance of ten miles in direct line cannot be much less than three hundred feet, allowing for undulations.

The rocks of this group extend along the shore of Lake Erie for about thirty or forty miles, before coming to the mouth of Chautauque creek. In the banks of this creek there are about

* See "Topographical Sketch of the State of New-York," in Transactions of the Albany Institute, p 97.

three or four hundred feet of thickness exposed, which, together with what is exposed on the lake shore, makes the aggregate thickness little less than fourteen hundred feet.

From the great breadth of surface occupied by this group, if the dip southward were uniform, its thickness would be much greater than here estimated; but it is evident, from numerous observations, that there are undulations which materially affect any calculations based upon the dip of the strata. By carefully examining the best natural sections, it appears that the average dip is about twenty-five feet in the mile; though in many localities, and indeed the greater number, the amount of dip is twice as great as this. In these cases, however, no account of the undulations is taken.

Minerals of the Portage group. — The concretions contain crystallized carbonate of lime, and sometimes sulphate of baryta. Iron pyrites is freely disseminated through the rock; and from its decomposition, the surface of the slaty laminæ and the sides of joints are often stained with iron. It also gives origin to sulphate of lime or gypsum, which often coats the shaly laminæ, or appears in the form of small crystals in the seams and joints of the same. Carbonaceous matter is disseminated through the black shales, and sometimes appears in seams of half an inch thick. Some fragments of large vegetable forms appear, and thin laminæ of coal usually accompany these. From the frequency of these small seams of coal, which are usually of no greater extent than the specimen procured, excavations and borings have been undertaken in search of larger beds. It is unnecessary to say that these always fail, as do all similar undertakings in rocks of this period. It is, however, impossible to prevent such useless expenditure of time and money, except by some source of information which can meet every one, and which shall find its way to all parts of the State.

Springs. — The country underlaid by the rocks of this group is well watered by never-failing springs. It must be remarked, however, that the practice of indiscriminately clearing the woods from hills and valleys will in time operate injuriously on the surface, by drying up those sources which now supply the pure and healthful springs which water the surface, refreshing both to man and beast. Except where the black slaty shale is thick, there is no difficulty in procuring water. In such instances the vertical joints appear to be more open, and to allow the percolation of water through the mass. There is here no remedy but to bore through the black to the green shales, which are less divided by joints, and usually impervious to water. In the present state of the country, however, there is little difficulty in procuring the desired supply, and that with little labor or expense. If the true origin of springs was known, and the means taken to protect them, there need never be wanting a sufficient supply of water on the surface. By the present practice, however, of cutting the wood from the higher grounds, many of the springs and smaller streams will eventually be dried up.

Agricultural Characters of the Portage Group.

In some parts of the country occupied by this group, we first notice a deficiency of calcareous matter in the soil. This change is indicated by a different growth of timber, and a corresponding change in the products of the cultivated soil. Wheat does not always prove a sure crop, after the field has been cultivated for some years. When first cleared, the land produces good crops of all the grains. In this statement, however, must not be included the valleys and the low northern slopes, which are deeply covered with northern drift and alluvium, containing a large proportion of calcareous matter. This on examination proves to be composed of the ruins of the limestone and calcareous shales before described, with a small admixture of sand.

This kind of soil is but sparingly spread over the higher grounds, and in many of the highest places is not known at all. In consequence of its absence, the character and productions of the soil of the valleys and of the hills are quite different.

The soil derived from the lower part of the group is a stiff clay, the sand being in too small proportions to produce much perceptible effect. As we ascend, the arenaceous matter increases, and the broken fragments of the sandy strata become intermixed with the finer materials, giving it the character of a clayey gravel. The fragments, however, show little effect of attrition; and from being flat and irregular, the soil is known locally as "*flat gravel,*" to distinguish it from that of the valleys, where the fragments are rounded into the form of pebbles.

In the valleys and on the low northern slopes of this group, the soil produces wheat with the same facility and equal certainty as the formations north of it. As we ascend to the south, the wheat crops are less abundant and less certain, and this gives place to the coarser grains and to pasturage. For the latter object, the soil is superior to that on the north of it, and the evidence is fully substantiated by the increasing number of cattle and the produce of the dairies. Without knowing any thing of the character of the soil or underlying rocks, the observer cannot fail to notice this great difference in the products and in the appearance of the farms, and the absence of the northern drift marks more strongly the distinction as we progress southward. The soil overlying all the groups as far south as the Tully limestone, whether it be clay, gravel or loam, presents one general character, viz. that of being highly calcareous; but after we leave these formations, we soon become sensible of the change; and although the same external characters of soil are presented, yet from the absence of the calcareous ingredients, it does not produce the same vegetation naturally; and neither will the skill of the cultivator enable him to do so for any considerable time, unless he supplies the matter which is wanting.

It will hereafter be shown in what manner these soils may be benefited by the application of certain manures, with the means and places of obtaining them. It is, however, very questionable whether any improvements rendering these soils capable of producing permanently good crops of wheat, will render them more profitable, or enable such farms to compete successfully with well stocked farms.

At present the occupants of farms of the southern tier of counties have many difficulties to contend with; the land in the first place is heavily timbered, and when this is overcome, it is found difficult to procure good stock. In many instances, and perhaps the greater number, the farmer has not the means of clearing and stocking his farm at the outset, so that he is continually laboring under difficulties, which are only surmounted by years of patient industry and economy.

We may look forward, however, to a different state of things: in a few years more, this portion of the country will wear a different aspect; the improved breeds of cattle and sheep will place the owners of the grazing farms in a position of equality with their usually adjudged more fortunate neighbors upon the wheat-growing soils; and the strong arms and manly fronts that have borne the toil and exposure will reap the harvest.

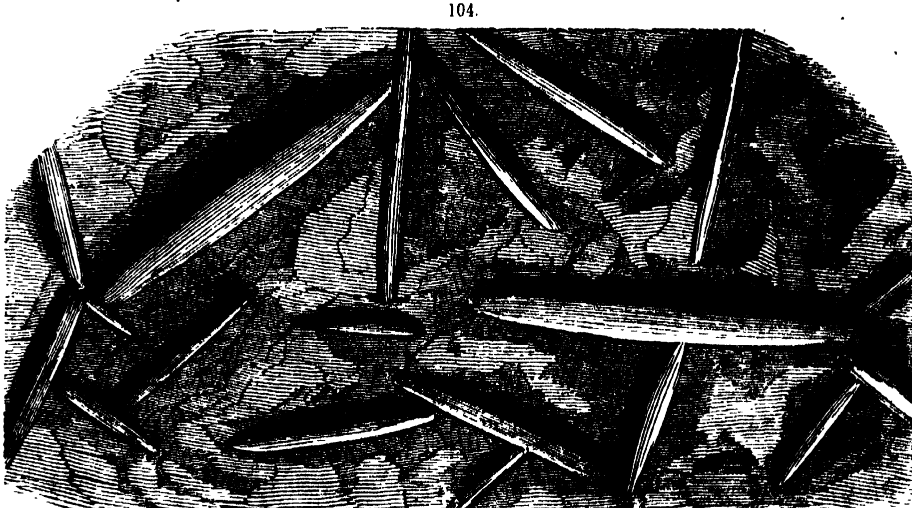
Organic Remains of the Portage Group.

The paucity of fossils in this group, when compared with those below and above it, is one of its most striking characters. Whole days may be spent in searching, in some parts of it, without finding more than a few, and perhaps even no shells. In a few fortunate localities, some forms have been detected which seem peculiarly typical of the group, and, so far as at present known, have never been found elsewhere. They are not only specifically unlike, but some of them even generically different from any that have been seen in the other groups in the district.

In this absence of fossil shells, we have a great abundance of marine vegetation, or fucoids, and these are very characteristic of the group. Scarcely a locality can be examined, where one or more species does not occur.

The following woodcut illustrates the most abundant form, and one which everywhere marks the central portion of this group:

104.



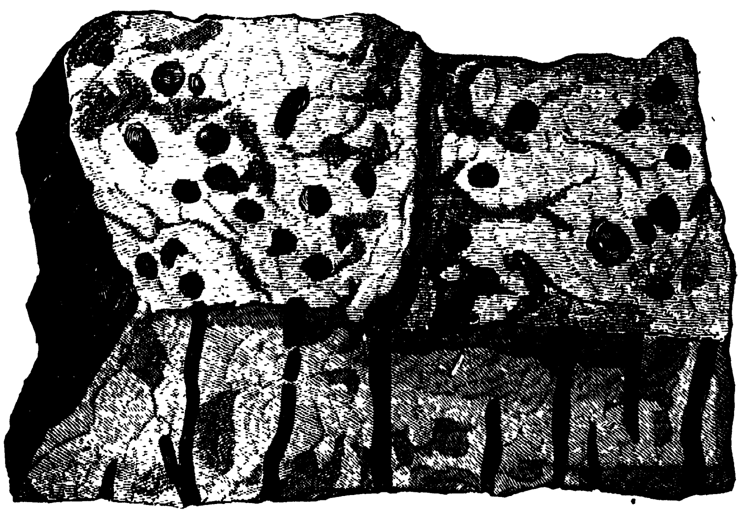
Fucoides graphica.

This fossil occurs in short rigid fragments, lying in great confusion, spread over the surface of the thin flagstones of the middle part of the group. It is only by its general form and the arrangement of the fragments that it can be characterized. It can be found in all localities of the flagstones, and, from the extensive use of these, it may be seen on the sidewalks of all the villages upon or near the group. Some of the finest specimes I have ever seen are used in the streets of Geneva, and the numerous little ridges upon their surfaces will be recollected by every one who has been in this village. At Penn-Yan the same character is presented in the flagstones, but less perfect than at Geneva.

Almost all the thin sandstone layers present this appearance, and the beds of the ravines are strewed with them.

This species of fucoids disappears towards the upper part of the group, where the sandstone becomes thicker and in greater proportion, and gives place to another species. This consists of small round stems, extending vertically through the strata, as if they were growing at the time the sand was deposited around them.

105.



Fucoides verticalis.

This species has always been found characteristic of the upper part of the group; and although in the higher rocks there are sometimes vertical fucoids, they never present the same character as those of Portage.

It may be seen at the Lower falls of Portage, and in many of the sandstone strata above this; but it is most abundant in the upper sandstone at Portage, and the terminating mass of the group is everywhere known by its presence.

In the Cashaqua shale, or lower member of this group, there are several species of shells which have not been seen in any other rock, and at the same time there are no fossils found with them which are known in other rocks beyond the group.

The following woodcut presents the more common forms:

106.

1. Avicula speciosa.
2. Ungulina suborbicularis.
3. Bellerophon expansus.
4. Orthoceras aciculum.
5. Clymenia? complanata.
6. Goniatites sinuosus.
7. Pinnopsis acutirostra.
8. Pinnopsis ornatus.

1. *Avicula speciosa*, n. s. — Semioval or semicircular; hinge line straight, extended beyond the width of the shell, and angulated at either extremity; surface marked by about ten ribs, which are crossed by beautifully curved concentric lines.

1 *a*. A specimen presenting both valves, attached at the hinge. This is not an unusual condition of this fossil.

The shell is usually very minute; its markings are very beautiful, and easily recognized. It is quite abundant in the Cashaqua shale, and alone seems sufficient to identify the mass.

Locality—Cashaqua creek; Genesee river; Penn-Yan; Eighteen-mile creek.

Ungulina suborbicularis, n. s. — Shell suborbicular; surface marked with fine concentric striæ, and a few stronger folds; beak rather prominent.

This fossil is not uncommon, but imperfect specimens are usually found.

Locality—Cashaqua creek; shore of Lake Erie.

3. *Bellerophon expansus?* — The spire is wanting, and this imperfect specimen, presenting the expanded bilobate lip, is all that has been seen in the rock. It closely resembles the figure of Murchison, pl. 5, fig. 37.

4. *Orthoceras aciculum*, n. s. — This very delicate and beautiful species is usually replaced by iron pyrites, and so much destroyed as to be unfit for a figure.

Locality—Cashaqua creek.

5. *Clymenia? complanata*, n. s. — Flattened involute; whorls numerous, crossed by numerous slightly raised striæ, which often appear undulated.

This fossil always occurs replaced by iron pyrites, and more or less decomposed. It is provisionally referred to the genus *Clymenia*, its structure not having been satisfactorily ascertained.

6. *Goniatites sinuosus*, n. s. — Discoidal, usually somewhat flattened, rapidly expanding from the first whorl; volutions crossed by unequal undulating striæ; septa sinuous.

The specimen figured is a fragment; there is a perfect one in the State Collection, measuring four inches in diameter.

Locality—Cashaqua creek, with the two last; also Lake Erie shore.

7. *Pinnopsis** *acutirostra*, n. s. — Sub-cuneiform; surface marked by about twenty-six diverging ribs, which are crossed by numerous faint undulating lines, and a few stronger wrinkles of growth; beak extended, acute and slightly incurved.

This is one of the peculiar forms of this group, and apparently referable to no established genus.

Locality—Cashaqua creek.

8. *Pinnopsis ornatus*, n. s. — Obtusely cuneiform; surface marked by more than forty diverging ribs, which are crossed by beautifully arched striæ.

The specimen is slightly imperfect on one side.

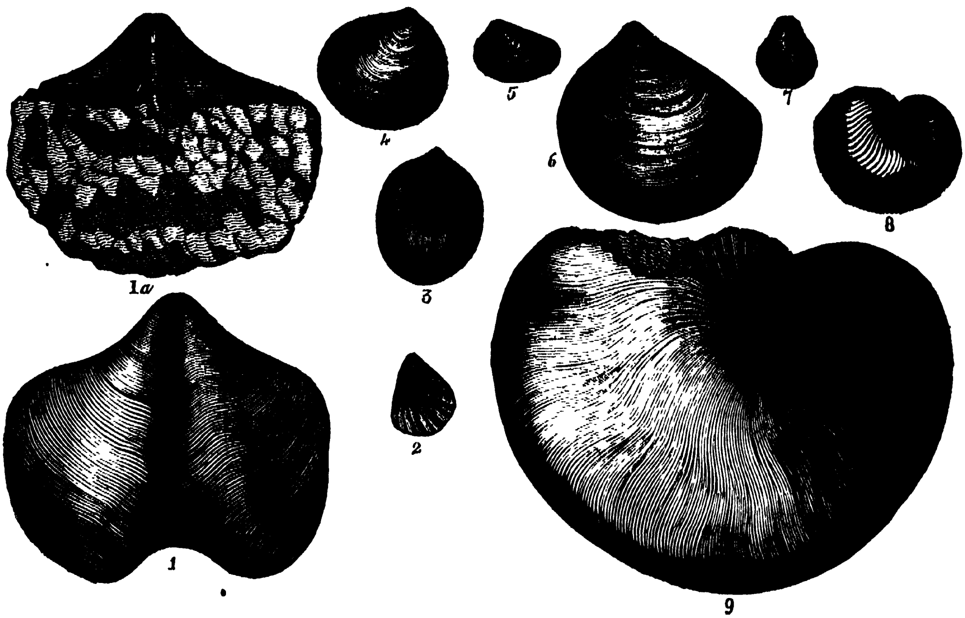
This and the preceding species occur together, and from their similarity, are not often distinguished; the number of ribs and the form of the shell are, however, sufficiently distinctive marks.

Locality—Cashaqua creek.

* This generic name is proposed for the two fossils here figured, from their resemblance to the *Pinna*.

The specimens illustrated in the following woodcut occur in the more central or higher part of the group, being unknown in the Cashaqua shale, except No. 9.

107.



1. Delthyris lævis.
2. Cardium? vetustum.
3. Orthis tenuistriata.
4. Lucina? retusa.
5. Nucula lineolata.
6. Astarte subtextilis
7. Bellerophon striatus.
8. Goniatites bicostatus.
9. Goniatites sinuosus.

1. *Delthyris lævis*, n. s. — Somewhat semicircular; surface smooth, or with scarcely perceptible concentric lines, and sometimes a few strong folds near the margin; mesial fold moderate, strongly impressed in front; beak prominent; cardinal area moderate; foramen partially closed.

This is the only fossil of the genus seen in the district, which is destitute of ribs. It is apparently limited in its range, being unknown beyond the borders of Seneca and Cayuga lakes. The fossil is often much larger than the figure.

Localities—West side of Cayuga lake; Shore of Seneca lake.

2. *Cardium? vetustum*, n. s. — Somewhat triangular; slightly carinated upon the posterior slope; ribs plain.

This fossil occurs in the soft green shale, usually presenting an obliquely triangular figure.

Localities—Cashaqua creek; Genesee river; Shore of Lake Erie.

3. *Orthis tenuistriata*, n. s. — Broad elliptical; beak small, rather prominent; surface covered with very fine radiating striæ, which are crossed by a few concentric wrinkles.

This is more finely striated than any shell of this genus in the district.

Locality—Shores of Crooked lake.

4. *Lucina? retusa*, n. s. — Obliquely suborbicular; beak small, oblique; surface marked by concentric lines, which are much stronger on the anterior margin.

Locality—Shore of Lake Erie, in Chautauque county.

5. *Nucula lineolata*, n. s. — Obliquely ovate; posterior slope straight; surface marked by regular, equal concentric lines, which terminate upon the posterior slope before reaching the margin of the shell.

Locality—Lake Erie shore in Chautauque county.

6. *Astarte subtextilis*, n. s. — Suborbicular; beak prominent; surface marked by strong concentric folds and finer lines, which are crossed by a few faint elevated radiating striæ.

The shell is incorrectly figured.

Locality—Lake Erie shore in Chautauque county.

7. *Bellerophon striatus?* (Bronn. · Phillips, *Palæozoic Fossils*, pl. 40, f. 198.) — Subglobose, carinated; "keel narrow, elevated; surface marked by fine arched striæ which meet the keel in a slight retral angle." *Phillips*.

Our fossil agrees precisely with this part of the description, but the aperture is less broad than the figure of Mr. Phillips.

Locality—Shore of Lake Erie, Chautauque county.

8. *Goniatites bicostatus*, n. s. — Sub-globose or discoidally involute; umbilicus moderate, very distinct; last whorl with a distinct subdorsal elevated line on each side; surface marked by arched striæ extending from the umbilicus and meeting the elevated line at an acute forward angle, and receding from it on the back at a more acute retral angle.

Locality — Shore of Lake Erie, Chautauque county.

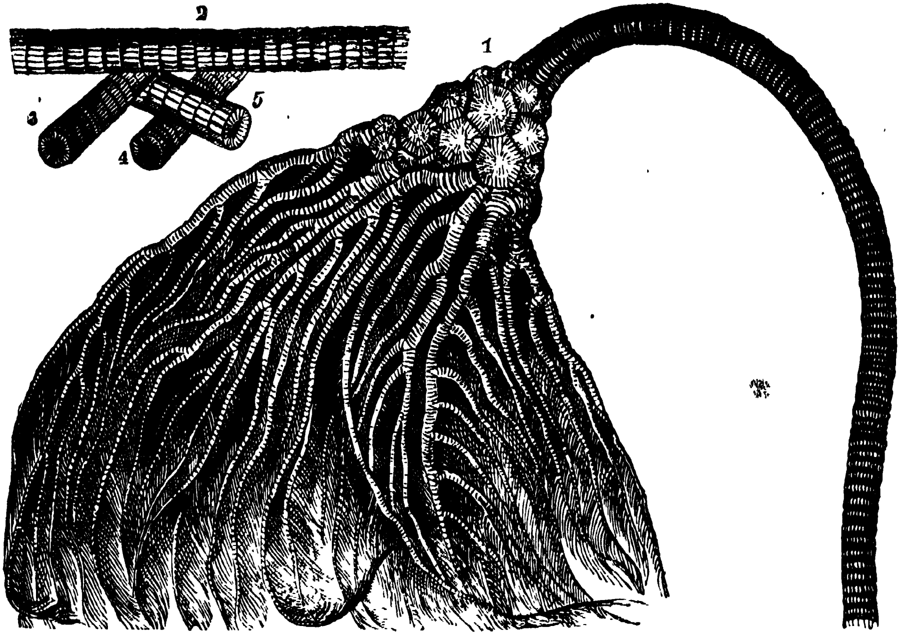
9. *Goniatites sinuosus* (Illustration No. 106, page 243). — Discoidal; involute; surface marked by undulating striæ.

This fossil seems referable to the species above, though the marks of septa are very indistinct. It is thus known to range from the Genesee river to Lake Erie.

Locality — Lake Erie shore, Chautauque county.

The following among the most beautiful of the crinoideans in the system, occurs in this group; the sculptured column and tentaculated arms and fingers place it among the most ornamental forms of this family of fossils.

108.



1. *Cyathocrinus ornatissimus*, n. s.—Pelvic plates five, pentagonal; costals five? somewhat heptagonal; scapulars hexagonal. Arms in part proceeding from the scapulæ, and dividing and subdividing into hand and finger joints, which are tentaculated. Column somewhat pentangular above, becoming rounded, and the joints increasing in thickness below.

2, 3, 4 and 5. Portions of the column nearer the base.

This fossil occurs only in a limited stratum, upon the shore of Lake Erie, in the town of Portland. Some fragments of columns were first found on the shore near Eighteen-mile creek; subsequently a larger number were found farther up the lake, and finally these were traced to the original stratum which is not more than six inches thick, and thinning out in every direction within five feet of the centre. This stratum is composed almost entirely of the columns of this fossil, closely packed together. They appear to have flourished in great numbers in this favored spot, and to have been swept down suddenly, the whole forest becoming inundated by a deposit of mud.

From the immense numbers of columns and the fragments of the superior extremity, there must have been several hundred individuals living in this small space, and so suddenly and completely were they overwhelmed that not a fragment appears to have escaped.

Localities of Superposition.

The junction of this group with the one above is nowhere so well defined as the instances already illustrated. The terminating mass of the Portage group is usually a heavy thick-bedded sandstone, marked by the presence of vertical fucoids. Above this we find shales and shaly sandstones, differing in some degree from those below, and manifesting the presence of Delthyris and Atrypa.

The channel and lateral streams of the Genesee above Portage present a continuation of the series almost completely. The order is illustrated in the section passing through Allegany county (Pl. xi.). The Portage sandstone is succeeded by olive shaly sandstone and shale, and this by black micaceous slaty shale, with septaria; to this follow shales and coarse sandstones, with fossils of the Chemung group.

On Lake Erie the thick-bedded sandstone terminating the Portage group is succeeded by coarse shales containing fossils of the Chemung group. This junction may be traced south of Laona. Again, on the Chautauque creek the sandstone is scarcely defined, and there is little change in lithological characters from one to the other.

At many intermediate points the change here indicated can be readily observed, but the absolute contact of the two groups is rarely visible.

The greatest development of this group, and the point where it is most distinctly separated from the next above, is on the Genesee river. Although it is obviously marked farther east, there does not everywhere occur the thick-bedded sandstone at the termination; and it would appear from the investigations in the Third District, that there are not the distinctive characters in the fossils which are so prominent throughout the western part of the State. Again, as we approach the western limit of the State, we do not find the distinctive features of the two groups so well marked. The lower part of the Chemung containing fossils typical of that group, possesses more of the lithological nature of the Portage group than it does farther east. Still farther west, where I have examined these rocks, in Ohio and Indiana, there is a closer resemblance in the lithological nature of the strata of the two groups, and the change is attended by a great diminution in the number of fossils in the higher one. In this part of the country, no distinction has been made between different parts of the mass; neither is it there of much practical importance.

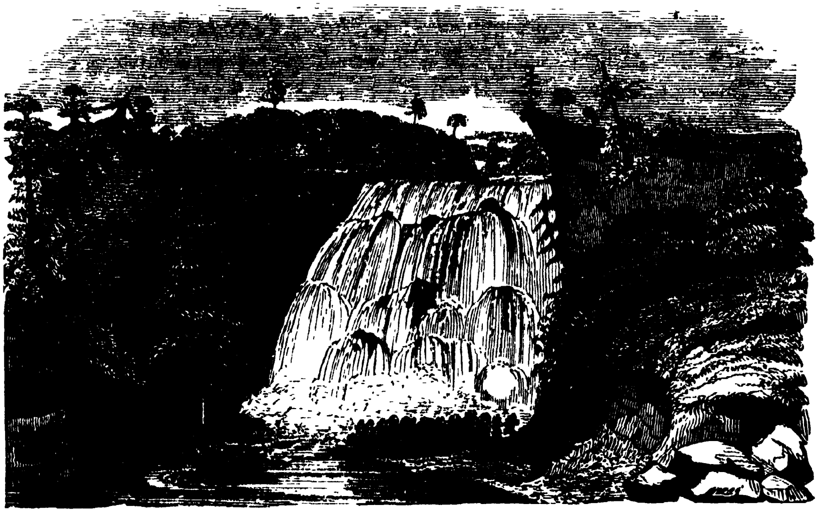
The facts in relation to this group, and its connection with the one above, are not peculiar to these, but appertain more or less to all our sedimentary deposits. The distinction, therefore, between groups where the whole series is sedimentary, cannot be relied upon over extensive districts; and all such subdivisions can be considered no more than those of convenience, which in some places are strongly marked and readily identified, while in others the lines of demarcation are obscure, and the distinguishing characters fail in a greater or less degree.

Whenever we have an opportunity of comparing a complete tabular list of the fossils, with their geographical distribution, we shall find, that what in one portion of the country are limited in their stratigraphical range, are nevertheless in other places not thus restricted:

and we shall do well to bear in mind, what has been before remarked, that the conditions of the ocean bed and the nature of the sedimentary deposits has greatly influenced the character of the organic forms.* It may thus happen that the fossils so typical of the Chemung group commenced their existence in the eastern part of New-York much earlier than in the western part; and, therefore, the strata equivalent in age to the Portage group may there contain fossils which at the west appear only at a later period.

109.

110.



Fall creek, near Ithaca. From a sketch by MRS. HALL.

Ithaca Group.

In the annual reports, this name was adopted for designating the highly fossiliferous shales and shaly sandstones, so well developed at the inclined plane of the railroad, and on the Cascadilla and Fall creeks, near Ithaca. Subsequently an examination of the highly fossiliferous strata along the Chemung river, and particularly in Chemung county, resulted in the adoption of that name as designating this portion of the system.

Succeeding examinations satisfied me of the identity of the formations at Ithaca with those of Chemung, and this opinion was advanced in the annual report of 1841.

The reasons for merging the two in one, were stated to be the impossibility of identifying them as distinct by any characteristic fossils. The same opinion is still entertained, after a full examination of the strata, and a comparison of the fossils collected here and elsewhere in well authenticated localities of the Chemung. There is scarcely a fossil known at Ithaca, which is not found at numerous other localities; though it is true, not only of Ithaca but of many other places, that some of the fossils are confined to the single locality in which they occur.

By careful and extended examination, the Chemung group may be subdivided locally, where it is most perfectly developed; but these divisions will hold good only over small districts of country, position and lithological character having had much effect in producing these distinctions dependant on fossils. Examples of this kind will be noticed under the description of fossils.

111.

Chemung Narrows. From a sketch by Mrs. Hall.

28. CHEMUNG GROUP.

Including the Ithaca and Chemung groups of the Annual Reports.

(No. 9 of the Pennsylvania Survey.)

[See section, Plate VII., and R of woodcut, page 27.]

This group consists of a highly fossiliferous series of shales and thin-bedded sandstones, sometimes in well-defined and distinct courses, and an infinite variety resulting from the admixture of the two ingredients. Except in a few localities, there is no very strongly marked line of division between this group and the one below. The distinction consists in the presence of numerous fossils and the coarser grained sandstones, which are usually more impure from argillaceous admixture than those below. Its lithological characters, however, are variable ; and though well marked across a single line of section from north to south, still another at a short distance east or west of this presents considerable variation.

These rocks, however, can everywhere be described as a series of thin-bedded sandstones or flagstones with intervening shales, and frequently beds of impure limestone resulting from the aggregation of organic remains. The whole series weathers to a brownish olive, and even the deeper green of the shales assumes this hue.

The shales vary in color from a deep black to olive and green, with every grade and mixture of these. The sandstones are often brownish grey or olive, and sometimes light grey. More generally, however, there is a tinge of green or olive pervading these strata. Towards the upper part of the group, in many places, there is a tendency to conglomerate; and in a few localities the mass becomes a well-characterized puddingstone, still retaining the fossils of the shales and sandstones. This conglomerate nowhere attains sufficient thickness or importance to merit a distinct description; but in hasty observations it may sometimes lead to erroneous inferences, since it resembles in many respects the distinct and well-defined conglomerate which rests upon this group in the western part of the State, but which is totally distinct from the same.

Many of the shaly sandstones and shales of this group are highly micaceous; and towards the upper part of the whole, the shales are reddish, coarse and fissile, with much mica in small glimmering scales. There is also in these shales a slight change in the character of the prevailing organic forms.

From being well developed along the Chemung river at numerous localities, and particularly at the point represented in the woodcut at the head of the group, this name has been adopted for its designation.

These strata rise to the south from the Portage group, forming the higher elevations of the southern counties, and covering nearly the whole surface of the same. The greatest elevation of these hills is about 2500 feet above tide water, and from 600 to 1000 feet above the deepest valleys of the surrounding country.

The outline section crossing this part of the State from east to west (Pl. 12), will give an idea of the general contour of the surface. The deep valleys are bounded by abrupt hills, while the surface between them is, for the most part, but moderately undulating. This feature of the surface is entirely due to denudation, the valleys being all produced by this cause, and the slight undulations in the strata have scarcely affected the surface in any perceptible manner. The evidence of the denuding action is often plainly visible in some of the harder strata, but the perishable nature of most of them has obliterated all traces of this kind. An inspection of the sections crossing these counties in a north and south direction (Plates 9, 10, 11 and 12, as well as the outline section), where the comparative elevations are given, will suffice to give an impression of the vast amount of material removed. The outliers of conglomerate resting on some of the higher hills of this group also prove the same fact, and show how powerfully and effectually this agency has operated. An inspection of the map also shows numerous points of the same, often with broad and deep valleys between them. In the valleys in this group are some of the highest lakes in the country; these will be noticed in another place, with their elevations.

The numberless natural sections along the deep ravines and river channels afford good opportunities of studying this group in all its various developments throughout the district. In many situations, its relations to the groups below can be distinctly traced in an almost continual line of section from the Hamilton group upwards. Its relations with the rocks above it are not so clearly seen in many localities within the State, but they are sufficiently so for satisfactory investigation, and localities beyond the limits of the State present the same order in the most conclusive manner.

The lower beds of this group are well exposed a little south of the head of Seneca and Cayuga lakes, and at some distance above their level. The broken margins of the northern escarpments, along the whole extent of the district, present good exhibitions of the same; while the water courses along the southern border of the State expose the higher beds, and their connection with the rock next above.

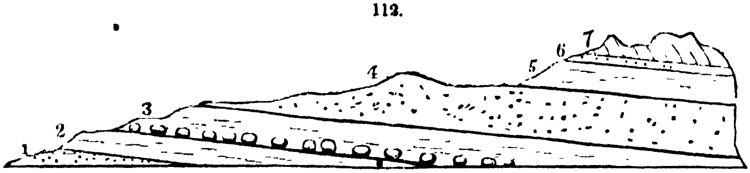
This group requires to be studied at several localities, in order to understand the variations in lithological and other characters which it undergoes in its extension westward, as well as in passing southward toward the upper termination of the same.

Along the eastern margin of the district the strata are, as a whole, darker colored, with more frequent intermixtures of the shales and sandstones, which less often appear in distinct and well-defined beds. The shales are of a dark olive color, and the same for the most part pervades the sandy strata, and it is only toward the southern border of the State that well-defined courses of black shale are found. As we go westward, this character continues in a greater or less degree, and there is little change along the sections from the head of Seneca and Crooked lakes southward.

On the Genesee river we find the limits of the products better defined; the shale often in thick beds, of a bright green color, and scarcely interrupted by sandy layers. The sandstones at the same time are purer and of a lighter color than those farther east, and less intermixed with shaly matter. Several subdivisions can be recognized along this river, which, however, are not as clearly defined elsewhere.

The following section presents the order and character of strata in this line of section:

112.



1. Portage sandstone. 2. Olive shaly sandstone. 3 Black slaty shale, with septaria. 4. Green shale, with grey sandstone. 5. Grey and olive shales and shaly sandstones. 6. Old Red sandstone. 7. Diagonally laminated sandstone and conglomerate.

On going westward from the Genesee river, there appears to be a constant augmentation in the quantity of the green shale, which is often the predominating rock; though from weathering to an olive color, it does not always appear as distinctly. The sandstone strata become less perfectly defined in general; though in several places in Cattaraugus county there are some thick masses of greenish grey sandstone, very durable, and readily quarried into large blocks.

In the ravines in Chautauque county, extending toward Lake Erie, the shale still retains its green color; the sandstones are for the most part thinly laminated, and partake of the color of the surrounding shale. The dark olive sandstones, like those of Painted-post and other places in Steuben county, which are thick and important masses, are recognized in Chautauque county only as thin layers of brownish sandy shale containing the same fossils as farther east.

This thinning out of some portions of the group is not fully compensated by increase of some other parts, (the green shale ;) and there is an evident diminution in thickness, and a constantly decreasing number of fossils, many species which are common farther east having disappeared, while scarcely any new forms are seen. Fossils, however, are numerous in many localities, and the same general appearance in their manner of aggregation and imbedding is preserved throughout.

Besides the general diminution of sandy matter and the absence of the brownish sandstones, the red sandy micaceous shales have not been recognized ; and they are nowhere visible in the ravines west of the Genesee river, so far as observed.

The frequent alternations of shales and sandstones, the interlamination and mixture, all prove the operation of similar causes as in the group below. Although there is scarcely any definable difference in the products of the two, yet we see an immense increase in the number of species and individuals of organic forms. Judging, therefore, both from the condition of the deposition and the nature of the organic forms of the two, the lower part of the Portage group was deposited in a deeper ocean ; and although there were numerous oscillations toward the conclusion of the period, yet the conditions favorable to the production of numerous species of shells did not supervene till after the final deposition of the Portage sandstones. These remarks apply to the Fourth District ; how far they are applicable farther east, I am unable to decide. It is very clear, however, that as we progress westward there is a diminution of the Avicula, Cypricardia and allied forms, while the Brachiopodous fossils are at first more abundant, and finally themselves diminish also. It is also equally plain that the origin of the materials of this deposition was to the east of central New-York, and, probably, to the southeast, as is evidenced by the thinning of the deposits, and the diminution of sandy strata at the west. The increase of shaly strata in the same direction, which finally diminish also, proves the same ; for this being longer suspended, was transported beyond the sand. We have here a corroboration of the same view as presented under the Hamilton group, viz. a position in eastern New-York, near the margin of this ancient sea, while towards the southwest we approach that part of more profound depth and greater distance from shore. The evidence continues throughout the Hamilton, Portage and Chemung groups ; for in all these, and the intermediate beds of shale and limestone, we find a constant diminution southwesterly.

There is also another fact of the same import, viz : In eastern New-York we find, both in the Hamilton and Chemung groups, specimens of land plants, or such at least as did not grow beneath an ocean. These are rare in central New-York, one or two fragments only having been found ; and at the southwestern part of the State, and in Ohio, I have seen nothing of similar character. The inference naturally follows, that these were derived from land on the eastern margin of this ocean ; and that some fragments floated westward, and were deposited with the sand and mud. Many of the thin sandy laminæ throughout the district are often almost completely covered with small fragments of carbonaceous matter, apparently derived from terrene vegetation. These seem to have been comminuted fragments of vegetables brought down by streams from the continent or islands on the east, and being spread evenly over the surface of the water, were distributed widely, and deposited with the sand and mud. Similar deposits are going on in the lakes and in the bays of the ocean at the present time, and it is a common occurrence to see the water of either covered with a thin scum of comminuted particles of wood, extending for great distances. These appearances upon the strata in New-York are seen in Ohio, specimens from the two being scarcely distinguishable.

All facts of this kind are interesting, as showing an approach to that period when terrene vegetation flourished on a grand scale, and in its destruction gave origin to the great coal measures of the United States. Throughout all the lower rocks of the New-York system, there is no evidence of terrene vegetation, and consequently no proximity to coal-bearing strata, and it is only subsequently to the deposition of all the limestone formations of this system that this kind of vegetation appears.

The character of strata and materials composing the Chemung group can be illustrated by a section or two, much better than by description. Hundreds of sections of the vertical cliffs have been noted, but as they present little variation, a repetition would not be instructive. The following is a section of the cliff at Chemung Narrows, from above downwards:

	Feet.	Inches.
1. Fissile olive shale, with Aviculæ	15	0
2. Compact shale, with Cyathophylli and other corals	0	6
3. Compact shale, with thin courses of sandstone separated by seams of shale.	13	0
4. Greenish grey sandstone, with seams of shale	10	0
5. Greenish grey sandstone, with the weathered edges stained by oxide of manganese and iron	7	0
6. Shale and sandstone, with Aviculæ, Atrypæ, and other fossils	5	0
7. Soft greenish olive shale	3	0
8. Compact sandy shale, with fossils	2	0
9. Shale in three distinct courses of 2, 4, and 6 feet	12	0
10. Corallines	0	2
11. Olive shale, with abundance of fossils	3	0
12. Compact shaly sandstone	2	6
13. Shale with thin layers of sandstone, containing abundance of fossils	6	0
14. Concretionary sandstone	3	0
15. Shale with thin layers of sandstone	8	0
16. Below this to level of river, the character of rock not ascertained	14	0

This may be considered a specimen section, and gives the general character of the rocks of the group in other places. The fossils of this place are chiefly *Avicula pecteniformis*, *Strophomena membranacea*, *S. interstrialis*, *Orthis interlineata*, *Delthyris prolata*, *Atrypa aspera*.

Another section at Painted-post, in a different part of the group, presents the following alternations from above downwards:

		Feet.	Inches.
1.	Sandstone, becoming shale farther south	6	0
2.	Concretionary strata of shale and sandstone	5	0
3.	Sandstone	1	0
4.	Shale, olive or brownish, and fissile	5	0
5.	Sandstone	1	0
6.	Shale similar to No. 4	6	0
7.	Thin stratum of sandstone.		
8.	Shale	4	0
9.	Greyish olive sandstone 6 to 20 inches thick, running out and again reappearing.		
10.	Shale	4	0
11.	Brownish olive sandstone	3	0
12.	Shale, olive and greenish	2	0
13.	Sandstone and interlaminated shale	2	0
14.	Shale	7	0
15.	Sandstone in thin layers	3	0
16.	Shale	7	6
17.	Sandstone in thin layers	5	6
18.	Shale	3	0
19.	Sandstone in thin layers	2	0
20.	Shale	2	0

The fossils at this place are *Cypricardia*, *Avicula spinigera*, *Delthyris*, *Orthis* ———, large numbers of *Orthis unguiculus*, *Orbicula*, *Loxonema*, *Tentaculites*, &c. Scarcely a fossil is common to the two localities, though the lithological character is in a great degree similar. Both the shales and sandstones are more deeply colored than at Chemung Narrows.

These sections are given from points where every inch can be measured, and consequently there is no error respecting thickness or character; and as the whole is seen in connection, there is no repetition of the same strata. At other places similar sections show some variation from these in lithological characters, and also a considerable difference in the species of fossils which the strata contain. We often find, in an exposed cliff of a few hundred feet extent, that several of the sandy strata thin out, sometimes reappearing, though often not again seen. Such changes on a small scale are the same which the whole group undergoes in its western extension, the evidences of which are already given.

Diagonal lamination, and structure of strata.— The shaly strata of this group appear to have been quietly deposited in the bed of the ocean, as we should naturally suppose of a mass having its origin eastward. The sandy strata are constantly diminishing and disappearing, and they present various interesting phenomena of diagonal deposition, interlamination, and intermixture of shaly matter. The sand has evidently often been deposited at intervals, being pushed along over the bottom covering a previously inclined surface; and this has been frequently repeated. This character becomes more marked towards the west, where nearly all the strata present lines of diagonal deposition. This structure has been before illustrated, under Medina sandstone and Portage group.

Concretions, and concretionary structure of strata. — In the shales of the lower part of the group, well defined concretions frequently occur in great numbers. These are highly calcareous, and present the common appearance of those in the groups below, being divided by seams of crystalline calcareous matter, and contain cavities often partially filled with bitumen. Towards the higher strata of the group, the shaly sandstone often becomes concretionary, the laminæ folding entirely or partially around a nucleus. These present various degrees, being often nearly spherical, and becoming less and less perfect, till they present only strong and abrupt undulations in the laminæ of the stratum.. Such structure usually occurs in the micaceous shaly sandstone, and more strongly marked when such a stratum passes into shale. The following section, near Painted-post, illustrates this structure:

113.

Concretionary strata of shaly sandstone.

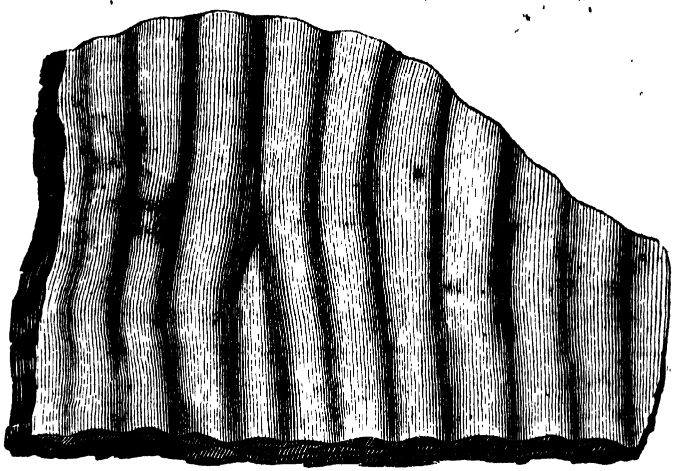
A similar structure is observable in the exposed cliff at Chemung narrows, and near Elmira. The laminæ of these concretionary masses preserve the same lines of division as where the strata are plain, and they separate readily.*

Spheroidal desquamation. — Fragments of the sandstone, of some parts of this group, after weathering upon the surface, desquamate in concentric laminæ to the depth of the weathering. This seems due to partial decomposition, which causes the separation, and obliterates the lines of deposition. The blow of a hammer will often separate these concentric layers to the thickness of an inch, while the apparent nucleus presents a different color, and the parallel lamination of the mass is often visible. The influence of the weathering is very perceptible; and is evidently the cause of the separation.

Ripple-marks. — The thin-bedded sandstones and sandy shales of this group are often ripplemarked; but from the frangible nature of the strata, it is not often easy to preserve them. The following woodcut is from a beautiful specimen, from Chautauque county, where the undulations of the ripple are perfectly preserved:

* These separated laminæ form large troughs, bowls, etc., which are frequently used in this part of the country as substitutes for more perishable articles of the kind. At a farm-house, I have seen them used for wash-hand basins; and in other places, I have seen the swine and barn-yard fowls feeding from similar forms.

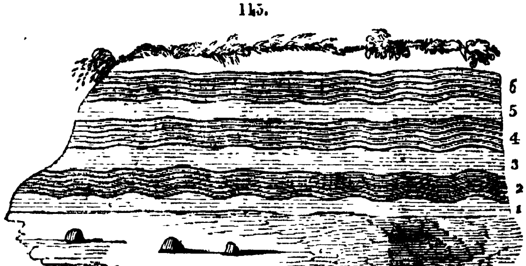
114.



This structure has been before explained as giving evidence of shallow water, and the evidences exist in all the strata of the district which are composed of sand, or sand and clay intermixed, from the Medina sandstone upwards. In the purely argillaceous and calcareous strata, these markings are not seen.

In many places the rippled sandstones alternate with shale, presenting a very interesting appearance. The edges of the sandstone are undulating, while those of the shale are horizontal, and this is repeated several times in succession. The following section, from the banks of the creek above Lodi in Cattaraugus county, illustrates this structure :

115.



Section of vertical cliff on Cattaraugus creek.

1, 3, 5. Horizontally stratified shale.
2, 4, 6. Undulating, arenaceous strata.

Localities.— There is scarcely a ravine, or bank of a river or stream in the southern range of counties, where the rocks of this group are not exposed ; therefore localities for examination are almost innumerable. There are a few points, however, where observations can be much better made than at others, and where the different characters of the rocks and their contained fossils can be more readily examined.

Along the eastern side of the district, the Inclined plane of the Railroad at Ithaca, and the Cascadilla and Fall creeks are the best localities for the lower part of the group. Farther south, the banks of Cayuta creek, and the lateral ravines joining the same, offer good exposures of the middle and higher parts of the group, with numerous fossils not seen at the more northern localities.

At the Chemung Narrows (see sketch at the head of the group), in the town of Chemung, there is a very good exposure at a cliff upon the river bank, and the artificial excavation for a road has much increased the value of this locality. Some of the quarries near Elmira are of interest, but the exposures extend only to a few feet in depth. The hills in the vicinity of Bath offer many interesting localities, and some fossils not elsewhere seen. At Painted-post, along the excavation of the Blossburgh railroad, the strata are well exposed, and contain numerous fossils. This is one of the most interesting localities in that part of the State, and presents some features of the strata not so well exposed elsewhere.

On the Genesee river, and in the banks of its tributary streams, there are several points of great interest. The most northerly of these is Caneadea creek, where there is a great exposure of green shale, with sandstones towards its termination. At Rockville on Black creek, there is an exposure of green shale, becoming olive on exposure, which contains an abundance of organic remains, and among these are several which have not been seen at any other locality. In the creek at Hull's mills near Angelica, there is a good exposure of shale and sandstones with some fossils. At Hobbieville and Phillipsburgh, a few miles farther south, we find an association of strata very similar to those of Rockville, and many of the same fossils, together with numerous other species. This neighborhood is one of the most prolific localities of fossils in the group, Farther south, at Vandemark's creek, some of the higher strata, loaded with a large *Delthyris*, are well exposed, and fine specimens can be obtained. At Wellsville, a few miles south of the latter point, the rocks of this group terminate, and are succeeded by some thin ferruginous strata of the Old Red sandstone, and this again by grey diagonally laminated sandstone and conglomerate.

In Cattaraugus county, there are good opportunities of examining the strata, at Bailey's in the town of Leon, two or three localities near Cadiz, and in the southern part of Great-valley. The ravines on the south side of the Allegany expose the strata in numerous places, but there are few points where fossils can be obtained.

In Chautauque county, the deep ravine of Chautauque creek affords the best opportunity of investigating the rocks of this group, which there contain numerous fossils. The outlet of Chautauque lake at Dexterville also affords a good opportunity of examining the strata, which in some parts are loaded with fossils.

The localities enumerated are sufficient for a thorough investigation of the group; those upon the Genesee alone afford a very good exposure for a single line of section, but, as before remarked, there are many variations of character in an east and west direction, which present new and interesting features. The differences in the character, both of strata and of fossils, on which subdivisions may be founded, will appear after an examination of these localities.

Thickness.— This group, in the eastern part of the district, can scarcely be less than 1500 feet thick. This thickness is estimated from the dip over a distance of thirty or forty miles, and the height of the hills towards the southern boundary of the State, which rise to eight hundred feet above the valleys.

The summit of the Portage group, on the Genesee river, is less than 1200 feet above tide water, and the lowest passes in the hills south of this, occupied by the Chemung group, are from 1500 to 2000 feet above tide water. The highest hills toward the south part of the State are scarcely less than 2500 feet above tide water, showing a difference of elevation between the two groups of 1300 feet. Allowing for undulations, which render the dip irregular, the whole thickness is above 1500 feet. At the western limit of the State the group has evidently thinned to a considerable degree, though no good opportunities of measuring were presented. When examined beyond the limits of the State, the evidence of its diminution becomes more apparent; and when we go as far as Indiana, the whole of this group and the Portage is embraced in a thickness of less than 400 feet. Still farther west, it is very probable that they have disappeared altogether.

Mineral contents of the group.— There is little of interest throughout the whole extent of this group. Some of the septaria present the same minerals as those in groups below. Iron pyrites often takes the place of fossils, and carbonate of iron is very commonly found replacing the stems of crinoidea and some other fossils. This mineral becomes more abundant in the upper part of the group, and is rarely seen in the lower part. The decomposition of the rocks gives rise to the sulphates of iron and alumina, showing the presence of iron pyrites very universally diffused. The strata are often stained by the oxide of manganese, and the production of wadd in many places proves its occurrence in the strata in considerable proportion.

Springs.— The same remarks apply to that portion of country occupied by this group of rocks as the last. When covered by forests, the surface is well watered by perennial springs and streams in great numbers. As the improvements progress, the wood is gradually cut from the higher grounds and the broad sloping hill-sides; the surface being thus laid open to the direct rays of the sun, many of the springs fail, and the small streams are dried up. The present system of clearing the country, and the wanton destruction of the forests, will eventually produce serious evils, in the want of water; and the inhabitants should remember, that unless they obey the laws of nature in this respect, their sins will be visited upon their children, and they will be driven out, and a stranger shall possess the land. This subject will be farther noticed under the chapter on agriculture.

Agricultural characters.— The soil resulting from the decomposition of the rocks of this group is a compact clayey loam, which, with the great abundance of angular fragments of the rock, gives it the character which is termed "*flat gravel.*" The soil of the valleys, particularly of the larger and deeper ones, consists of a large admixture of northern materials, among which may be recognized the pebbles of the different limestones and of the Medina sandstone. Sometimes pebbles of the harder strata of the Hudson-river group occur with these, and it is probable also that some of the limestone pebbles may be of the lower limestones north of Lake Ontario and of the Mohawk valley, although they are not distinguishable by their fossils, being usually worn very small.

These circumstances often cause a contrast in the productions of the neighborbood; the valleys, from the calcareous nature of the soil, being good wheat lands, while that of the hills beyond the influence of northern drift is unfit for growing wheat after the first few years from its clearing, unless properly manured. This soil, from its compact nature, is better adapted to grazing than to grain-growing, and this adaptation is beginning to be well understood.

Organic Remains of the Chemung Group.

The rocks of this group abound in fossils, presenting a great variety of forms of the same genera. In the Fourth District, few forms known in the Hamilton group extend into the Chemung. Species of the Brachiopoda are almost equally numerous with the Hamilton group, while Aviculæ are much more abundant both in species and individuals. The species and individuals of *Nucula* and *Cypricardia*, and some others, are about equally numerous in both groups. Trilobites are rare, and there are but few species of coralline fossils.

The fossils are often very unequally distributed through the strata; localities being found where few or almost no fossils can be obtained, and again the strata are completely charged with them. Different localities also often present a great abundance of certain forms which are rare in others.

The green sandy shales of Rockville and Phillipsburgh contain a great abundance of fossils, mostly of *Avicula*, *Lima*, *Cypricardia* and *Inoceramus*, while *Delthyris* and *Atrypa* are much less common. Again, the dark sandstones and sandy shales of Painted-post, Jasper, Troupsburgh and Dexterville, contain myriads of the little *Orthis unguiculus*, and large numbers of *Delthyris*, *Atrypa*, and more rarely *Avicula*. At Chemung narrows, several species of *Avicula*, with large numbers of *Atrypa* and *Strophomena*, are found, with very few of the fossils of the localities before noticed. Scarcely a locality abounding in fossils can be examined, but some new form will be discovered. In this respect this group offers a contrast with the Hamilton, which, where well developed, will yield nearly all the known fossils in a single line of section. This remark applies to the Fourth District, though changes are manifested farther east.

In the following woodcuts, the fossils are grouped principally according to the generic relations, and they embrace the greater number of forms which have been seen in the district.*

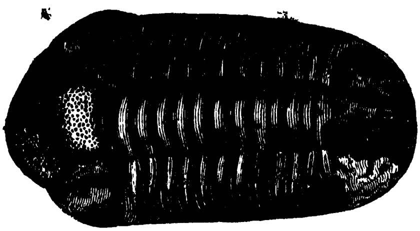
* A large number of these will not appear in this place, but may be found in the forthcoming volume on the Palæontology of the State.

Some that could not be satisfactorily determined, and some others which have been figured in the Report of the Third District, are not here presented.

As just before stated, the remains of Crustacea are rare in this group, which in this respect contrasts with the Hamilton, where, although there are few species, still they are abundantly distributed. The head of *Calymene Bufo*, and the tail of *Dipleura Dekayi*, have both been seen not far from Ithaca.

The following illustration is the only perfect trilobite found in this group in the Fourth District:

116.



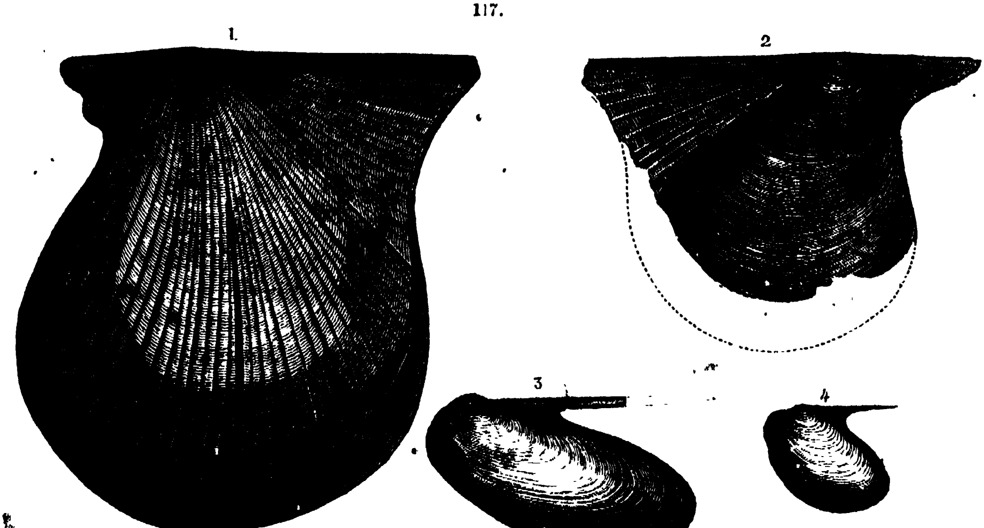
Calymene nupera, n. s.—General form elongated, sides parallel; head three-lobed, middle lobe largest, and much extended anteriorly; articulations of the abdomen eleven, of the tail? Eyes like those of *C. Bufo*, but less prominent.

This fossil resembles the *C. lævis* of Phillips, *Palæozoic Fossils*, pl. 55, fig. 250.

Locality—Chemung creek.

Among the Aviculæ, the first two figures are typical of that part of the group about Chemung Narrows and several places in that county, and of the strata holding the same position in other places. The two next figures are of species marking the brownish sandstones at Painted-post, Jasper, and other localities holding the same position in the group.

117.



1 and 2. Avicula pecteniformis. 3. Avicula longispina. 4. Avicula spinigera

1. *Avicula pecteniformis*, n. s.—Plano-convex; upper valve flat, surface (except the wings) plain or with fine concentric striæ; posterior wing with strong elevated radiating ribs; anterior wing acute, with a fold; lower valve slightly convex, surface and posterior wing marked by strong radii or ribs of unequal size, which become obsolete or undulating toward the margin; anterior wing with a single strong fold, and finer radii; posterior wing large, and extending into an obtuse angle beyond the margin of the shell.

The flat plain upper valve, and the unequal ribs which become obsolete toward the margin of the lower valve, are distinguishing characters of this shell.

Localities—Chemung narrows; Cayuta creek.

3. *Avicula longispina*, n. s.—Obliquely subovate or elliptical, convex; surface marked by concentric lines; beak prominent, extending above the hinge line; anterior margin scarcely produced into a wing, but slightly extended in a curve beyond a deep fold; posterior wing very small, and suddenly extended into a long spine.

From the convexity of the shell, the wing and spine are usually covered, which may lead to mistaking the fossil. It is not uncommon.

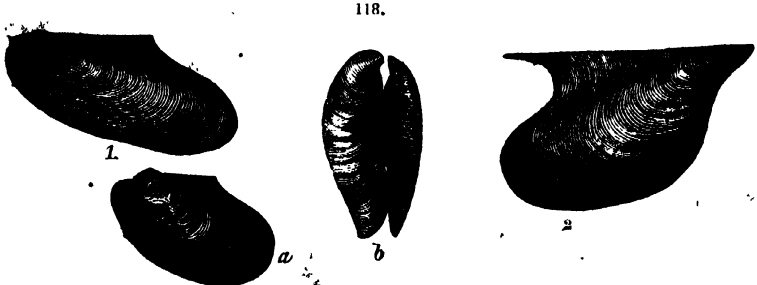
Localities—Painted-post; Jasper; Cassadaga lake.

4. *Avicula spinigera* (CONRAD, *Jour. Acad. Nat. Sci.*, Vol. 8, p. 237, pl. 12, fig. 3).—Obliquely subovate, with concentric lines and wrinkles; anterior wing short, obtuse; posterior wing small, suddenly produced into a long slender spine.

The spine is often broken off in removing the rock from around the shell, but some portion of it can always be seen. In this species the spine is less parallel to the direction of the shell, which is also smaller than No. 3; both often occurring together.

Localities—Painted-post; Jasper; Chemung.

118.



1, *a* and *b*. Avicula Damnoniensis. 2. Avicula acanthoptera.

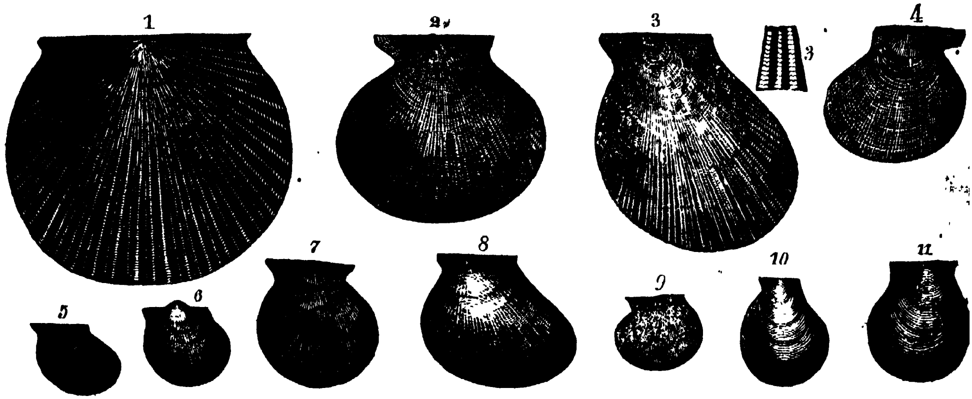
1, *a* and *b*. *Avicula Damnoniensis*. (SOWERBY in *Geol. Trans.*, New series, vol. 5, pl. 53, fig. 22. PHILLIPS, *Palæozoic Fossils*, pl. 23, figs. 90, 91, 92.)—Fig. 1 is the usual form; *a*, a shorter variety; and *b*, a specimen compressed so that the wing is scarcely perceptible.

In these specimens, which are from the soft green shale of Steuben county, the longitudinal striations are not visible; though in specimens from other localities, they are distinct.

2. *Avicula acanthoptera*, n. s. — Obliquely ovate, with a small acute anterior wing; the posterior wing ending in an acute spine, which extends as far as a line parallel with the posterior margin of the shell. *Locality*, Phillipsburgh.

The following forms are found in the green and olive shales and shaly sandstones of Rockville and Phillipsburgh on the Genesee, and they are the prevailing fossils. They are all entirely distinct in form, and in the style of marking upon the surface.

119.



1. Pterinea? suborbicularis. 2. Pecten duplicatus. 3. Lima rugæstriata. 4. Pecten cancellatus. 5. Avicula? signata. 6. Pecten? convexus. 7. Pecten? striatus 8. Pecten? crenulatus. 9. Pecten? dolabriformis. 10. Lima glaber. 11. Lima obsoleta.

1. *Pterinea? suborbicularis*, n. s. — Suborbicular, or broadly semi-elliptical; surface marked by numerous, somewhat undulating ribs, which alternate with smaller ones toward the margin; ribs crossed by concentric wrinkles, producing a rugose surface; wings scarcely distinct; hinge line angulated at the extremities.

Locality—Hobbieville, Allegany county.

2. *Pecten duplicatus*, n. s.— Ovate-orbicular, equilateral, convex above; ears small, nearly equal; surface marked by numerous radiating ribs, which are plain above, and equally cancellated by concentric lines, but becoming uniformly duplicate and rugose toward the base.

This fossil is readily distinguished by its great breadth and the duplicate rugose striæ. It bears some resemblance to *P. plicata*, Sowerby.

Locality—Phillipsburgh, Allegany county.

3. *Lima rugæstriata*, n. s. — Oblong, obliquely ovate, moderately convex; ears small, not very distinct from the shell; surface with strong radiating striæ, which augment toward the base, and are crossed by elevated undulating lamellæ, giving the surface a rugose appearance, which is visible in the enlarged portion.

Localities—Rockville; Hobbieville, Allegany county.

4. *Pecten cancellatus*, n. s. — Obliquely ovate; ears small, distinct, posterior one rather strongly plicated; (left valve) surface evenly cancellated by fine radiating and concentric lines.

In form this shell resembles the last, but the striæ are more even, and never rugose; the form of the posterior wing is likewise different.

Locality—Phillipsburgh, Allegany county.

5. *Avicula? signata*, n. s. — Obliquely sub-ovate; ears small, distinct, posterior one acute; surface marked by sharp concentric lines or lamellæ, which give the shell a peculiar aspect.

Locality—Rockville, Allegany county.

6. *Pecten? convexus*, n. s. — Orbicular, very convex; beak much elevated above the hinge line; surface marked by radiating striæ, which are crossed by concentric undulating lines, giving the shell a very pretty appearance.

This fossil is readily distinguished by its great convexity and orbicular form.

Locality—Rockville, Allegany county.

7. *Pecten striatus*, n. s. — Erect, ovate; ears small, nearly equal; shell moderately convex, surface finely and evenly covered with radiating striæ.

This differs from all the others in the fine, even, radiating striæ.

Locality—Painted-post, Steuben county, in brownish sandstone.

8. *Pecten? crenulatus*, n. s. — Obliquely sub-ovate; posterior wing extending down the side of the shell more than half way to the base; anterior wing short; hinge line crenulated; surface of the shell faintly marked by obsolete, radiating and concentric lines.

Locality—Rockville, Allegany county.

9. *Pecten? dolabriformis*. — Obliquely suborbicular, moderately convex; ears small, posterior one sharply angulated; beak a little elevated above the hinge line; surface marked by fine radiating and concentric striæ.

This shell somewhat resembles No. 6, but is much less convex, more oblique, and the proportion of the ears different.

Locality—Phillipsburgh, Allegany county.

10. *Lima glaber*, n. s. — Erect, oblong-ovate; hinge line very short; ears small; shell very glabrous, with a few concentric, scarcely visible undulations.

The distinguishing character of this shell is its elongated form, its narrowness just below the hinge line, and the very glabrous surface.

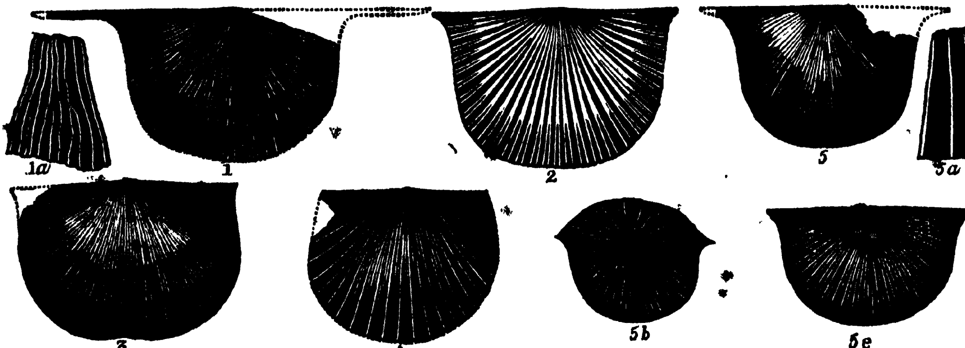
Locality—Phillipsburgh, Allegany county.

11. *Lima? obsoleta*. — Somewhat obliquely ovate; slightly convex; surface faintly marked by concentric lines, which are stronger upon the ears; hinge line crenulated. This fossil is referred, with doubt, to the genus Lima, the hinge being crenulated.

Locality—Phillipsburgh, Allegany county.

Among the Brachiopoda, the following have been selected as most characteristic of the group, though there are other species, perhaps, equally numerous.

120.



1. Strophomena nervosa. 2. Strophomena bifurcata. 3. Strophomena arctostriata. 4. Strophomena pectinacea. 5 a, b, c. Strophomena interstrialis.

1. *Strophomena nervosa*, n. s. — Semicircular, with the hinge line greatly extended, forming a spine-like prolongation; surface marked by undulating, nerve-like striæ, which augment in number toward the margin, and between which are finer striæ.

1 *a*. An enlarged portion of the shell. The shell resembles the nerved wings of some insects, which with the greatly extended hinge line is sufficient to distinguish it.

Localities—Bath; Campbelltown.

2. *Strophomena bifurcata*, n. s. — Broadly semi-elliptical; hinge line extended beyond the width of the shell, and angulated at the extremities; surface marked by about 34 to 36 ribs at the hinge, which uniformly and regularly bifurcate once or twice before reaching the margin.

This is a widely distributed fossil of the Chemung, extending over 150 miles in an east and west direction.

Localities—Napoli, Cattaraugus county; Chemung.

3. *Strophomena arctostriata*, n. s. — Broadly semi-elliptical or semicircular; lower valve very convex, slightly impressed in front; hinge line scarcely extending beyond the width of the shell; surface covered with numerous, crowded, unequal striæ.

Localities—Hobbieville; Chemung.

4. *Strophomena pectinacea*, n. s. — Semi-oval; lower valve very convex; hinge line shorter than the greatest width of the shell; surface marked by from 24 to 28 prominent sharp striæ, with two or three intermediate ones which are less prominent.

This fossil somewhat resembles the next species, but the striæ are more prominent and fewer in number. It is a widely distributed fossil in the group.

Localities—Hobbieville; Rockville; Cattaraugus county.

5 *a, b, c*. *Strophomena interstrialis* (*Orthis interstrialis* and *Leptæna interstrialis*, Phillips, *Palæozoic Fossils*, pages 61 and 216, pl. 25, fig. 103). — Semicircular; lower valve convex, upper one flat or slightly concave; surface marked by sharp radiating striæ, which are sometimes continuous to the margin, and at others interrupted or divaricating; between each pair of these striæ are four or five others, much finer, and slightly undulating.

5, is the inner side of the flat valve from Chemung.

5 *a*. A magnified portion of the shell.

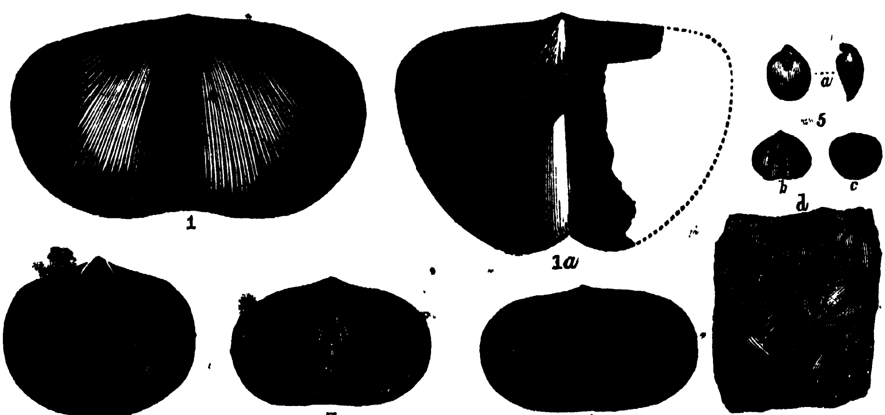
5 *b*. The two valves, somewhat compressed, from Ithaca.

5 *c*. The convex valve, with the shell partially removed, from near Elmira.

The *S. inequistriata* and *S. mucronata* (*Jour. Acad. Nat. Sci.*, Vol. 8, p. 254 and 257, pl. 14, figs. 2 & 10), appear to be identical with this shell of Mr. Phillips, and since his name has precedence, it is retained. It is readily known from the character of its larger and finer striæ, in which it resembles the *S. sericea* and *S. transversalis*, from both of which it is quite distinct.

It is one of the most widely distributed fossils in the group, and has a somewhat different aspect in the shales, sandstones and calcareous layers.

121.



1 and 1 *a*. Orthis carinata. 2. Orthis impressa. 3 and 4. Orthis interlineata. 5. Orthis unguiculus.

1. *Orthis carinata*, n. s. — Semicircular; lower valve very convex, with a depression extending from beak to base; surface covered with fine radiating striæ; upper valve flat, with a sharp ridge along the centre, which is very prominent in the cast; cast of the subrostral impression very prominent and acute at the beak, and not deeply indented below.

1, lower valve; 1 *a*, upper valve.

This character of the cast of the upper valve is always sufficient to distinguish the shell, and it is usually the most obvious character.

Localities—Painted-post; Chemung; Jasper, in brown sandstone.

2. *Orthis impressa*, n. s. — Circular; hinge line short; upper valve nearly flat, suddenly depressed in front (as if the finger had been applied when the shell was flexible); surface covered with fine equal striæ, which are more strongly marked upon a narrow border on the margin; cast of the muscular impression at the beak small, bilobate by a narrow sinus.

The form is perfectly represented in the figure, which is a cast. It is often associated with the next species in the soft and green shales about Elmira and elsewhere.

3 and 4. *Orthis interlineata* (SOWERBY in *Geol. Trans.*, 2d series, vol. 5, pl. 54, fig. 14. PHILLIPS, *Palæozoic Fossils*, p. 63, pl. 26, f. 106.) — Transversely elliptical, depressed; hinge line much less than the width of the shell; upper valve flat, with a ridge along the centre; lower valve moderately convex, with a shallow depression from beak to base; surface radiated by numerous unequal or divaricating striæ.

Fig. 3 is a cast of the upper valve, in which the inequality of the striæ are less perceptible.

Fig. 4, lower valve, showing near the beak the spaces from which the subrostral plates have been removed.

The figures of Sowerby correspond better with our fossils than those of Mr. Phillips. The casts, however, fig. 3 above, and 106 *a* of the latter, very closely resemble each other, and there can be no doubt of the identity of the fossils.

Localities—Cayuta creek; Chemung; Elmira.

5. *Orthis unguiculus.* (*Atrypa unguiculus*, SOWERBY in *Geol. Trans.*, 2d series, vol. 5, pl. 54, fig. 8. *Spirifera unguiculus*, PHILLIPS, *Pal. Fossils*, pl. 26, f. 119.)—Hemispherical, varying in the proportions of length and breadth; beak large, inflated and incurved; lower valve very convex, with a central impressed line extending a part or the whole distance from beak to base; upper valve flat, or slightly convex on each side of a depressed line in the centre.

This fossil usually appears as casts, frequently abundant, and covering surfaces many feet in extent.

5 *a.* Cast from Bald hill, near Ithaca.

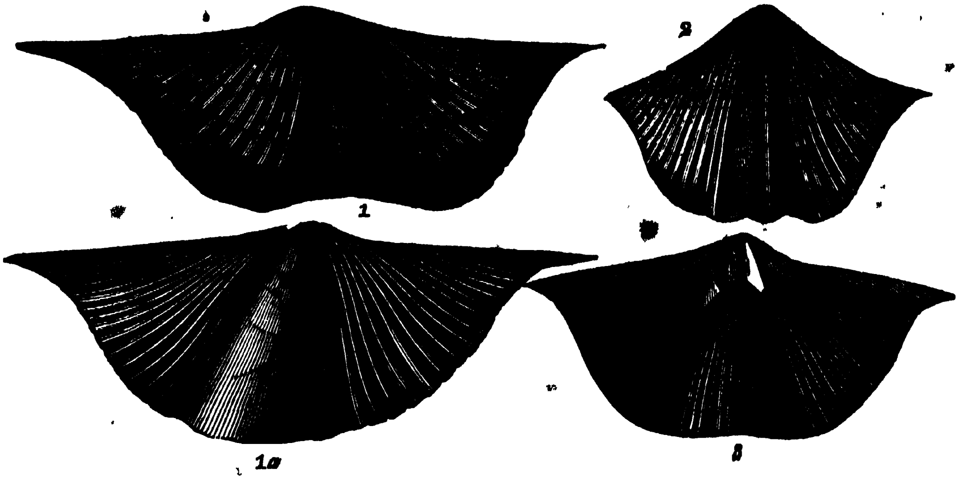
b. Lower valve; broad variety. Dexterville, Chautauque county.

c. Upper valve. Painted-post, Steuben county.

d. Fragment of brownish sandstone, covered with casts of the shell. Jasper, Steuben county.

This fossil differs from the *O. umbonata* of the Hamilton group, which it considerably resembles.

122.



1. Delthyris mesastrialis. 2. Delthyris mesacostalis. 3. Delthyris disjuncta.

1. *Delthyris mesastrialis*, n. s. — Semicircular; hinge line extended into short, acute ears; upper valve broadly emarginate in front; mesial fold very broad and deep, finely striated, and well defined; surface marked by from fourteen to twenty rounded ribs on each side the mesial fold; ribs prominently rounded and finely striated longitudinally. The ribs are sometimes crossed by a few elevated laminæ of growth, as in fig. 1, the upper valve; while in 1 *a*, the lower valve, they are not visible.

The beautifully striated mesial fold is alone sufficient to distinguish this shell from any other in the group. Of two others with a striated mesial fold, one has flat and the other very sharp ribs.

Locality—Cayuta creek.

2. *Delthyris mesacostalis*, n. s. — Sub-rhomboidal; beak very much elevated above the hinge line; hinge extremities terminating in abruptly acute ears; lower valve very convex; mesial sinus angular, deep, and with an obtusely angular rib along the centre; surface marked by about fourteen obtusely angular ribs on each side the mesial fold.

The angular rib in the centre of the mesial fold, with the nearly equal length and breadth of the shell, are the distinguishing characters.

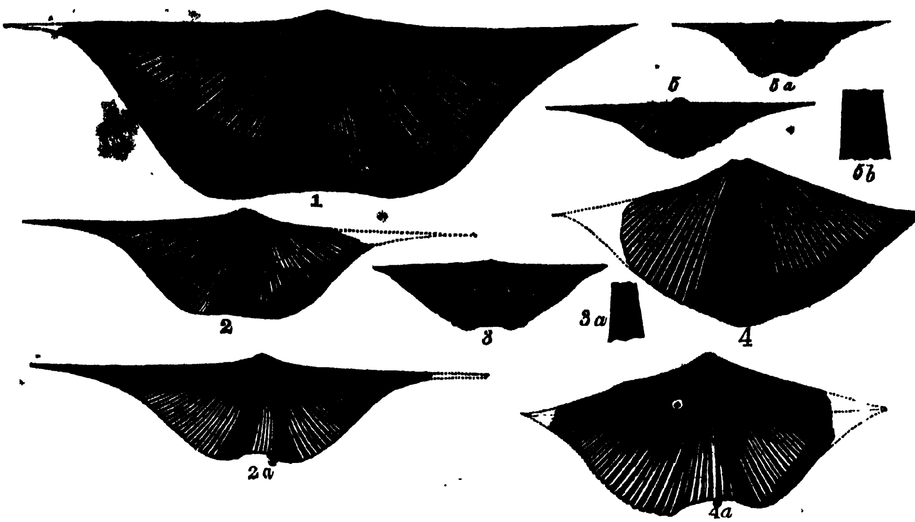
Locality—Angelica, in grey sandstone.

3. *Delthyris disjuncta?* (PHILLIPS, *Palæozoic Fossils*, pl. 29, fig. 128, *f*, *g*, *h*, and 129; pl. 30, fig. 129.) — Semicircular, convex, broadly emarginate in front; hinge line extended into short acute ears; mesial fold broad, not defined at the borders; surface marked by twenty-five to thirty small plain ribs on each side the mesial fold; radii on the mesial fold smaller, and bifurcating toward the margin, where there are often fifteen in number.

The principal differences between this description and that of Mr. Phillips is that the mesial fold is not deep, and the ribs are not divaricating or duplicate toward the margin, except as mentioned.

Locality—Chemung, associated with *Atrypa laticostata*, in great numbers.

123.



1. Delthyris cuspidata.
2 and 2 *a*. Delthyris acanthota.
3. Delthyris mucronata
4 and 4 *a*. Delthyris inermis.
5 and 5 *a*. Delthyris acuminata.

1. *Delthyris cuspidata*, n. s.—Somewhat semicircular; hinge line extended into acute ears; broadly emarginate in front; mesial fold broad, moderately deep, and undefined at the borders; surface marked by many equal entire ribs (about 30 on each side the mesial fold), those on the mesial fold smaller; ribs crossed by elevated lamellæ toward the margin of the shell.

It is perhaps not improbable that this fossil may be referred to some variety of *Spirifera disjuncta*. (Sowerby, *Geol. Trans.*, New series, vol. 5, pl. 54, figs. 12, 13; pl. 55, fig. 2. Phillips, *Palæozoic Fossils*, pl. 29, fig. 128, *f*, *g*, *h*, and fig. 129; also pl. 30, fig. 129.)

Localities—Cayuta creek; Chemung; Vandemark's creek on the Genesee river. Often occurring in immense numbers.

2. *Delthyris acanthota*, n. s.—Semicircular; hinge line greatly extended into ears; emarginate in front; mesial fold well defined, often oblique, expanded at the [illegible], and marked by divaricating striæ; shell marked by about eighteen equal undivided ribs on each side the mesial fold, and five or six smaller ones on each wing.

2, the upper, and 2 *a*, the lower valve.

There is considerable resemblance between this shell and the last, and they may prove to be varieties of one species, the hinge line more extended in the younger ones.

Localities—Ithaca; Cayuta creek; Chemung.

3. *Delthyris mucronata?* (See page 205, fig. 3.) — Transversely elongated; hinge line extended into mucronate points; beak little elevated above the hinge line; mesial sinus well defined, with a small rib in the bottom; surface marked by about fourteen rounded, imbricated ribs on each side the mesial fold. 3 *a*, an enlarged portion of the shell.

This fossil differs in no respect from the *D. mucronata* of the Hamilton group, except the rib in the centre of the mesial sinus. It is referred to this species, till more specimens have been examined. *Locality*, Troupsburgh, Steuben county.

4. *Delthyris inermis*, n. s. — Semicircular; beak of the lower valve much extended above the hinge line; hinge line not extending beyond the shell; surface marked by about twenty-five equal, simple ribs on each side the mesial fold; mesial sinus deep and well defined, marked by about eight divaricating ribs, which are smaller than those on either side.

This fossil is very abundant in Chautauque county, forming layers of several inches thick and many yards in extent. *Localities*, Chautauque creek; Twenty-mile creek.

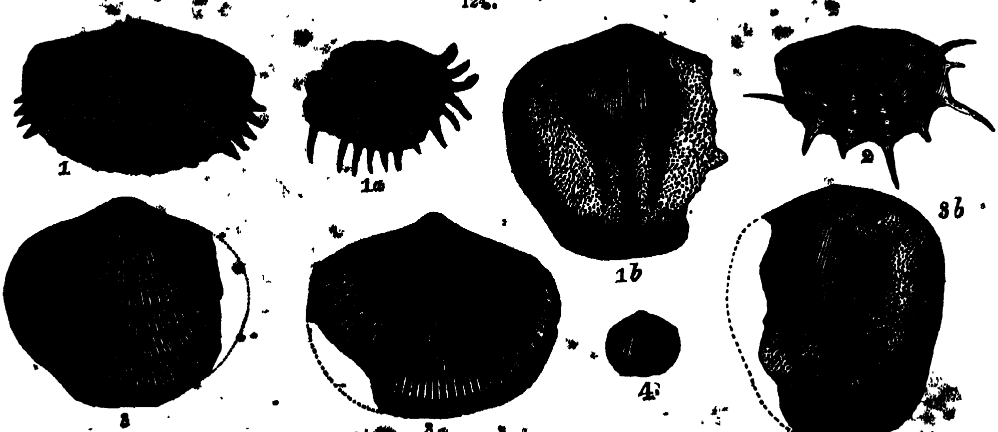
5. *Delthyris acuminata*, n. s. — Transversely elongated; hinge line much extended into long acuminate points; mesial fold simple, well defined; surface marked by sixteen simple ribs, which are crossed by abruptly undulating elevated lamellæ, usually much better seen in the external casts of the shell.

5 and 5 *a*. Internal casts of the upper and lower valves.

5 *b*. Enlarged portion of a cast of the external surface.

Localities—Ithaca; Chemung; Cayuta creek.

124.



1. Atrypa dumosa. 2. Atrypa hystrix. 3. Atrypa tribulis. 4. Atrypa? tenuilineata.

1. *Atrypa dumosa*, n. s. — Semicircular, or somewhat transversely elliptical; beak of the flatter valve scarcely prominent; surface marked by about 32 rounded radiating ribs; the ribs are crossed by elevated, concentric, undulating, thread-like lines, and at more distant intervals, elevated lamellæ; the lamellæ upon each rib are folded into a short round spine.

Fig. 1 and 1 *a*, are faithful representations of two specimens, the latter imperfect.

1 *b*. Cast of the interior of the flat valve, punctured throughout, except the subrostral impression.

This fossil is abundant, though the spines are usually removed, and the surface presents a squamose appearance, which had induced me to refer it to *A. squamosa* of Sowerby.

Localities—Chemung; Cayuta creek; Elmira.

2. *Atrypa hystrix*, n. s. — Transversely subelliptical, often approaching to circular; beak scarcely prominent; surface marked by about eight broad ribs, which are crossed by five or six elevated lamellæ; at the junction of these with each rib, proceeds a long slender spine.

This fossil is totally distinct from any form of Atrypa figured, and is one of the most striking fossils in the rocks to the south of Bath, Steuben county.

3. *Atrypa tribulis*, n. s. — Hemispherical; upper valve very convex, with the lateral edges pressed downwards; lower valve nearly flat, elevated in front, and reflexed at the sides; beak rather prominent; surface marked by numerous divaricating radii, which are crossed by few concentric lines of growth.

3, lower valve. 3 *a*, upper valve. 3 *b*, cast of the interior of the flat valve.

There is considerable resemblance between the cast of this fossil and that of *A. dumosa* (1 *b*), but on closer comparison, they will be found to differ essentially. In this species, the cast of the subrostral depression is longer and less strongly defined; the subrostral plates are likewise compound, while they are simple in *A. dumosa*. This will be seen by the small, projecting, tooth-like process, extending into the space on each side the beak, and which shows a division of the plates, which were proportionally larger than in the other species.

Unlike as these fossils appear, it is often difficult to distinguish them under different aspects, when imbedded in a different matrix, and in various stages of perfection. The casts of these, as well as other species of the genus, will be found reliable.

There is a very close resemblance between this fossil and the forms usually refered to *A. prisca*, *A. affinis*, &c., and I was disposed to refer it to that species; but further examination has induced me to consider it distinct, until an opportunity offers of examining the internal structure of those analogous or identical species in the lower rocks.

Localities—Ithaca; Chemung; Elmira.

4. *Atrypa tenuilineata*, n. s. — Nearly circular; beak small; surface marked by numerous very fine radii.

It is possible that this fossil is an Orthis.

Locality—Cattaraugus county.

125.

In the Fourth District, there are few fossils belonging to the Polyparia, but some of these forms are abundant. The little *Millepora gracilis* is found from one extremity of the district to the other. There is also a species of *Retepora* which is equally abundant; but beyond these two forms, the species are all limited, and occur but rarely. Near Bath, and at Chemung, there is a species of *Cyathophyllum* which has not been seen elsewhere; and in one or two localities, I have seen a specimen of the *Turbinolopsis*.

At Ithaca, Hector and Enfield in Tompkins county, the fossil of which the accompanying figure is an illustration, is found in considerable numbers. It occurs in single detached specimens, or in tufts which appear to have centered in a single base or root. At first view, it appears like a species of *Filicites;* but from its uniform size, the regular angle at which the leaves are given off from the stipe, and the absence of carbonaceous matter, it seems more like the tentaculated fingers of a crinoidean, or perhaps more analogous to the Sertularia.

The structure is so minute, that I have thus far been unable to satisfy myself of its proper relations, and it is left for further investigation. The specimen figured presents parts of several stipes, all apparently centering at one point at the base, and slightly diverging above.

It has before been mentioned that some fragments of land plants have been noticed in the lower part of this group, and even as low as the Genesee slate. In the eastern part of the State, as will be seen from the Report of the Third District, some similar fragments have been found as low as the Hamilton group, but these have not been observed in Western New-York. As we approach toward the termination of the Chemung group, we find some forms very analogous to those of the Coal formation, giving evidence of the approach to that period. These may have drifted from dry land farther east, and in many instances have undoubtedly done so; in others, from the perfect preservation of the fragments, it seems hardly possible that they could have drifted far, except in a quiet sea.

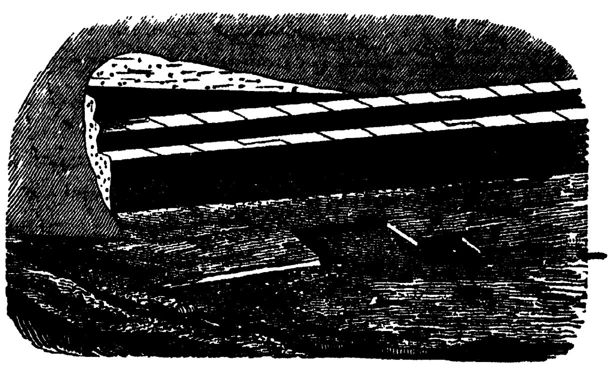
Most of the specimens obtained have been fragments, however; and of the more solid portions of the trunk, a few fragments of ferns have been found, and a single specimen in a tolerably perfect condition, of which the opposite page exhibits an illustration.

It appears referable to the genus *Sphenopteris*, but differs from any figure in Brongniart's *Végétaux Fossiles*, which is the only work of reference within my reach. The name *laxus* is suggested from the want of rigidity in the branches, which characterizes most of the species.

This unique specimen was obtained by Mr. E. Sexton, of Pine valley, Chemung county, from his quarry in the vicinity; and through his liberality, it has been placed in the State Collection.

The quarry referred to presents a peculiarity in the arrangement of the strata, not elsewhere noticed; the lower beds have a uniform northerly dip, while a thin bed of similar materials resting upon these, dips in an opposite direction, as represented in the section below. The position of this quarry is just below the more highly fossiliferous rocks of the Chemung group, which occur in the same hill.

126.

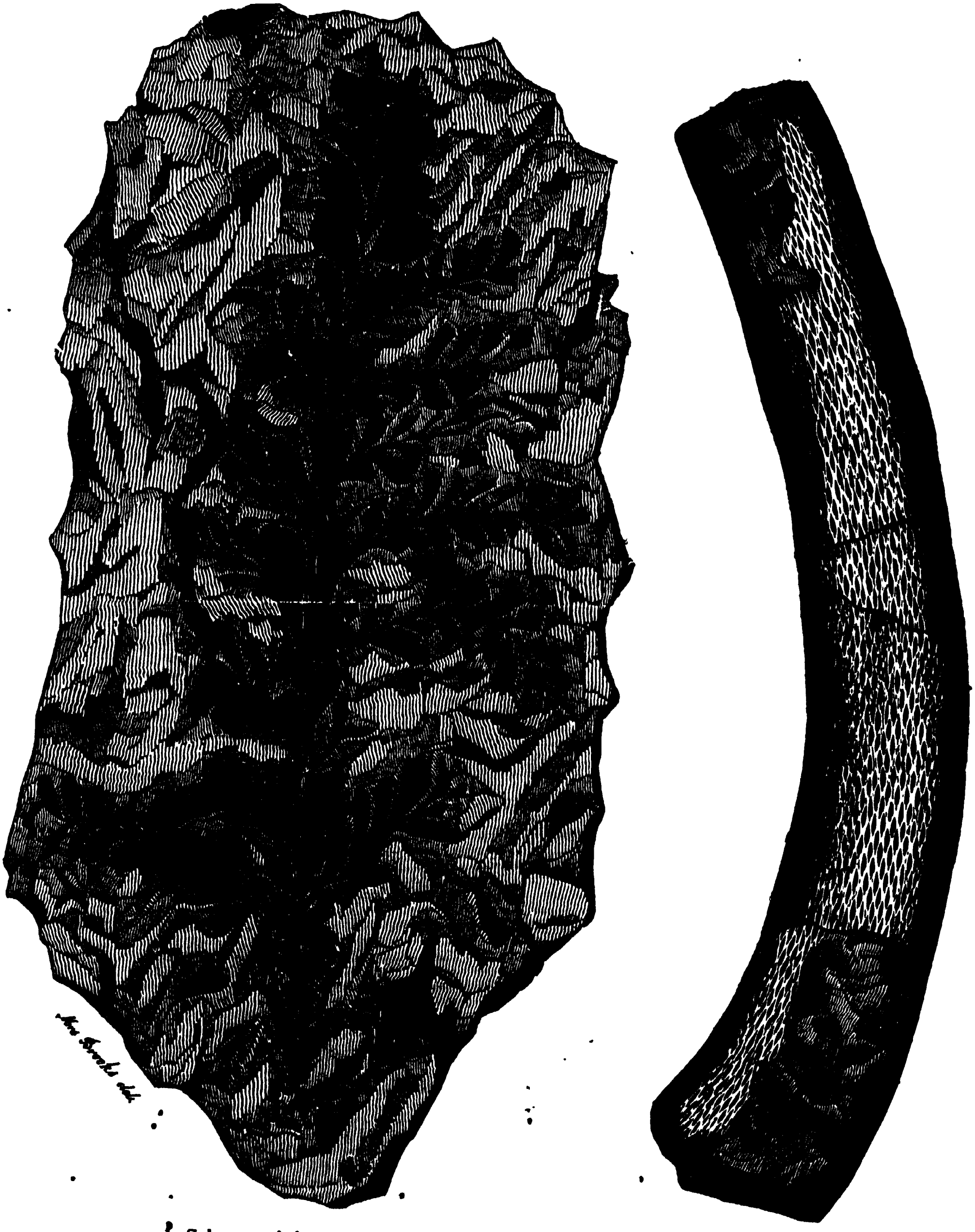


Section of Sexton's quarry, Pine valley, Chemung county.

Fragments of fossil vegetables referable to the genus *Sigillaria*, occur somewhat rarely in the higher rocks of the group. A fine specimen of this character was obtained by Mr. Horsford in the vicinity of Black creek; and another, of which the illustration is also on the opposite page (fig. 2), was found in Wisner's quarry near Elmira.

Other specimens referable to the genus *Calamites* have been observed in the rocks of this group, and some in which no definable structure exists.

127.



1. Sphenopteris laxus.

2. Sigillaria Chemungensis—one-half the natural size.

Localities of Superposition.

There are few localities, where the junction of this group with the one next above is obvious. Throughout the greater part of the district, the higher rocks have been removed by denudation. In a few points, it is succeeded by a thin band of the Old Red sandstone, which is a highly ferruginous stratum, and contains few fossils. In other places, the conglomerate of the Coal formation rests directly upon the Chemung group.

The section, page 253, shows the order among the rocks of the Chemung and the successive formations along the Genesee river. The same is seen in the section of Allegany county, Plate 11. In Plate 10, the section across Steuben county shows the Old Red succeeding the Chemung. In Plates 11 and 12, the sections of Cattaraugus and Chautauque counties show the conglomerate resting upon the Chemung group. This occurs from the thinning out of the Old Red sandstone, as will be seen under the description of that rock.

The series even where the Old Red intervenes is nevertheless incomplete; and the perfect order of succession from this point upwards cannot be established in New-York, from the absence of the Carboniferous limestone.

With the rocks of the Chemung group, terminate all those included in the New-York System. The reasons for uniting all the rocks and groups below the Old Red sandstone in one system, and for considering the latter as distinct, have already been stated briefly. The termination upwards of the Chemung group has been shown in the sections given, and the character of the strata composing it fully described. It will be seen, that in the eastern part of the State, many of the fossils of the Hamilton group extend into the Chemung, and at the same time the lithological character is nearly the same in both. Farther to the west and southwest, the lithological character of the two groups is quite different, and at the same time we find few of the fossils of the lower group extending into the higher. Even where there is the greatest distinction in lithological and fossil characters, the two can only be separated as parts of a great system, being the productions of continually operating causes from beginning to end. The products differ in character, and the fossils are of different species, but they are of the same prevailing genera.

Where the best opportunities for examination exist, the change from the Chemung to the Old Red sandstone is abrupt in character. The greenish and olive shales and sandstones charged with *Strophomena, Delthyris* and *Atrypa*, are succeeded by a red sandstone, containing none of the organic remains of the lower rocks. The change in lithological character is accompanied by a change in the fossils, even more decided. Few shells are known, but the rock every where contains the remains of fishes, which are often preserved in a very perfect manner.

It is quite evident from lithological character alone, that these two deposits are not synchronous; the materials differ in character, and the extent of the higher rock is very limited. The Old Red sandstone is scarcely known west of the Genesee river, where the Chemung is in greatest force ; and from this early thinning in a westerly direction, as well as from other facts, it is evident that it had not the same origin as the rock below.

In examining rocks westward, the place of this never presents any remaining matter that indicates its former existence, or any marks by which we can infer that it has been previously swept off. In many places the conglomerate rests upon the Chemung group, without the intervention of any other rock.

The rocks of the New-York system, although many of them diminish westward, are most or nearly all of them represented as far as the Mississippi river. The change, for the most part, is well marked in all cases between them and the higher rocks, and they as evidently constitute one great system over all this extent of country.

It may not be out of place here to remark, that the rocks of the Chemung group are regarded by some geologists as forming a part of the Old Red sandstone, and that the "Devonian system" of Mr Phillips includes both these rocks and the red sandstone which succeeds them. I have already remarked, that in the eastern part of New-York, there are many fossils typical of lower rocks which extend upwards into the Chemung group ; and should the latter be united to the Old Red, it offers too intimate an association of strata, and of organic remains, to allow of any separation beyond that of simple groups ; whereas by leaving the Chemung united to the rocks below, we have a very marked change in the productions of the succeeding formation.

CHAPTER VI.

OLD RED SANDSTONE.

Catskill group; Montrose and Oneonta sandstone of the Reports.

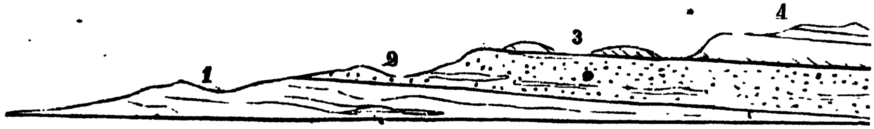
(No. 11 OF THE PENNSYLVANIA SURVEY.)

The rocks now recognized as belonging to the Old Red Sandstone, where fully developed, consist of various strata of sandstone, shale and shaly sandstone, conglomerates and impure limestones. The prevailing color of the arenaceous portion is brick-red, though often lighter, and sometimes of a deeper color from a larger proportion of iron; while the coarser parts are often grey, and the shales are green. Beds of green shaly sandstone are interstratified with the red friable sandstone, and these are succeeded by a compact kind of conglomerate rock. The strata rest conformably upon the grey, olive and greenish shales and sandstones of the Chemung group, and pass beneath the conglomerate of the Coal measures. (See Section, Plate 7, and woodcut below.)

In the Fourth District, this formation is of no great thickness or extent; but in passing eastward, we find it expanding and augmenting in thickness, till finally it rises in the high and prominent peaks of the Catskill mountains, the highest of which has an elevation of more than three thousand feet above the level of the sea. From the diminution of the lower groups, the base of this formation approaches the base of the mountains, giving a great part of their elevation for its thickness.

Along the Genesee river, and in some of the higher hills south of the Canisteo in Steuben county, it consists of a thin mass of calcareous sandstone, highly charged with iron, and containing remains of fishes. By tracing it southward, it is found to expand, and presents many of the features of the same farther east. It rises from beneath the Coal measures of Pennsylvania, extending northward, and resting upon the rocks of the Chemung group, as in England it does upon the Ludlow formation, the equivalent of the latter.*

128.



1. Chemung group. 2. Old Red sandstone. 3. Conglomerate, and diagonally laminated sandstone. 4. Coal measures of Pennsylvania.

* Compare the woodcuts, No. 128, and Plate 7, with the sections, Plates 31, 33, &c. of Silurian Researches.

The whole series has not yet been sufficiently investigated, to know if it admits of the same subdivisions here as in England; yet it is very true, that to a certain extent, it possesses the same lithological characters, and contains some at least of the same organic remains.

The existence of this rock, although so well known in England and some other parts of Europe, was for a long time considered enigmatical in this country; and it is only since the commencement of this survey, that it has been satisfactorily identified by its fossils.

In 1824, Prof. Eaton first suggested the existence of the Old Red sandstone on the Catskill mountains,* though he appears to have overlooked this fact in his subsequent arrangements. Some years afterwards, R. C. Taylor, Esq., in a report upon the Coal region about Blossburgh, Pa., mentions the Old Red sandstone as existing there, and between that point and the State line on the north. There was no other notice of its existence in this part of the country, till the publication of the Geological Reports for 1840, when it was fully identified by its fossils.

To the west of the Genesee, I have only detected this rock in loose masses upon the surface, though it is possible that it may occur at some of the elevated points, which, from being entirely covered by forests, have escaped observation. Farther west, however, where good opportunities for examination exist, it is not found; and it thus becomes evident, that in this direction the rock disappears not far from the Genesee, in Allegany county. From this fact it will be perceived, that there is a very rapid diminution in thickness from the Catskill mountains to the point of its disappearance. This shows a condition of the primeval ocean greatly different from its state during the deposition of the preceding groups, where a series, with a thickness less than this one in its greatest development, extends nearly or quite as far as the Mississippi, more than one thousand miles beyond the termination of the Old Red sandstone. This change in condition was evidently, in part, a diminution in the transporting power of the oceanic currents, which had previously carried forward similar materials over the broad extent before described. Other changes may have supervened, but we can scarcely conceive of any other which would produce similar phenomena.

The materials forming the Old Red Sandstone are, to a great extent, as easily transported as those of the rocks below; still their extent is limited in New-York, and westward as far as Ohio this rock is not represented at all. Still farther west the rocks of the Chemung group are succeeded by sandstones and thin beds of limestone, wholly unlike the red and green sandstones and sandy shales of New-York; and they contain, at the same time, a different assemblage of organic remains. Other changes, too, have supervened at the west, of which we have no evidence in New-York; and the most striking is the occurrence of an important mass of limestone below the conglomerate, which is the great supporting rock of the Carboniferous system.

In order to institute a comparison between the rocks of this period in New-York and those at the west, the following woodcut, illustrating the relative position of rocks in Indiana, will serve to give the reader all necessary data.

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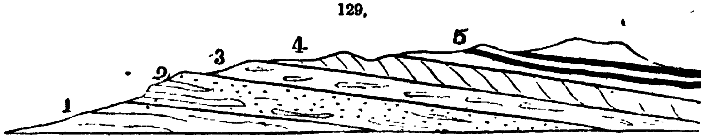
* Canal Rocks, p. 92.

129.



1. Chemung group. 2. Grey sandstone, with beds of oolitic limestone. 3. Grey limestone, oolitic above. 4. Diagonally laminated sandstone and conglomerate. 5. Coal measures.

In the Fourth District, the thinning margin of the Old Red Sandstone, from the large proportion of ferruginous matter it contains, has usually more the appearance of an iron ore than a sandstone. It appears to be a compound of sand, clay, and calcareous matter, with a large proportion of the hydrate of iron, and contains, in abundance, small fragments of bones and scales of fishes. These are generally too small and too much worn to be recognized, except in the general similarity with better characterized specimens of scales and bones of Holoptychus from other localities. In some places the whole mass is an iron ore of tolerable quality, containing probably 20 or 30 per cent. of that metal. In such cases, however, it is very thin, and I have been unable to find any rock above it in connection.

This rock is much better developed in the First and Third Districts; and it is to be hoped that some one with powers of investigation and description, like Mr. Miller of Glasgow, will one day give us a work upon the Old Red sandstone of the Catskill mountains, similar to his on the same rock in Scotland.*

Localities.—The principal localities where this rock can be seen in the district, are near Wellsville on the Genesee; and at another point near Spring mills, in the southeastern part of Allegany county. It likewise appears in several places in Steuben county, on the tops of the hills between the Canisteo and the south line of the county.

The mass is too limited in extent to produce any important influences upon the surface or soil, though it tinges the latter of a deep red, like the red shale of the Onondaga salt group.

Organic Remains of the Old Red Sandstone.

In passing from the rocks of the Chemung group to the Old Red sandstone, we find a marked change in the organic contents. Immediately below the latter we have green shales and shaly sandstones charged with shells of Delthyris, Strophomena and Atrypa; while after leaving this

* Few works have ever appeared on the subject of geology, of greater interest than the book entitled "The Old Red Sandstone, or New Walks in an Old Field," by Hugh Miller. The clear and fascinating style of the author has here rendered highly interesting, what in most other hands would have consisted so much of dry detail as to have been forbidding to many readers. This work, and other writings of the same author, show what can be accomplished by a man who began life as a quarryman, and who, having toiled through all the privations and discouragements of that kind of life, now stands among geologists in such a position that the Rev. Dr. Buckland offers to give his right hand to possess the same felicity of description as Mr. Miller.

rock, we find nothing of that character. The shells which occur in the Old Red, so far as known, are quite distinct from those of the Chemung. The most characteristic fossils are the bones and scales of fishes. These meet the eye in all localities, from their strong contrast with the ground in which they are imbedded, being usually nearly white or bluish in the brownish-red rock. These scales and bones are often in minute fragments, and so permeated by iron as to offer no contrast in color; but in other places they are perfect, and from an inch to one and a half inches in diameter, appearing like patches of extraneous matter.

By far the most common of these are the scales of *Holoptychus nobilissimus*, a fossil well known in the same rock in England and Scotland.

130.

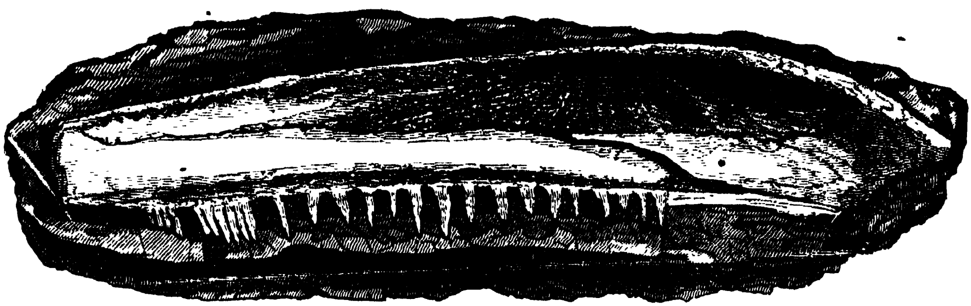
Scales of Holoptychus nobilissimus and Sauripteris Taylori.

The enamel of the scale (fig. 2) is marked by large undulating furrows and ridges, which become obsolete towards that side covered by the scale next in front. This character alone seems sufficient to indicate the fossil. The enamel is often removed from weathering, and casts of its outer surface are preserved in the rock.

Many fragments of bones and some of teeth have been found in the same situation with these scales (fig. 4 of woodcut 130 is one of these). Some of the teeth bear a very close analogy to the figures of the teeth of Megalichthys. The fragments of bones often resemble those of the buckler of Cephalaspis.

The jawbone with teeth of the following figure were found in the same association. The whole length of the jaw was about seven inches. From the prevalence of scales of Holoptychus, I had supposed it to belong to that fish, but farther examination has led me to doubt the correctness of this opinion.

131.



Besides these, I obtained in a lower situation in the rock a fin and a large number of scales. The fin presents a structure differing from any fossil fish of the Old Red sandstone which I have seen described, and evidently partakes of the nature of the fish and the Saurian. From this character of the fin, I have proposed the name Sauripteris.*

GENUS SAURIPTERIS.

Provisional characters—Pectoral fin composed of the rudiments of a humerus, the radius and ulna, and phalanges; from the latter of which proceed bony rays. Enamel of the scale punctured, as if for the insertion of small bristly points. The surface is slightly corrugated, bearing the character of shagreen.

Sauripteris Taylori (plate 3, figures 1, 2, 3, and fig. 1 of woodcut). — This fossil consists of the clavicle with the rudimentary bones just mentioned, from which proceed bony rays. Some thick heavy bones, of an apparently cartilaginous structure, occur a little in advance of this. These were probably the bones of the head, and one of them contains several teeth. The scales were very numerous, and, from being closely connected with the fin, are considered as belonging to the same animal. No other remains were found in the same situation in the rock.

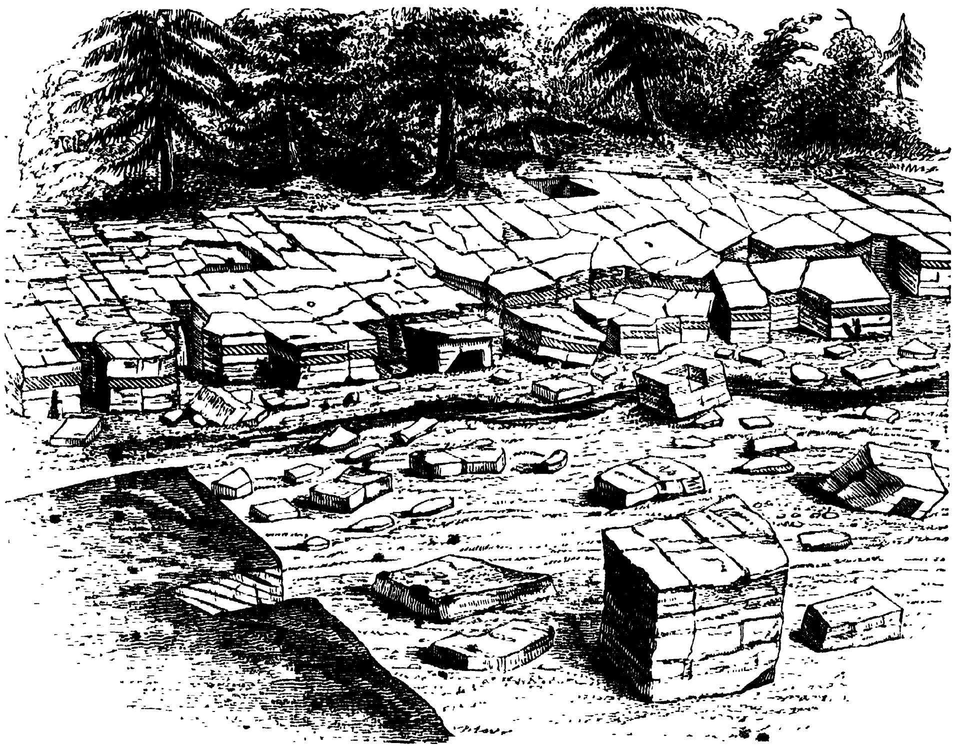
The remains figured in this plate and the woodcuts above, are all from near Blossburgh, Pa., none being found in the Fourth District of New-York in sufficient perfection.†

* A notice of this fossil was read before the Albany Institute in 1840, in which the name Sauritolepis was proposed, and I afterwards published it under this name in the Annual Geological Report. Being at that time desirous of founding the generic distinction upon the scales, in accordance with the system of Agassiz, I overlooked the more obvious character of the fin. Since this has never before been figured, and the name probably not adopted, it will give rise to no confusion by changing it to Sauripteris, from the sauroid character of the fin.

† I had felt disposed to wait the appearance of the Geological Report of Pennsylvania, by Prof. H. D. Rogers, before giving any figures of these fossils; but on consulting him, he, with his usual liberality, expressed not only a perfect willingness, but a desire that they should appear in my report, as they were obtained in extending my examinations beyond New-York, to a more perfect exhibition of the Old Red sandstone in Pennsylvania.

Thus far we know little of the fossils of the Old Red, but, from the rich harvest of these cursory explorations, it may be expected that we shall yet bring to light a much greater number of species; and if we are not able to compare in number and singularity of forms with the fishes of this rock in Britain, we may, perhaps, discover others which will throw new interest around the investigations of the Old Red Sandstone. The Sauripteris, if I am correct in my inference regarding its structure, enables us to extend the sauroid type to a lower position than heretofore; and from what has been remarked under the description of the lower rocks, we are now able to extend the evidences of the existence of fishes to a lower point in the system than has ever been previously done.

132.



Sketch of the northern edge of the Conglomerate, six miles south of Olean in Allegany county. By Mr. E. N. HORSFORD.*

CHAPTER VII.

CARBONIFEROUS SYSTEM.

CONGLOMERATE, OR EQUIVALENT OF THE MILLSTONE GRIT OF ENGLAND.

Under the term *Carboniferous system,* it is intended to include all those deposits which are considered as belonging to that period in which the great coal-fields were produced. These are marked throughout by characters which indicate a certain prevailing condition in the ocean and the nature of the deposits, and a similarity in the nature of the organic products. All the workable coal seams of the country are confined to this formation, and none have ever been known to occur in the rocks previously described in this Report.

* The illustrations of this chapter, and that upon jointed structure, were mostly sketched by Mr Horsford.

The second member only of this system is known in New-York; and from the situation in which it occurs, little of interest or importance can be expected from it, except as showing the remains of an important formation, which once extended widely over the southern tier of counties, but from subsequent operations has been almost entirely removed, leaving only the isolated fields and blocks which indicate its former extent and importance.

The Old Red sandstone in the Fourth District, is succeeded by a coarse siliceous conglomerate, and a grey diagonally laminated sandstone, the former generally prevailing. The conglomerate consists of a mixture of coarse sand and white quartz pebbles, varying from the size of a pin's head to the diameter of two inches. They are generally oblong, or a flattened egg shape. Some of these are of a rose tint when broken, but white upon the exposed surface. Pebbles of other kinds are very rare in the mass, though red and dark colored jasper are sometimes found.

This rock in the Fourth District occurs in outliers of limited extent, capping the summits of the high hills toward the southern margin of the State. It is represented on the map by small dark spots, and its relative position is seen by an inspection of the sections crossing the counties (Plates 10, 11 and 12). From the absence of the red shales and sandstones forming the Old Red, this rock, on the west of the Genesee, rests directly upon the Chemung group.

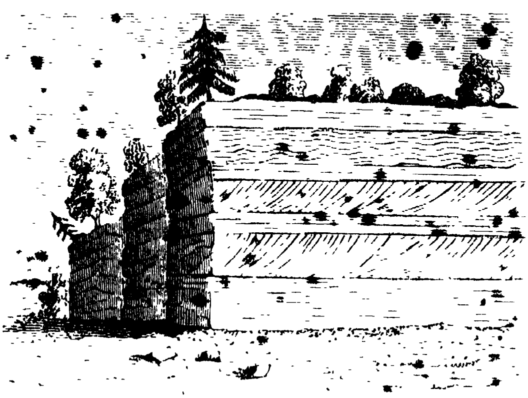
From its position, it has been much undermined; and separating into huge blocks, by vertical joints, which are often many feet apart, the places have received the name of *ruined cities*, *Rock city*, &c. The sketch at the head of the chapter will give an idea of the character presented by this rock in its exposed edges. In many situations it can hardly be considered as being in place, the wearing away of the rocks beneath having allowed the mass to fall down, so as to occupy the side of a hill instead of the summit.

It is often much broken, and scattered fragments extend on all sides of the principal outliers to considerable distances. In many instances I have detected huge fragments of this rock nearly as far north as the northern limit of the southern range of counties, lying on the hill-sides, and sometimes in the valleys. At first I was disposed to consider these as transported from the south, knowing no rock in place of the kind so far north. Subsequent investigations, however, have convinced me that these fragments are the remains of the rock itself, which once extended continuously much farther north than its most northern outliers at the present time.

In some instances, we find perhaps but a single mass; again we may find several, and in a few instances I have found a long range of fragments flanking the southwestern slopes of hills, and a similar arrangement upon an eastern slope, and again upon the summit of a broad flat table land surrounded by higher hills. These fragments have all the characters of the rock in place, and some of them occur in the immediate vicinity of such localities, and in one or two instances to the south of points where the rock is known in place. The occurrence, therefore, of single fragments, or of several in proximity, in the southern counties of the district, must be regarded as evidence of the former existence of the rock at these points, or farther to the north.*

In some places where this rock is a sandstone, the marks of furrows and striæ are still clearly preserved upon its surface; showing the influence of that denuding agency which removed the greater part of the rock, and probably the same which excavated the deep valleys crossing this part of the country from north to south, as well as many lesser ones in other directions.† The prominent outliers of this rock upon the high and distant hills furnish good landmarks for showing the extensive denudation which this part of the country has suffered. From its great extent northward, it appears very probable that originally some of the lower beds of the Pennsylvania coal-fields extended into New-York, and that being of more destructible materials than the conglomerate, they have been entirely swept off. This may appear more reasonable, when it is stated, that about six miles south of the State line, on a high ridge of land between the Allegany river and the Connewango creek, a bed of coal lies upon the conglomerate, which latter extends thence northward into New-York, its broken outliers appearing for ten or fifteen miles north of the State line.‡

133.



Diagonal lamination in sandstone.

Diagonal lamination.—The diagonally laminated structure is often beautifully presented in the broken cliffs and large fragments of this rock, and this is one of the most obvious characters.

The illustration No. 133 is of a quarry at "Burned hill," in the south part of Allegany county. The alternation of horizontally laminated strata shows the varying conditions of deposition. The stratum below the upper one shows an undulated structure very much like the rippled surfaces, but not so well defined.

* I am frequently reminded that these huge fragments, scattered upon the hills in this manner, are the loads deposited by immense icebergs, which have here stranded, and subsequently melted away. But however plausible this argument may be, I prefer another solution of the phenomena, which appears more in accordance with facts here given. Although this would show a former extension of the conglomerate to points twenty miles north of where it is now known in place; the inference seems unavoidable, and well substantiated.

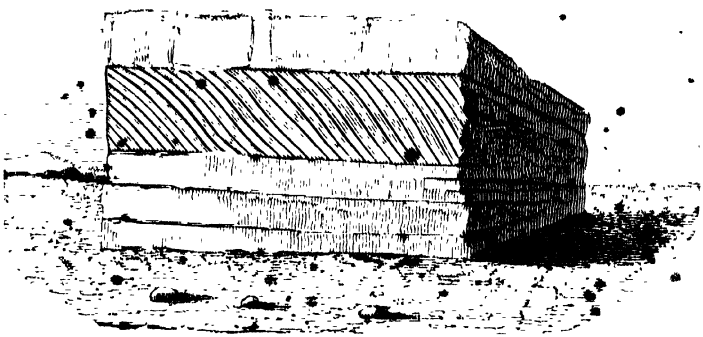
† The points where these striæ and furrows occur, are on some of the highest hills in Chautauque county, and nearly two thousand feet higher than similar markings along the borders of Lake Ontario.

‡ There is another conglomerate in Chautauque county and in some places in Allegany county, which was briefly noticed under the Chemung group. This, however, is a thin mass, and wherever it has been found in place, is associated with fine-grained compact sandstones and frequently contains the fossils of the Chemung group. In the northern part of Chautauque county, I found some loose masses of this conglomerate containing fossils known to belong to the Chemung group, and by this they were chiefly identified. The aspect of the rock is also somewhat different, the pebbles smaller, more round, and not of the same white quartz which occurs in the higher rock.

At this point the conglomerate was not seen *in situ*, though numerous fragments were found upon the slope of the hill.

The following is a section showing a similar structure in a block of conglomerate in the "Rock city," south of Ellicottville.

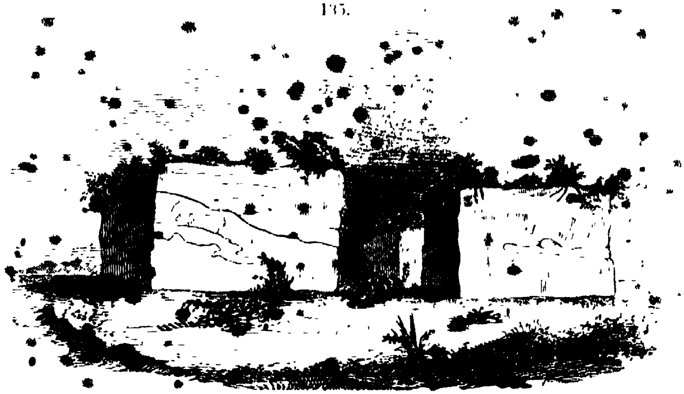
134.



Concretions and seams of iron ore.

In many places this rock is traversed with seams of iron ore, which often stand out from the surface of the blocks, having resisted the influence of the weather which destroys the mass. These seams are sometimes in right lines; at other times, undulating; and rarely, if ever, in the direction of the lines of deposition. They are evidently segregations from the mass, and the irregular and undulating direction is due to accretionary force. In some instances, nodules of hydrate of iron have been found; at other times, the folded seams or laminæ enclose a mass of sand, which has apparently resisted the formation of a solid concretion of iron ore.

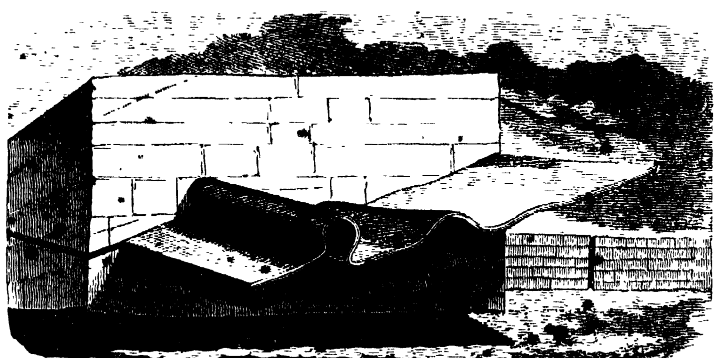
135.



The illustration above exhibits these seams as they appear in two blocks of conglomerate at Rock city. The seams are an inch thick; the lower one at the left hand folding irregularly around, and enclosing a portion of sand: the same concretionary tendency is seen in a part of the seam on the right hand side.

The illustration No. 136 represents a thicker seam of the ore upon the surface of a loose block, where the weather has removed the rock above. This shows a tendency to folding, as in the other instances. Small nodules are sometimes found, though rarely, which do not enclose sand.

136.



The existence of these seams, and the concretionary structure is noticed here, from the fact that farther westward, small concretions of ore, and concentric seams similar to these, are of frequent occurrence, and seem to characterize the mass.

At the Cuyahoga falls in Ohio, the cliffs of conglomerate presents some interesting exhibitions of these seams, which the following woodcut illustrates:*

137.

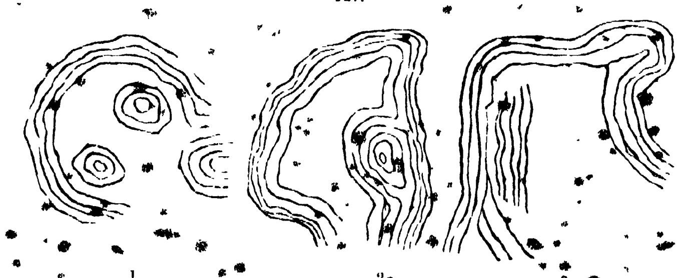


Fig. 1 is an example where two centres are formed, which are subsequently enveloped by concretionary laminæ.
Fig. 2 exhibits concentric rings or laminæ, which expand farther upon one side.
Fig. 3 presents irregular concretionary or concentric laminæ, enclosing a few undulating ones, but with no well defined centre.

* See Transactions of the Association of American Geologists and Naturalists, Vol. 1. 1843.

Localities. — The first evidences of this rock noticed in the district, were in Chemung county, where a few boulders and fragments were found. The same were observed in Steuben county, at several points; but the rock was nowhere found *in situ*. In Allegany county, there are several places where appear the remains of the mass, and which hold their original position. One of these is near Wellsville, on the Genesee; a second is in the town of Scio, about five or six miles west of the former. The first point presents only the diagonally laminated sandstone, with loose blocks of conglomerate; the second is a coarse conglomerate, the finer parts of which have been used for millstones.

There is another locality still farther west, in the town of Little-Genesee, where the rock is of the same coarse character as in the last.

About six miles south of Olean,* and nearly on the State line, there is a tract of several acres occupied by this rock; its northern outcropping edge is much broken, and huge masses are scattered for a mile or two around on the slopes. Some of the blocks, where the rock lies apparently undisturbed, are sixty or seventy feet long and thirty or forty feet wide, and so widely separated by vertical joints that they offer spaces like streets and alleys, converging as we approach the rock in place. Sometimes the roots and loose vegetable soil has extended over these fissures, and they then present covered ways which often lead to the dens of wild animals, and which, in the early settlement of the country, were tenanted by bears and wolves. At present, except in rare instances, the fox and hedgehog appear to be the only occupants of these places.

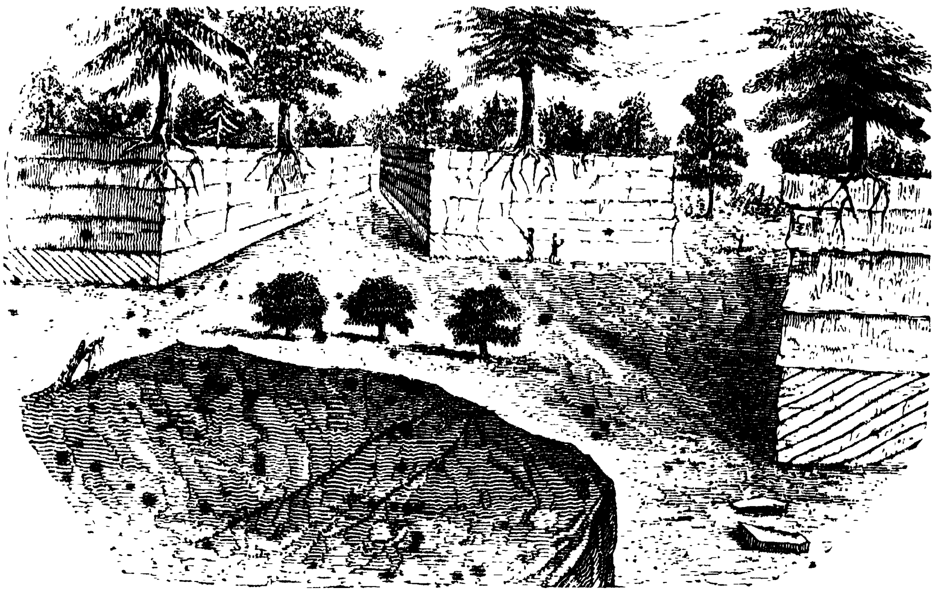
There are several points in Cattaraugus county where the conglomerate is very well exposed upon the tops of the hills. The best known of these is the "Rock city," about seven miles south of Ellicottville. This place is upon the top of a hill, about two thousand feet above tide water. The situation is very similar to that south of Olean; the blocks are widely scattered along the margin of the hill, and as we approach the undisturbed parts of the rock, they become more numerous, and soon assume a regularity in arrangement which shows them to remain nearly in their original relative position, except that the joints are widened by the undermining of the rock below, and partly, perhaps, by the destruction of the rock itself. The whole presents an appearance like a cliff of harder rock resting on a more destructible one below, which has been exposed to the waves of the sea or large lakes, examples of which are presented on a smaller scale in some of the sketches along Seneca lake. In some places where the blocks are otherwise closely arranged, there are large spaces, where the masses have been removed or disintegrated, presenting a fancied resemblance to courtyards or squares in the midst of the numerous streets and alleys. The whole area occupied by the rock at this place is estimated at an hundred acres, though the space where the rock is not scattered is not more than half this extent.

The sketch below represents a few of the immense blocks at this place, with the passages between them. The large trees which stand upon the top, have often sent their roots down

* See the illustration at the head of the chapter.

the sides, where they are sustained in the deep soil, supporting the huge growth above upon an almost barren rock.

138.



View in Rock city, seven miles south of Ellicottville. From a sketch by Mr. E. N. Horsford.

The masses present the same features as before described, and offer fine exhibitions of the diagonal lamination and contorted seams of iron ore. The rectangular blocks are from thirty to thirty-five feet in thickness, and standing regularly arranged along the line of outcrop, present an imposing appearance, and justify the application of the name it has received.

Near Judge Wright's, a few miles southeast of Ellicottville, the conglomerate appears on the tops of two hills, separated from each other by an east and west valley. It also appears between Napoli and Little-valley, and at another point between the latter place and Great-valley. There are also several places on the south side of the Allegany, where it appears on the tops of some of the highest hills. In all, except two or three of the localities enumerated, the rock appears in scattered blocks.

In Chautauque county there are numerous localities where this rock appears, either *in situ* or in scattered masses. It is frequently nearly free from pebbles, and furnishes a good quarry stone. The principal places where it has been quarried, are upon the top of a hill two miles west of Ashville; at Williams's quarry four miles north of Panama, and at another place one mile north of the latter. At Panama, the conglomerate in huge masses lies along the eastern slope of the hill, and upon both sides of the stream. It rests upon the soft green shale of the group below, and has evidently been thrown down from a higher elevation by the removal of the rock beneath. The masses are sixty or seventy feet long and of equal thickness, having a breadth of thirty or forty feet. The rock appears to be nearly continuous, separated only by fissures of greater or less extent and width.

All the localities known in this county were enumerated in the annual report of 1841; and they are all indicated by the dark spots upon the map.

Thickness.—The thickness of this rock varies at different localities from twenty-five to thirty-five feet. At Panama it is about sixty feet thick, and this is the greatest thickness known in the State, though a short distance south of the State line it becomes one hundred and fifty feet thick. The varying thickness may arise from original inequalities, or from denudation, which has operated unequally in different places. In many localities where the same rock appears in Ohio, Indiana and Kentucky, the thickness is nowhere greater than one hundred feet.

This rock, for the most part, occurs on the high grounds which still remain entirely uncultivated; where, however, the land has been cleared of the forests, it is unfit for cultivation, but it is equally valuable for the building and underpinning stone which it furnishes, there being few other rocks in that region which are fit for these purposes.

Organic Remains of the Conglomerate and Sandstone.

Fossils are extremely rare in this rock, having been seen in one locality only, and in this the sandstone predominates largely over the conglomerate. Beyond the limits of the State, vegetable fossils are of frequent occurrence, though but a few imperfect fragments have been seen in the Fourth District.

139.

1. Euomphalus depressus. 2 and 3. Cypricardia? rhombea. 4. Cypricardia contracta.

1. *Euomphalus depressus*, n. s.—Depressed-spiral; lower side broadly concave; whorls, about three, round.

This fossil closely resembles the *E. serpens* (PHILLIPS, *Palæozoic Fossils*, pl. 36, fig. 172).

2 and 3. *Cypricardia? rhombea*, n. s.—Sub-rhomboidal; oblique; beak prominent; shell smooth.

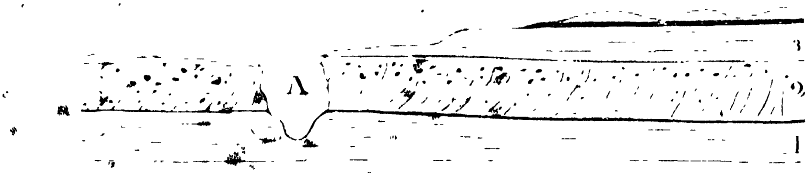
4. *Cypricardia contracta*, n. s. — Oblong, sub-elliptical, very inequilateral; contracted in the middle; surface marked by concentric wrinkles, which are stronger toward the anterior margin.

Locality.—The three species here figured occur at a single locality about four miles north of Panama, Chautauque county.

Along the northern boundary of Pennsylvania, this conglomerate forms the margin and immediately underlying rock of the coal measures. Tracing it westward into Ohio, we find it there holding the same relative position to the rocks of New-York, and to the coal, that has before been shown. The absence of the Old Red sandstone brings it directly in contact with the Chemung group below, over all the western part of New-York, and it holds the same place in Ohio at all localities examined. As before remarked in the last chapter, the intervening strata which separate this rock from the Chemung group are absent, having apparently never been deposited over a very large tract of country. Its outliers in the Fourth District offer less satisfactory sections than the same rock when more continuous.

The following section at Cuyahoga falls, in Ohio, exhibits the relative position of this rock and its associates.

110.



1. Chemung group 2. Conglomerate. 3. Coal measures. A. Channel of the Cuyahoga.

The river bank presents the two lower rocks in connection, and the coal beds with shales and sandstones occupy a slope extending eastward from this point. This is near the western extremity of the coal-field; and when we next meet the conglomerate in a western direction, we find it resting upon a limestone, and its relation to the rocks of New-York is illustrated in woodcut No. 129 on page 280.*

The conglomerate still holds its relations to the coal measures as before, forming the eastern and southern margin or edge of the Great coal-field of Illinois and Indiana, which likewise extends into Kentucky. The same rock forms the western margin of the Ohio coal measures throughout the State, and extends north and eastward, as just mentioned, bordering the Pennsylvania coal-fields; and Prof. Rogers remarks, that it also extends into Maryland and Virginia, holding the same relative position. These facts are of the highest interest, both in an economic and scientific view; for since its extent is so well marked and widely known, it may, in all places, be relied upon as indicating the proximity of coal.

From its relative position to the coal and the lower rocks, I had inferred that it was the equivalent of the Millstone grit of England. The presence of the great limestone formation beneath it at the west, still further sustains this opinion; but since we know perfectly well its relations to our own rocks, both above and below it, its identity to, or difference from, foreign rocks, is of less consequence.

The section, Plate 13, illustrates the relative position of this rock and its associated strata, both as regards the eastern and western coal-fields. The series, throughout the Fourth District, is so little disturbed that there is not the most remote possibility of a coal bed being found in any depression or fault of the strata, and vague surmises and useless explorations for this mineral will doubtless soon cease.

Since it is well ascertained that coal of the true coal formation does not exist within the limits of the State of New-York, it may be well to state here, for the benefit of my readers, the position in which this mineral has been sought. The dark shales and shaly sandstones of the Hudson river group and the Utica slate, are the lowest positions which have been explored for this mineral. Along the Hudson river, as already stated in the annual reports of the First District, there have been immense amounts expended in search of coal. In the Fourth District, the lowest rock in which it has been sought to any extent is the Marcellus shale, and above this the Genesee slate, and various parts of the Portage and Chemung groups, particularly where the slate is black and highly bituminous. Thin seams of coal do sometimes occur in these situations, but they rarely extend beyond a few feet, and are usually less than an inch in thickness.

These seams or strings of coal are not indications of its existence in larger beds; and the lithological character of the strata, though ever so similar to that about coal mines, cannot alone be relied upon. In all situations where coal beds occur, the shales and shaly sandstones contain the remains of land plants, like ferns, often in great abundance; and the absence of these in strata, with the occurrence of certain marine fossils, may be looked upon generally as conclusive evidence of the absence of coal. The organic remains of these strata thus become of the utmost importance in identifying their position; and those forms previously figured as marking rocks below the coal, will always be found in the neighborhood of any excavations made in the rocks of the Fourth District. This negative knowledge of the absence of coal in the State is of the utmost importance; for although it may not enrich the possessor as much as a coal mine, it will still enable him to avoid a useless and wasteful expenditure in search of that mineral.

The reasoning, or rather assumption, with which my arguments and facts are often met, particularly in the southern counties, is, "Why may we not as well have coal in our hills, as they have in Pennsylvania?" "I am sure there must be coal, or some mineral, in these hills, for they are good for nothing else." The reasons why coal does not exist in these hills, is already shown to be because they hold a lower position than any rocks which contain coal in workable seams. That these hills are fit for nothing else, I beg to dissent; for by proper treatment in their cultivation and the use of means within the reach of every farmer, they may be rendered the best kind of grazing land, and produce all other articles required for the support of man. So long as the belief exists that there is mineral wealth in these rocks, so long will the cultivation of the soil be neglected, and consequently the country will remain unproductive, not because the Creator made it so, but because man has proved an unfaithful steward.

In these situations, as well as in all others, there is room enough for rightly directed enterprise; and a knowledge of what does and what does not exist, is of the utmost importance in guiding that spirit which has built up the thriving village, the lofty spires of the city, or spread the widely cultivated farms where the primeval forests but lately held dominion, and which, even to the remotest bounds of civilization, is drawing from the earth treasures richer than the gold mines of the south.

These show to us that our favored country, even in its widest extent, possesses preëminently the means of ameliorating and exalting the condition of mankind, and of promoting the arts of civilization in the highest degree. It is a wise arrangement, that those things which we prize highly should not be placed within our reach at every point, for they would soon cease to be valued. A variety of pursuit and production are necessary to the welfare and improvement of man, and the surface of the earth is so adapted as to compel this diversity of pursuit; and man, whether he will or not, submits to the laws imposed upon this earth and all its created beings. And although in some points man may reason that himself, or his neighbors, or his posterity might be benefited by a different arrangement of what he considers the rich or the desirable things, yet he is to remember that himself and those around him form but a small part — a link in the great chain of community, which is ordered and governed by laws which emanate from the great source of all order and harmony in the universe.

111.

Uplift in the strata two miles above Eighteen-mile creek.

CHAPTER VIII.

Uplifts, Dislocations and Undulations of the Strata in the Fourth District.

Situated as the western part of New-York is, mostly remote from any known rocks of igneous or hypogene origin, there are, as we should naturally infer, but few of those disturbances which manifest themselves along the margin of mountain ranges, or the vicinity of intruded rocks. Those which do present themselves are of little comparative importance, except as illustrating the extent of this force, which, in other places, has produced phenomena of the most stupendous kind.

The existence of trap dykes upon the immediate borders of the district, show that the dynamics of igneous agency have not entirely slumbered. The undulations which extend, like immense waves, over the whole breadth of the district, show also the influence of some subterranean agency which converted the rocks into a billowy sea.

The manifestations of local disturbance, whether from deep seated causes or from some local operation, are confined to a few slight upliftings or dislocations of the strata; sometimes an abrupt flexure marks the point of the application of force, where the strata have not been broken. The figure at the head of the chapter represents a slight uplift of the strata at the upper part of the Hamilton group. The thin mass, which is the encrinal limestone below the Moscow shale, together with this rock, is abruptly elevated about four feet. The limestone has been broken suddenly off, while the shale, though less sharply broken, is, nevertheless, plainly fractured, and the small fragments in the joint are crushed and partially ground to clay. The amount of lateral motion may have been greater than appears; for an oblique fissure, extending from the vertical one to the left, was found to have the surfaces striated. Such a phenomenon could scarcely have resulted, unless from the moving of one surface over the other, by a lateral force.

Beyond this point, in a southwest direction, the dip continues as uniform and gentle as on the northeast.

Several other points along the lake present similar appearances. The following occurs a few miles northeast of the Pennsylvania line, in rocks of the Portage group.

142.

Elevation and fracture of the strata. Ripley, Chautauque county.

The strata are mostly shales, or shaly sandstones, with a single thick bed of sandstone, which is broken at numerous points along the curve. The irregular fracture is strongly stained by decomposing pyrites; and there seems to have been injected mud, which has forced its way into all the fissures and between the shaly laminæ, for several inches, and often for several feet. The laminæ of slate and shaly sandstone are broken, and stand in the fracture at various angles, from nearly horizontal to vertical.

The fracturing of the strata has rendered the mass much more destructible, and the waves have worn a deep, cavernous depression, which recedes fifteen or twenty feet beyond the general line of the cliff. Many of the indentations along the shore are produced in this manner, their commencement being the fracture in the strata. I have seen several where the amount of excavation is much greater than in this, but much of the same character.

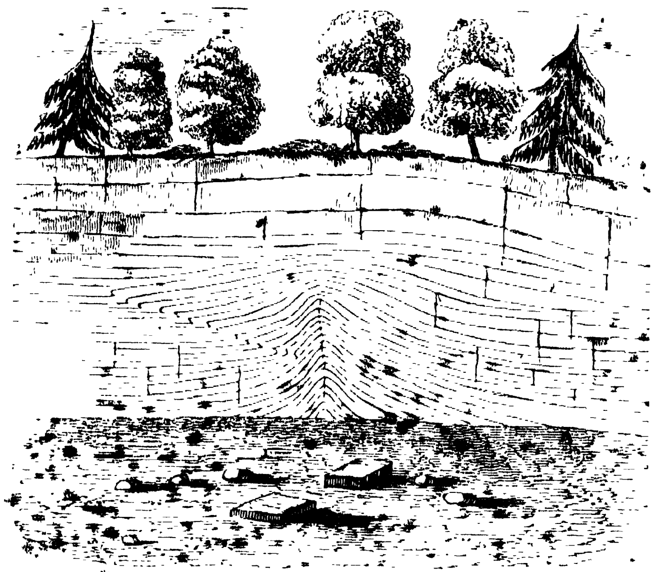
In other parts of the district these uplifts have produced lines, which, being more easily excavated, have become the channels of streams. Many beds of streams present this appearance, but in most cases I have been inclined to refer the apparent phenomena to very partial uplifting of the strata by ice. Very many instances are doubtless due to this latter cause, but there are others which cannot be referred to such an influence. The following is a section of the south branch of the Cattaraugus, with an elevation of the strata upon either side.

118.

The disturbance is here so great, that it seems due to some more powerful agency than the freezing of water. Still, however, so many points present similar appearances, which are evidently due to the latter cause, that it is not easy to decide.

This effect of uplifting is sometimes manifested only along the line of fracture; the strata, on either side, manifesting the same line of dip as if it had not occurred. The following illustration is from a cliff on the south branch of the Cattaraugus, one and a half miles above Little's mill. The strata on either side of the line of fracture are apparently as undisturbed as if it had not happened.

141.



There is an oblique line of fracture, as represented, ascending to the left; and this is a common circumstance attending nearly all these fractures or dislocations. It will be perceived that the amount of dislocation is never so great as to produce any evidence upon the surface; and these localities are only interesting as showing the influence of causes which, at other points, have wrought such mighty changes. In every instance which I have observed, the direction of this force is at right angles to the line of dip, or in the direction of the outcropping edges of the strata. It is in the same direction mainly that the great undulations extend, and both are probably due to the influence of the same agency.

Besides these fractures and dislocations, others appear to have a local origin, such as the downheaves along the line of dip in the limestones. In tracing the limestone southward in Seneca county, we find its dip often greater than the average of the strata in other places; and after its disappearance, we again find the same layers rising to the surface still farther south. Although the soil covers the surface, and the absolute fracture is not seen, yet it doubtless exists, and is probably due to the falling down of the layers on the north, from the removal of the soft marls of the Salt group below.*

The same layers appear at the successive points 1, 2, 3, or at least they are so precisely similar that there is no possibility of distinguishing them; and we farther know, that if the thickness of the rock is estimated from adding all these successive outcrops, it would be greatly increased over the same in other places.

* See illustration, page 163.

115.

View of the Cliffs on Fall creek. From a sketch by Mr. E. N. Horsford.

CHAPTER IX.

Jointed Structure of the Rocks of the Fourth District.

In addition to the slaty cleavages which separate the rocks of the Fourth District into laminæ parallel to the planes of deposition, and those lines of separation which divide the siliceous and calcareous masses into thicker blocks, we have another series of divisional planes, for the most part vertical to the line of deposition, and often penetrating to great depths, as seen in high cliffs and river banks. These lines of division have two directions, crossing each other, generally, in slightly oblique angles; though there are cases where the direction is nearly rectangular, as in the conglomerate, which is divided into huge blocks, often separated several feet from each other.

Where these joints are numerous, they divide the rock into blocks of convenient size for quarrying, with vertical faces of great regularity; and where the blocks are too large, they are readily split in a direction parallel to the natural faces. These vertical divisions are of immense importance in quarrying, particularly in the limestones. I have seen quarries wrought to the depth of twenty or thirty feet, and for several rods in length, the back formed by a single plane, or by the salient and reentering angles of the lines of these joints. Owing to this circumstance, a great amount of labor and expense is saved over what would be necessary if the whole length and depth was to be wrought down by blasting.

In cases of slight disturbances or upliftings of the strata, as there have been in some places, the slaty cleavage seems more perfect, and the joints more numerous as well as better defined.

116

Section on Twenty-mile creek.

In this instance, from some cause or other, the joints are exceedingly abundant; and they are not all vertical, but cross diagonally from one to another; neither are the planes all parallel in their horizontal direction, frequently meeting, so that the block between them wedges out at a very acute angle.

The same formation of rock has, in one place, a more perfect jointed structure than in another, though there has been no perceptible influence exerted. Still, however, it may be due to similar causes, and only at a greater distance from the centre of influence.

These joints, though usually perpendicular to the planes of deposition, or slaty cleavage, (which are coincident,) are not invariably so; they are sometimes oblique to this direction, and even curved, leaving a spheroidal surface upon the mass below as the upper becomes removed.

Notwithstanding that joints are far more numerous in the vicinity of slight uplifts, still I would not infer from this fact that they are due to the same cause. The manifestations of disturbing influences at such points may be owing, as suggested by Prof. Phillips, to their presenting less resistance than others; and for this reason, though the force were applied equally under the whole area, that point where joints were most numerous would yield first.

It becomes a subject of interesting inquiry, why certain slaty masses are destitute of this symmetrical division, while others of the same age possess it in a high degree; for so far as external appearances are concerned, they are as susceptible of such effects as those where this structure is perfectly developed. Several modes of explanation offer themselves to account for these phenomena; but future observations are required, before any satisfactory hypothesis can be advanced.

From all the facts observed, there seems reason to believe that these joints are due to galvanic or magnetic agency which has pervaded all the strata; but that certain subterranean influences, operating at certain periods or under certain circumstances, may affect this condition. Where such an agency has acted more powerfully over a limited area, it may have produced a greater development of this symmetrical structure. The fact that these joints for the most part follow a uniform direction, points to some universal law like galvanism, or pervading heat, as the primary cause of their production. The uniform direction of metallic veins is not more persistent than is the direction of these joints; and if we refer the cause of the former to galvanic agency, why should we not refer the latter to some influence equally universal?

The tendency of our ordinary clays to separate into laminæ parallel to the lines of deposition, and also by vertical planes into rhombic masses, indicates the same structure, and the operation of the same laws as those producing more extended effects upon our slate rocks.

The shores of our lakes, the banks of rivers, and the high cliffs bordering the ravines of the southern counties of the district, present these joints in great perfection. The whole effect produced by them, the sliding down, the undermining and destructive action of the weather, is picturesque in the highest degree. In some places, their great number and regularity suggests the idea that they may have been produced by causes not unlike the symmetrical divisions in the trap and basaltic rocks. This effect, though not as regular as the latter, is often nevertheless constant in certain rocks, and as equally governed by certain laws, and we may not unaptly term it *mountain crystallization;* yet, although we cannot prove that the ordinary laws of crystallization have had the slightest influence, so neither can we in the columnar basalts. In these we find the direction of the columns at right angles to the cooling surface; and in the jointed structure, we find, with few exceptions, that the direction is at right angles to the plane of deposition.*

From the smoothly vertical faces of these joints where the rock is of a uniform composition, we are compelled to ascribe the cause to something beyond that which contraction on desiccation would produce; indeed, from analogous cases, this latter kind of structure is not produced in right lines, but in variously curved and undulating directions. Another objection to this latter view is presented in the fact that some of the most argillaceous masses, or those which on desiccation would contract most, are nevertheless almost or entirely free from these symmetrical divisions. Limestone, on the other hand, which in many cases we must suppose was

* Sandstone in conjunction with trap, often becomes columnar for a distance from its point of junction with the trap, and I have seen fragments of furnace hearthstones, which had become columnar in like manner. In these cases, we cannot doubt that this columnar arrangement has resulted from the action of the heat upon the sandstone. The jointed structure is often very analogous to this, and in the vicinity of slight upliftings of the strata, the joints cross each other so closely as to give the mass, where partially broken or removed, a columnar appearance. Granite or gneiss often takes upon itself this columnar aspect so perfectly, that at a little distance it might be mistaken for columnar basalt.

produced by corals, and often much crystallized, being in a condition to exhibit less of these divisions on desiccation, is nevertheless always strongly characterized by a jointed structure. Slates, also, where the laminar structure is well defined, have always this jointed structure in great perfection; while in those where the slaty cleavage is not observed, the joints are likewise very obscure, or but imperfectly developed. Although there may be no sufficient reasons to induce the belief that one is dependent upon the other, still, in rocks of similar composition, where one is absent, the other is likewise.

In many instances we find a fossil perfectly divided by a joint, the respective portions remaining on either side of the fissure. Numerous instances of this kind may be seen in the plane of a single joint in the fossiliferous portions of the Chemung group. Had these joints been due to any thing like the cracks in ordinary clays, or those produced during desiccation, it is hardly possible that these fossils would have been divided in this regular manner.

This structure is fully illustrated by the following woodcuts and descriptions. These sketches could have been greatly multiplied, but these only have been selected from a numerous collection, particularly in the higher rocks.

Jointed Structure of the Limestones.

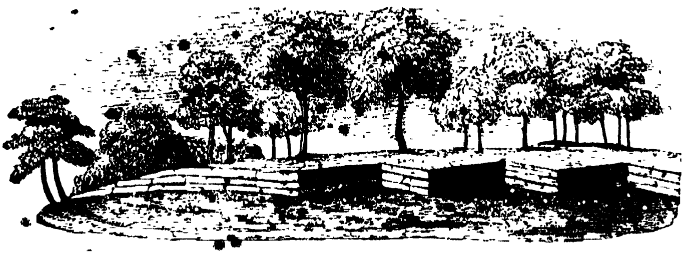
The direction of these joints in the limestone is for the most part very uniform; still, however, there are exceptions. Where the rock is exposed upon the surface, these lines of joints are very manifest, and from weathering, often present wide fissures; these, in favorable situations, become so much worn beneath the surface as to be cavernous. They influence the thin soil upon the surface by draining the water into the fissures of the rock, often leaving the surface dry.

In the lower part of the Niagara limestone these are prominent characters, and in the quarries near Lockport, are of the greatest importance in facilitating the removal of the stone. The central portion of the mass, which is concretionary and irregularly bedded, does not present the well-defined joints of the lower part; indeed, in some places they appear to be nearly or entirely wanting. Again in the upper part, which is thinly bedded, though curved and apparently contorted, the joints are strongly defined, and together with the thinly bedded structure, enable the workmen to quarry the rock without the aid of blasting. The sketch on page 94 is a natural face of the rock in the direction of a joint.

In the limestones of the Helderberg division, this structure is more strongly manifested than in the Niagara limestone. The joints on the surface often appear as broad fissures, leading to caverns below, and the sinkholes observed are produced by the widening of these fissures.

Where this rock is wrought for quarry stone, the same structure is strongly manifested, the lines of division often penetrating the entire rock. The woodcut below is an illustration of a quarry worked on the line of outcrop, and shows the facility offered in removing the rock.

147.



Limestone quarry near Waterloo.

In the impure limestones of the Salt group, these joints are often manifested in some degree of perfection, but they are more usually closed, and evident on the surface only from weathering. They are much more numerous than in the purer calcareous rocks, and separate the layers into small blocks.

Jointed Structure of the Shales and Sandstones.

In the incoherent strata of soft shales, like the Niagara shale and those of the Onondaga salt group, as well as in some of the softer shales of the higher groups, the jointed structure is but very imperfectly developed. In the softer portions of the salt group, this structure is scarcely more developed than in the recent clays; and almost the same may be said of the soft red marl and shale of the Medina sandstone, and the shale of the Niagara group. In some parts of the Hamilton group, and in the Cashaqua shale of the Portage group, joints are often scarcely perceptible. In the impure and less compact sandstones, the joints are imperfectly developed; but in the purer and more compact strata of this nature, they are very perfect. In all parts of the higher groups, however, the joints are very perfectly developed, and very clearly and exactly defined. In the slaty shales, where they have been freshly exposed, the surfaces are scarcely separated, and of the most perfect smoothness and regularity. The surfaces are usually plane, but sometimes they are curved, as in the following woodcuts:

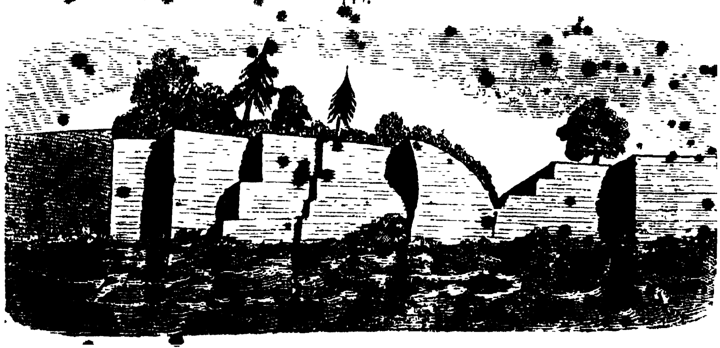
118.

Fig. 1, is a sketch from the western shore of Seneca lake, near Big-stream point.
Fig. 2, is a sketch from the bank of the creek above Lodi falls, near Wyckoff's mill.
a, a, a, are uniform planes of perfect smoothness.
b, b, are curved surfaces, having a general vertical direction, and of equal smoothness with the others.

Sometimes the interstratified impure sandstones interrupt the joint, and the lines above and below do not coincide. In the greater number of instances, however, these thin strata offer no impediment to the passage of the joint, and the whole mass is divided into huge blocks or prisms. This structure, particularly along the lake shores, presents some of the most picturesque scenery, resembling the gigantic ruins of Cyclopean architecture, crowned in its decay by trees, shrubs and festoons of moss and vines.

The following sketch is from a beautiful example of this kind, on the shore of Cayuga lake, near Ogden's ferry.

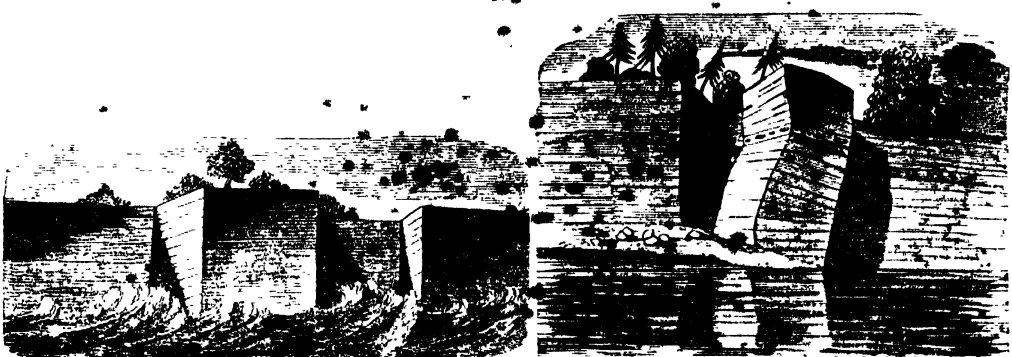
119.



Jointed structure of the cliffs on Cayuga lake.

The cliffs are divided by vertical and curving joints, separating a long line into blocks of ten to twenty feet long and broad. The action of the water is constantly widening these joints, and undermining the masses. These fall down, one after the other, and their fragments are dispersed by the waters; sometimes a single one of a whole range is left standing alone, with a long interval between it and any other, as in the illustration below (fig. 1). In fig. 2, the high block is isolated from the cliff behind it, and from the range to which it belongs on the left. Its relations to the adjoining cliff may be seen by the range of concretions which are thickly dispersed through a certain stratum. Some of these concretions are divided by the joint as regularly as if sawn asunder; in other instances they project from the mass, having been unaffected by this divisional structure.

150.



1 2

The process by which these masses are destroyed, by the undermining action of the waves below and the weathering from above, is illustrated in the following woodcut:

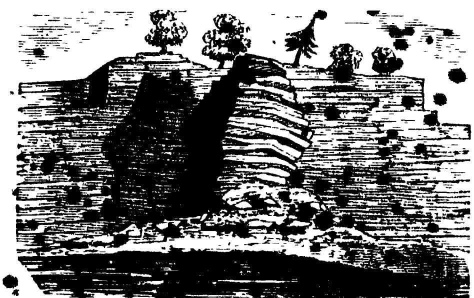
151.

The strata are composed of alternating hard and soft materials, which unequally resist the influence of water and air. After a time the wearing action of the water below is so great that the base becomes too narrow to sustain the mass above, and it usually falls over on the seaward side, when it is soon dashed in pieces, and is removed by the waves.

The "Chimney rock," below Jefferson, about two miles from the head of Seneca lake, is another example of this kind. A single block, originally one of a range separated by vertical planes, remains standing against the cliff, like a huge chimney upon the outside of a wall, to which it bears a fancied resemblance.

The following is a sketch of this place:

152.



Where the water finds its way entirely around, the mass wears down much sooner than where one side continues attached to the main cliff. In some instances these blocks stand out along the line of the cliff in bold relief; and, from long weathering and wearing by the waves, have become rounded in outline, and the point of their attachment is constantly narrowed, until finally a separation takes place. The projecting edge overhangs the lake by several feet, and the water is so soon drained off through the smaller fissures that the larger trees near the edge die.

1[illegible]

In many places, it is evident that there has been but little change during long periods; for large trees are found growing in the fissures, and others upon the separated blocks, extending their roots down the sides of these and into the soil below. Such appearances are observable in the banks of deep ravines, where there is conclusive evidence that large streams of water have flowed at some former period.

Jointed Structure of the Conglomerate.

This structure in the conglomerate usually divides the blocks into more rectangular forms than the rocks below. In the outliers of this rock which appear in the southern counties, the whole mass often appears in isolated blocks, as can be seen in the illustration under the description of that rock. The following sketch also illustrates the same. In the corner of the block, on the left, it will be seen that a portion has been removed by the intersection of two planes, which did not extend entirely to the surface.

154.

CHAPTER X.

Mineral and Gas Springs rising from the Rocks of the New-York System in the Fourth District.

The general phenomena of springs have been noticed under each rock or group, where there existed any circumstances to modify their production, or otherwise affect their frequency or copiousness. The origin of all the springs of pure water, or that of ordinary purity, is simple and readily understood; in other instances, there seems more obscurity attendant upon them.

In this district the only mineral springs of interest are the salines, the sulphur springs, the inflammable gas springs, and the springs of Canoga, yielding nitrog

1. Nitrogen Springs.

The only springs in the district which are known to yield nitrogen, are at Canoga in Seneca county. One only is very copious, and, therefore, the only one usually noticed. It is situated at the base of a gentle slope, and near the southern termination of the Corniferous limestone. The basin is not over six feet in diameter, but the water rises, in less quantity, over a space of twenty feet. The sand and gravel are kept in continual agitation, rising in little cones, and again falling away and appearing at another point. The water, in its ascent, is accompanied by nitrogen gas, which rises to the surface in large quantities. The force of the water and the escape of the gas give the spring the appearance of a boiling vat. The water is perfectly limpid, and leaves no sediment of any kind; it first spreads over a bottom of gravel and boulders, from which the finer parts have been removed for several rods, and then flows quietly through a narrow channel towards the lake. The outlet of this spring is joined by a similar smaller one, which flows in from the northeast. There are also several points in a swamp near this, where the same gas issues.

These springs have all the characters, except temperature, of the thermal springs along the eastern border of the State, the gas from which is known to be chiefly nitrogen. The springs of Canoga, with several in Franklin county, N. Y., are the only ones I have seen yielding nitrogen, which were not above the ordinary temperature of the place. The temperature of these springs is about 10°, Fahrenheit's scale.

From the facts before noticed, under the description of Corniferous limestone, there is scarcely a doubt but these springs have their origin along a line of fault or fracture in the strata. Those on the eastern side of the Cayuga lake at Springport have, probably, the same origin; and it is interesting to observe that those in the eastern part of New-York are in similar situations, but much nearer to strata of igneous or hypogene origin. I am also informed by Mr. Vanuxem, that many which he has examined in Virginia, and at the south, are in similar situations.* Those of Chateaugay are near the junction of the granite and Potsdam sandstone, and in the Calciferous sandrock.

2. Springs evolving Carburetted Hydrogen and Petroleum (*Burning Springs*).

Springs of this character are numerous in the Fourth District. Sometimes the gas alone is the only product; and in others it is accompanied by petroleum, or liquid bitumen, which spreads over the surface of the water, and can be collected in considerable quantities. These are the "*burning springs*," which in our younger days were such a marvel as a part of geographical knowledge.

These springs are chiefly confined to the higher rocks, though there are a few places where they occur in the lower beds. The lowest situation in the Fourth District is at Gasport in Niagara county: this has already been noticed in the description of the Medina sandstone.

Along the outlet of Crooked lake, there are several places where this gas is seen to rise from the canal, and streams of water. The principal point is where there is an undulation in the strata.

A mile south of the village of Rushville, in Yates county, there are one or two springs which emit a considerable quantity of this gas; and when ignited, it continues to burn as it rises to the surface of the water. It was formerly conducted to a house near by, and used for lighting and warming the apartments. It is a popular belief, that wherever this gas rises, coal exists beneath the surface; and accordingly an excavation was commenced at this place, which of course resulted in disappointment. The geological situation is in shales of the Portage group.

In the town of Bristol, Ontario county, there are several springs from which this gas issues. The quantity is often large, and might be turned to some economical purpose.

The "*Oil Spring*," as it is termed, is situated on the dividing line of Allegany and Cattaraugus counties. "It is a dirty circular pool, about eighteen feet in diameter, filled nearly to its margin with foul water, having, at the time we saw it, a small quantity of petroleum in clots floating upon its surface."†

This description of the famed oil spring corresponds with its appearance when subsequently visited. There was a small quantity of the gas issuing at intervals through the viscid film

* Prof. W. B. Rogers has since published an elaborate paper on the "Connection of Thermal Springs in Virginia with Axes and Faults." (Transactions of the Association of American Geologists and Naturalists.)

† Vanuxem, Annual Report of 1837.

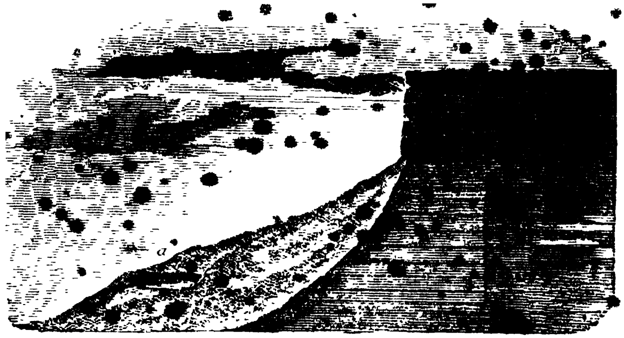
which covered its surface. About half a pint of the petroleum, or *Seneça oil*, was collected.

This spring is at the base of a hill on the Reservation, of one mile square, belonging to the Cattaraugus Indians, who reside on the Allegany river.

There are several other places in the county of less importance, where both petroleum and carburetted hydrogen gas are evolved from springs. The rocks, in nearly all localities, emit a bituminous odor on percussion, and the fluid bitumen often exudes from pores or cavities.

In Cattaraugus county, carburetted hydrogen gas issues from the springs and running streams in numerous places. In the town of Freedom, there is an oil spring similar in many respects to that of Cuba in Allegany county. The spring is situated on a slope below the outcropping edge of a highly bituminous sandstone, which rests on an impervious shale, as seen in the woodcut.

155.



a. The position of the spring.

The origin of this spring is doubtless from the bituminous matter which is carried down by the water as it percolates through the interstices of the sandstone. Several excavations have been made near this spring for coal; and in one of these, after breaking through a hard stratum in the shale, a large quantity of the petroleum, mixed with water, rushed up, entirely filling the cavity. The quantity was so great, that for a long time several gallons were daily collected.

In Chautauque county, a larger quantity of the gas issues from springs, streams and pools, than elsewhere in the district. In many instances the gas is accompanied by petroleum, which forms a thin pellicle upon the surface of the water; in other places the gas rises alone, and sometimes the petroleum occurs where there is no visible evolution of the gas.

Near Forrestville, there is a copious emission of this gas, and it has been in contemplation to convey it to the village, for the purpose of lighting the houses and stores. At Laona there is a stratum of highly bituminous sandstone, and the water, rising to the surface, is accompanied by petroleum and gas. The sandstone appears to be charged with this fluid: it issues from the pores on fresh fracture; and specimens, after remaining for two years in the cabinet, still emit a strong bituminous odor.

The village of Fredonia is lighted with this gas, which issues from fissures in the shale forming the bed of the stream at this place. During the day, it is collected in a reservoir, and furnishes sufficient for purposes required.

At Portland harbor, the Light-house is illuminated with this gas, supplied from the margin of a small stream on the lake shore, half a mile northeast of the harbor. The quantity at this place is so great that no reservoir is required; and I was informed, that during the night, as much passed off by the "escape pipe" as was consumed.

Large quantities of this gas issue from the waters of the lake near the shore, for three miles northeast of Portland harbor, and in numerous other places farther north and east. At Buffington's well,* it is constantly rising from the lake near the shore, apparently sufficient in the space of a few rods to illuminate a city. This product will doubtless be turned to important account when the population shall increase, and villages be formed in the vicinity. It could even at the present time be used in the village of Portland harbor, and with small expense conducted to Westfield. The only requisite expense will be the fixtures for collecting and purifying: the supply is constant, and probably inexhaustible.

This gas doubtless issues from the earth in equal quantities in other places, but they cannot be readily detected except on the presence of water. Along the sheltered banks of the lake, the odor of the gas is constantly perceptible for miles, and its presence is thus manifest when the water is too rough to render its escape perceptible.

Numerous other localities of minor importance might be noticed, but the foregoing are sufficient, as its existence and uses are well known.

3. Sulphuretted Hydrogen Springs.

These springs are numerous, and occur in almost every rock in the district; but those which are copious in water, and highly charged with gas, are confined to few situations. The most important springs are those issuing from the rocks of the upper part of the Onondaga salt group; these being almost the only ones resorted to for the medicinal properties of their waters. They contain, besides the gas, carbonate and sulphate of lime, which are deposited upon the stones and twigs over which the water flows. At some there is a considerable formation of calcareous tufa, often covered with a yellow coating, which apparently consists of sulphur and sulphate of lime. The water is usually perfectly limpid, though sometimes it has a whitish or chalky appearance when first flowing from the spring.

Springs of this nature which issue from different rocks, have an aspect and general character which indicate their relative geological positions. In the shales of the Niagara group, the water has usually a dark appearance in the spring, though limpid, and differs essentially from those of the Salt group; while those in the higher rocks are not only less copious, but are

* This is a deep boring (642 feet), made in search of salt water, on the supposition that if the level of tide water was reached, the salt water would be found. This is not the only similar *ignis fatuus* which has been followed in searching for coal, salt water and the precious metals; neither have these visionary projects ended at the present time.

often marked by a black and red deposit, as well as sometimes a whitish stain upon the rock or in the bottom of the spring. The flow of water is feeble, and it is less strongly impregnated with gas.

Such being the fact in relation to these springs, we are to look for some general cause why those in the Onondaga salt group are so much more copious, and strongly charged with gas, than any others. Since also there is no general line of disturbance or uplifting along the outcropping edge of this group, we cannot attribute their origin to any source below the rock itself; for if so, they would as probably be in other situations a little farther north or south; but as the facts stand, it is upon the very margin of this formation where they occur. The jointed and fissured limestone above affords a passage for the water from the surface, which falls down upon the impure argillaceous limestones beneath, and passes through these to an impervious stratum, when it rises to the surface.

Now all we have to account for, is the source of the gas, and by what process the water becomes thus charged? The rock contains iron pyrites, often very intimately blended; and on burning in the kiln, a large quantity of pure sulphur sublimes, and lodges upon the stones about the top. It is impossible, perhaps, to say that this is in a pure state in the rock; but may it not probably be in some other combination than with iron, and one which may be more readily decomposed by water and atmospheric agents? Since sulphur is known to be diffused through this rock, either in a free or combined state, it is very rational to suppose that it enters into combination with the hydrogen of the water, and thus produces the phenomena of gas springs.

The decomposition of sulphuret of iron, in moderately damp situations, gives origin to sulphate of iron; but this could not exist in the water of these springs, though there is usually present some other sulphates, as the sulphate of lime or of magnesia. In the higher shales, which all contain iron pyrites, we find the decomposition leaving an iron stain, and often sulphate of iron, almost always sulphate of alumina, and always sulphate of lime, which forms in small crystals upon the slaty laminæ. These products are the results of the decomposition of iron pyrites, in districts and situations where they are exposed to the weathering influences, but where there is not sufficient water to form springs. They do not differ, so far as they go, from those of sulphuretted hydrogen springs. I have made no detailed examination, but there is little doubt but an analysis of these dry efflorescences would prove them to contain all the products of sulphur springs, or at least to bear an equal comparison to the products of one spring with another. During rains, the odor of this gas is perceived from the situations where these dry efflorescences appear, though not at other times.

On the Niagara river, a short distance above Lewiston, there is a copious spring issuing from the cliff, highly charged with sulphuretted hydrogen gas, and the water impregnated with sulphate of magnesia; and judging from some incrustations upon the stone, it contains both the sulphate and carbonate of lime. Now this spring has its origin in a highly magnesian limestone, which is also charged with iron pyrites. In sheltered situations under the cliff, this rock is rapidly decomposed, and produces sulphate of magnesia, with a little sulphate of iron and carbonate and sulphate of lime. These substances can be obtained to the amount of several pounds in the space of a few feet. The decomposition of this rock, beyond ordinary exposure, from the percolation of water from above, will produce precisely the materials with which the spring is charged; and there can remain no reasonable doubt of this being their origin generally, or even universally in the Fourth District.

The quantity of this gas is not surprising, when we reflect that a single ounce of the bi-sulphuret of iron, if decomposed and its sulphur united with hydrogen, will produce more than two hundred cubic inches of the gas. This is a large amount of this noxious vapor from so small a quantity of the material; the decomposition of a few pounds of pyrites will be sufficient to supply an ordinary sulphur spring for several months; and in the more copious springs, it must be recollected that there are large surfaces exposed to the action of air and water.

The increased temperature noticed in all these springs may be due to chemical decomposition and recomposition, so that more caloric is evolved from the solids formed than is required for the production of the gas. Their great uniformity of temperature in widely different positions, would indicate the cause to be in chemical action, rather than to proceed from any deep-seated and general source, as we may suppose is the case with the thermal springs which evolve only nitrogen.

The same views will apply to those springs evolving carburetted hydrogen; the most copious being in the highly bituminous shales of the Portage and Chemung groups, while it is produced in smaller quantities from the lower rocks. Its origin is thus satisfactorily proved, and we have the same evidences regarding the production of the hydrosulphuretted springs. In the same rocks in the eastern part of the State, which at the west give origin to the carburetted hydrogen and petroleum, that substance is not manifest, and there are no springs of the kind. Again, the rocks most productive of the hydrosulphuretted springs are equally charged with sulphuret of iron in the eastern part of the State, and give origin to as copious and strongly charged waters as at the west.

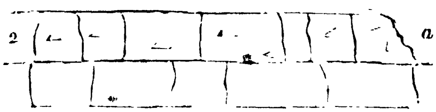
It is true that in some places carburetted hydrogen is very abundant at points where there has been a slight disturbance or uplifting of the strata; but it appears to be in consequence of finding more rapid egress through the numerous joints, rather than in any manner to depend on such fracture for its origin; and in many of the most copious ones, no such marks of disturbance are visible.

On September 1st, 1841, the temperature of the Avon springs was 50° Fahrenheit; the lower one a fraction less. The upper spring discharges about eight or ten gallons per minute; the lower one, fifty-four gallons per minute.

The temperature of the several springs at Manchester, which are the most copious of any in the district, and from which a larger quantity of gas is evolved than in any other, is 50° and 51° of Fahrenheit's scale. The quantity of water is much greater than at Avon.

The situation of the Avon springs is illustrated by the following woodcut:

156.



1. Limestone of the Onondaga salt group.
2. Onondaga and Corniferous limestones.
3 Marcellus shale.

a. Upper spring.
b. Lower spring.

The upper spring rises near the junction of the Onondaga salt group and the Corniferous limestone. The source, however, is much deeper, as it can be penetrated with a rod to the depth of fifteen feet or more. The lower spring rises from the same strata, at a lower position. There are also in the same neighborhood, at about the same level as the lower spring, several others in which the water is strongly impregnated with gas.

The position of the springs at Manchester, in Ontario county, is precisely similar.

1. Limestone of the Onondaga salt group.
2 Onondaga and Corniferous limestones.
3. Marcellus shale.

a. Point at which the springs issue.

The shale above the limestone does not approach within a mile or more of the edge of that rock; and it can scarcely be supposed to give origin, by the decomposition of its iron pyrites, to the gas which rises from the rock below.*

4. Salines, or Brine Springs.

The principal brine springs of the Fourth District have been noticed under the head of Medina sandstone and the Onondaga salt group. The first have their origin in the red shales and marls of the Medina sandstone, extending throughout the whole length of the district, and likewise known in Canada in the same rock. In the early settlement of the country, salt was manufactured from these springs; but its quality was often inferior, and highly colored from the red marl. The brine is also very impure, from the presence of the chlorides of calcium and magnesium.

Since the supply of brine in Onondaga county is so much more copious, and the facility of manufacturing and transporting the salt so much increased, all these springs in the Medina

* The large proportion of iron pyrites in the Marcellus shale, has been supposed by some to give origin to this gas.

sandstone have fallen into disuse, though very recently there seems some prospect of the manufacture being renewed. The situations, in most instances, are unfavorable to large accumulations of water upon the surface, and boring has not been attended with the most satisfactory results. So long as salt can be manufactured at the present prices, there is little probability that these springs will be of any importance.

There are several unimportant brine springs in the higher rocks. The most remarkable of these is at York in Livingston county, which, for some time after its discovery, yielded a large supply of water, but which has diminished since that time. Prof. Dewey informs me that the the water gives evidence of a large proportion of iodine, on the application of the usual tests.

The only brine spring of importance in the Onondaga salt group, is in Elba, Genesee county, and has already been described.

CATALOGUE *of the principal Mineral Springs in the Fourth District, with their geological position* [illegible] *ducts.*

Kind of spring	Geological position	Gas evolved	Contained mineral substances	County	Particular locality.
Brine......	Marls of the Medina sandstone,	A few bubbles of carb. hydrogen,	Chloride of sodium,	Monroe ...	Penfield, 1 mile from Lake Ontario, on the land of Ola Greig
Brine......	Medina sandstone ..	....	....	Monroe....	Near the head of Irondequoit bay
Brine......	Medina sandstone ..	....	....	Monroe....	Town of Greece, 9 miles N.W. of Rochester.
Brine......	Medina sandstone...	....	....	Monroe....	Three springs, on the banks of Salmon creek, town of Clarkson
Brine......	Medina sandstone...	....	....	Monroe ...	Town of Clarkson, 6 miles north of the preceding, on land of Mr Baxter
Brine......	Medina sandstone...	Carbonic acid	Chlor. of sodium, &c	Wayne	Near the head of Little Sodus bay.
Brine	Onondaga salt group	....	Chloride of sodium	Wayne	Two miles east of Lockville
Brine......	Marls of Onondaga salt group,	Carbonic acid	Chlor. of sod., cal mag., sulph. and carb. lime,	Wayne	Town of Galen, Old Galen salt spring.
Brine......	Marls of Onondaga salt group,	Carburetted hydrogen and carbonic acid,	Chloride of sodium,	Wayne ...	Village of Clyde, boring to the depth of 200 feet.
Brine......	Marls of Onondaga salt group,	Carburetted hydrogen,	Chlor of sodium, &c	Wayne	Two miles east of Clyde.
Brine......	Medina sandstone...	....	Chlor. of sod., magnesium and iron,	Wayne	Banks of creek north of Wolcott furnace.
Brine......	Medina sandstone ..	....	Chloride of sodium,	Orleans ...	Fairhaven, in the town of Gaines
Brine.	Medina sandstone...	....	Chloride of sodium	Orleans	Town of Kendall, lot 137. Salt was formerly made at this spring
Brine......	Medina sandstone ..	....	Ditto	Orleans	Near Scofield's mill, on Johnson's creek, in the town of Yates.
Brine......	Medina sandstone...	....	Ditto	Orleans ...	Town of Murray near Sandy creek. Two other similar springs in the same town
Brine......	Medina sandstone...	....	Ditto	Orleans ...	Medina, Oak orchard creek.
Brine......	Medina sandstone ..	....	Ditto	Niagara....	Three miles north of Lockport.
Brine......	Medina sandstone .	....	Ditto	Niagara....	Several on Eighteen-mile creek
Brine......	Medina sandstone...	....	Ditto	Niagara....	Several on Johnson's and Golden hill creeks.
Brine......	Shale of Hamilton group,	....	Ditto	Livingston ..	York, near Hall's saw mill.
Brine......	Portage group	....	Ditto and iron .	Steuben ...	Near the village of Jefferson
Brine......	Onondaga salt group,	....	Ditto	Genesee ...	Town of Elba, eight miles N W. of Batavia.
Brine......	Onondaga salt group,	....	Ditto	Genesee ...	Town of Elba, land of John G Satterlee.
Brine......	Chemung group....	....	Ditto	Cattaraugus	Near Rutledge, several unimportant ones.
Brine.	Chemung group.....	Inflammable gas	Ditto	Steuben	La Grange, land of Mr Davis.
Chalybeate..	Medina sandstone...	....	....	Niagara.....	Two miles north of Lewiston, on land of Capt. Leonard.
Chalybeate..	Portage group	....	....	Steuben	Near Jefferson, head of Seneca lake.
Chalybeate..	Onondaga salt group	....	....	Erie........	Williamsville, land of Mr. Youngs.
Sulphureous,	Portage group	Sulphuretted hydrogen	....	Cattaraugus .	Town of Randolph
Sulphureous,	Portage group	Sulphuretted hydrogen	Sulphate of lime..	Cattaraugus	Several on the banks of Cattaraugus creek

(CATALOGUE CONCLUDED.)

Kind of spring.	Geological position.	Gas evolved.	Contained mineral substances.	County.	Particular locality.
Sulphureous,	Portage group	Sulphuretted hydrogen	Sulphate of lime	Chautauque	One mile east of Van Buren harbor.
Sulphureous,	Portage group	Sulphuretted hydrogen	Ditto	Chautauque	Near the village of Laona.
Sulphureous,	Portage group	Ditto	Ditto	Chautauque	Several in and near the village of Fredonia.
Sulphureous,	Onondaga salt group,	Ditto		Erie	Grand island.
Sulphureous,	Hamilton group	Ditto		Erie	Several on the Indian reservation east of Buffalo.
Sulphureous,	Onondaga salt group,	Ditto		Erie	Several in the towns of Amherst and Clarence, below the limestone terrace.
Sulphureous,	Onondaga salt group,	Ditto		Genesee	Several in Byron and Bergen.
Sulphureous,	Onondaga salt group upper part,	Ditto		Livingston	Caledonia village.
Sulphureous,	Onondaga salt group	Ditto	Sulphate of lime, magnesia and soda,	Livingston	Several near West Avon, strongly impregnated.
Sulphureous,	Hamilton group	Ditto		Livingston	Near Moscow.
Sulphureous,	Niagara group	Ditto		Monroe	Village of Ogden.
Sulphureous,	Niagara group	Ditto		Monroe	Longmuir's in the city of Rochester.
Sulphureous,	Niagara group	Ditto		Monroe	Monroe spring, five miles east of Rochester.
Sulphureous,	Niagara and Onondaga salt groups,	Ditto		Monroe	Several in the towns of Mendon and Pittsford.
Sulphureous,	Niagara group	Ditto		Monroe	Ogden, on the land of Timothy Colby.
Sulphureous,	Clinton group	Ditto		Orleans	Holley village, two, weak.
Sulphureous,	Niagara group	Ditto		Niagara	Several near Lockport, one three miles south.
Sulphureous,	Onondaga salt group,	Ditto		Niagara	On Tonawanda creek, two miles from the village.
Sulphureous,	Niagara group	Ditto		Niagara	Bank of the river two miles below the falls.
Sulphureous,	Onondaga salt group	Ditto		Niagara	Pendleton
Sulphureous,	Niagara group	Ditto		Niagara	Three miles east of Lewiston.
Sulphureous,	Onondaga salt group	Ditto	Sulphate and carbonate of lime,	Ontario	Clifton springs, town of Manchester, several very copious and highly impregnated.
Sulphureous,	Onondaga salt group,	Ditto		Ontario	Banks of the outlet of Canandaigua lake.
Sulphureous,	Corniferous limestone	Ditto		Seneca	Waterloo.
Sulphureous,	Chemung group	Ditto		Steuben	Campbelltown.
Sulphureous,	Chemung group	Ditto		Steuben	Near the post office in Jasper.
Sulphureous,	Chemung group	Ditto		Steuben	Town of Canisteo.
Sulphureous,	Portage group	Ditto		Steuben	Urbana
Sulphureous,	Onondaga salt group	Ditto		Wayne	Brown's millpond, south of Newark.
Sulphureous	Medina sandstone	Ditto		Wayne	On Salmon creek, near the forge in Sodus.
Sulphureous,	Onondaga salt group,	Ditto		Wayne	At and near Palmyra
Sulphureous,	Onondaga salt group	Ditto		Wayne	Village of Clyde.
Sulphureous,	Niagara group	Ditto		Wayne	Half a mile northeast Marion Centre.
Inflamm. gas,	Portage group	Carburetted hydrogen,		Chautauque	In and near the village of Fredonia.
Inflamm. gas,	Portage group	Carburetted hydrogen,		Chautauque	Van Buren harbor.
Inflamm. gas,	Portage group	Ditto		Chautauque	Buffington's well.
Inflamm. gas,	Portage group	Ditto		Chautauque	Portland harbor.
Inflamm. gas,	Chemung group	Ditto		Chautauque	Town of Sheridan.
Inflamm. gas,	Chemung group	Ditto		Cattaraugus	Oil spring of Freedom, and several other localities.
Inflamm. gas,	Niagara group	Ditto		Monroe	Town of Riga.
Inflamm. gas,	Medina sandstone	Ditto		Monroe	Near the mouth of Genesee river.
Inflamm. gas,	Medina sandstone	Ditto		Niagara	Gasport, six miles east of Lockport
Inflamm. gas,	Medina sandstone	Ditto		Niagara	Several places between Lockport and Middleport on the canal.
Inflamm. gas,	Genesee slate	Ditto		Ontario	Bristol hollow, town of Bristol.
Inflamm. gas,	Hamilton group	Ditto		Ontario	East Bloomfield and Richmond.
Inflamm. gas,	Hamilton group	Ditto		Ontario	On both sides of the Canandaigua lake, within three miles of the village.
Inflamm. gas,	Portage group	Ditto		Yates	Federal hollow, one mile from Rushville.
Nitrogen	Corniferous limestone			Seneca	Canoga springs, near the village of Canoga.
Sulphuric acid,	Onondaga salt group,		Sulphuric acid, with lime, alumina and oxide of iron,	Genesee	Towns of Byron and Bergen.

CHAPTER XI.

NEW RED SANDSTONE, AND TERTIARY.

Of the formations (enumerated in the tabular view, pages 17 to 19) which succeed the Carboniferous system, there is nothing in the Fourth District which belongs to the period of the New Red Sandstone. The only known development of this rock in the State is in the southeastern part, within the limits of the First District.

The Tertiary formation is principally embraced within the First and Second Districts, though the clays and sands extending along the valley of Lake Ontario are nowise distinguishable in their lithological aspect from those which contain organic remains in the valleys of St. Lawrence and Champlain. From a comparison of these deposits, there is no difference which would justify a reference to different epochs; and it seems indeed quite probable that they are of the same age, and the products of a period subsequent to the gravel by which they are in many places underlaid, though in others the clay rests upon the rocky strata, which apparently remained uncovered after the deposition of the gravel. But if the presence of organic remains is to be the test in distinguishing the Tertiary from other superficial deposits, then all the blue and yellow clays, succeeded by yellow sands, in the Fourth District, must be referred to the subsequent period of drift.

During the summer of 1836, I examined the fossiliferous deposits on the Salmon river, a few miles from the St. Lawrence, and found them resting upon the Calciferous sandrock, which bears evidence of what is termed diluvial or glacio-aqueous action in the numerous striæ and grooves upon its surface. The lower deposit of shells, principally Sanguinolaria, rests upon a fine gravel. Dr. Emmons has shown the same fact with regard to this formation on Lake Champlain. Thus it appears that in reference to the lower formations, those of Ontario, St. Lawrence and Champlain valleys hold the same relative position; but since the former contain no shells, they will be described in this report among the superficial deposits, without reference to the Tertiary period.

I have remarked, that no organic remains have been found in these clays or sands on Lake Ontario. I am not unaware, however, that fragments of wood, freshwater shells, etc. are said to be discovered; but in all cases which have come under my own observation, these are of subsequent periods, either covered by a slide of the older materials, or inclosed in a superficial deposit. Although more time might have been given to these formations, yet those of more immediate interest have absorbed the principal share of my attention.

CHAPTER XII.

SUPERFICIAL DETRITUS.

The superficial materials covering the surface of the older stratified rocks of the Fourth District, and to a great extent concealing them from view, are due to successive operations on a more or less extended scale, which have broken up the indurated strata, and worn the fragments to different degrees of comminution. The agencies producing these effects have been sometimes almost universal throughout the extent of this district, and at others confined within very limited areas; and we may trace them through successive stages from the simple operations of freezing water, the running of streams and rivers, the washing of waves upon the lake shores, through more stupendous exhibitions, as the damming up of river channels, the excavation of new ones, the bursting of lakes, etc., till the phenomena pass beyond our means of comparison, and leave us to conjecture in what manner these have resulted, as they transcend the usual effects of causes before our eyes. These more extensive and least known operations have produced those deposits of loose materials, sometimes called *diluvium;* but as this term includes many deposits of local or very modern origin, the term *drift* has been proposed, as being unobjectionable in this respect, and unambiguous in its meaning.*

The scoring and striating of the surface of the strata, which seems to have been effected at the same period, as well as the excavation of broad and deep river channels, and the like, are all referred to an agency concerning which there is yet no settled opinion. The plausible theories of one observer are modified or overturned by new facts, or the bolder speculations of another; and at this moment, even the most extravagant hypotheses are advanced in order to account for these familiar phenomena.

While so many conflicting hypotheses are thus before the public, it would be of little moment to advocate the one or the other; and therefore the facts observed in the Fourth District will be stated, with the unavoidable conclusions to which they lead. There is always, in these investigations, great need of caution, not to confound the products or the phenomena of two or more periods; for it can readily be demonstrated that the superficial deposits of the State are of different ages, sometimes distinct and separate, and again mingled and confused. No one theory of formation can account for the whole, and we are therefore often to seek for causes close at hand, rather than venture too far into conjecture.†

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* See Murchison's Silurian Researches, page 509, note.

† Mr. Murchison has very clearly shown the successive periods in which the superficial accumulations of certain parts of England and Wales were produced; and the facts observed in New-York correspond precisely with his views and observations.

All the northern part of the district, and the low slopes and deeper valleys of the southern part, are covered to a greater or less depth by superficial materials of more northern origin, mingled with those of the rock on which the deposit rests.

The extreme northern margin consists of the worn fragments of lower stratified rocks, as the Hudson river group,* intermingled with a large proportion of those of the Medina sandstone. The former gradually diminish as we progress southward, and are finally lost altogether; those of the different successive formations taking their place, and constituting, in turn, either the greater or smaller part of the whole accumulation. Those which are of the most durable character continue farthest, and they may even be traced as far as the Pennsylvania line; but, in their passage southward, they have been much worn, and greatly diminished in size. Still, by careful examination, traces of all the stratified rocks on the north may be met with in these depositions.

As we pass southward, however, over the successive formations, we find that all have suffered greatly from denudation, and that the abraded fragments of each constitute a large proportion of the superficial materials resting on its southern neighbor. The size of the fragments always bears a proportion to the distance they have been transported from the parent rock; and in the Fourth District we often find a huge mass of a northern rock resting upon the margin of the one next south of it, while at a distance of ten or twenty miles farther south, only small pebbles of the same occur.

These remarks apply to the older deposits; and while it sometimes happens that a huge fragment has been transported many miles southward, having suffered little attrition, it seems due to some operation subsequent to that of the great accumulation below. Even in the deep valleys at the southern margin of the State, may be found pebbles of all the northern rocks of the district, except the soft shales, which will not withstand the transportation.

We find resting upon the limestone and calcareous shale formations a dark colored gravel, ranging from fine to coarse. This has accumulated most in sheltered situations where a succeeding bed or stratum rises to the south of it, as if it had been pushed onward over the bottom, lodging against the projecting edges of the strata. In this way it often happens that a rock, in its more northern extension, is covered with sand or clay, while the coarser materials are pushed farther onward. These phenomena occur where the deposit is evenly distributed over the surface; in other places the coarser and finer materials, intermingled in the greatest confusion, are heaped up into conical hills, which are thickly scattered over the surface. Again, the same materials are accumulated in long hills or ridges, having a determinate direction, and sloping down from a high northern elevation to the general level of the country on the south.

The Drift or Boulder period, the products of which are often confounded with more ancient deposits of similar materials, is certainly the most recent of all, and, except where they are intermingled with the previous deposits, are always the most superficial. In the valley of the Hudson, in the vicinity of Albany and Troy, I have searched in vain for a boulder or pebble of granite, or of any rock older than the Potsdam sandstone, in the deposits below the clay; while in a period subsequent to the deposition of the clays and sands, boulders of granite are by no means rare.

It may be remarked here, that the old deposits alluded to contain abundance of quartz pebbles and quartz with green chlorite; but these are from the quartz veins in the partially altered rocks of the age of the Hudson river group.

This condition of the surface clearly indicates the condition of the waters from which this deposition was made. On the one hand we have comparatively an evenly distributed deposit, as if made by the retiring waters of an ocean; in another, the long hills, with certain directions, show a determinate course and more powerful current in the ocean, while the irregular conical and dome-shaped hills, with deep, bowl-shaped cavities, show the force of contending currents, or of other obstructions in the course of the transported materials.

It becomes very evident, therefore, that to whatever cause we choose to attribute the phenomena of the superficial detritus of the Fourth District, the whole surface has been permanently covered by water; for it seems impossible that partial inundations could have produced the uniform character and disposition of the materials which we find spread over the surface, not only of the limited area we have been describing, but over several hundred miles farther east and west. That partial influences have operated, and partial inundations taken place, there is no doubt; and some of their effects will be enumerated. It is very possible also that many of the varying features of this deposit are due to causes not now recognized, and less universal than at first view may be supposed. In these I would often be disposed to include the abrupt, conical and elongated ridges, which, with no determinate direction, often cover considerable spaces, when the surrounding country is comparatively level.

There is also another fact to be borne in mind, viz. that the materials of the hypogene or primary rocks constitute but a comparatively small proportion of the superficial accumulations of Western New-York. The great bulk of the deposit, whether evenly distributed or irregularly raised into hills and ridges, is, nevertheless, composed, in large proportion, of the rock but a short distance on the north, or perhaps of the one on which it rests, with a constantly decreasing proportion of rocks of northern origin. It is true that boulders of granite and gneiss are often scattered in great profusion over the surface, sometimes indeed to the almost entire exclusion of every other rock, and they are more or less numerous in almost all situations where the superficial detritus has accumulated; still they rarely enter into the great mass so as to constitute any large proportion of the whole.

Although it may not be impossible that some of these boulders, of granite and other rocks of similar nature, have been transported at the period of this great accumulation of local drift, and forming a part of the great moving mass; yet they are, for the most part, due to subsequent operations; brought thither by a force which has transported them alone, and which has had no great effect, even upon the previously deposited superficial detritus; and we must carefully guard against confounding these accumulations with those of antecedent formation.

In many instances there has been an intermingling of the products of two periods, and sometimes the granite boulders appear to have rolled down from higher elevations, often indeed resting upon the most recent superficial deposits.* Instances of this kind are visible along the valleys of the northern part of the district. On the broad northern slope towards Lake Ontario, where hills are distant, there are numerous and extensive fields of boulders, resting upon the surface, or but partially imbedded in the soil, and holding such a position that it is

* Such as river alluvium, etc.

quite evident they are of subsequent origin to the great body of detritus. We find similar exhibitions too upon the great western prairies, where, for many miles, the difference in elevation is not more than fifty feet; and here we observe long lines of boulders stretching away for miles beyond the reach of vision, as if once forming a line of coast, or deposited along some channel or course of a current, though the general surface indicates no influence upon this portion beyond what is common to the whole.

The causes which have given origin to the superficial accumulations, will be noticed under different heads. The most universal and uniform in character were evidently produced beneath the water of the ocean, or during the elevation of this portion of country.*

The immense amount of denudation which has taken place in this portion of the State, could only have been accomplished beneath the ocean, when it entirely covered the surface of the country, and was subject to tides and currents like the present oceans. This view, too, acquires additional support from the fact, that portions of country along the sea shore, which have been recently elevated above the water, bear a very close resemblance in many particulars to the more anciently denuded and elevated districts. Along the Massachusetts bay, where the high hills of loose materials contain shells of recent marine species, leaving no doubt of their modern origin, the surface has all the characters of those sections in western New-York covered by drift or diluvium. Extensive tracts often occur, which are almost unbroken; while again the surface is broken into irregular hills or ridges, with deep bowl-shaped depressions, or long valleys, which often communicate in more extensive ones, or are enclosed on all sides by drift. The character of large tracts farther south, along the Atlantic coast, is extremely similar; and when we consider the difference in the nature of the strata beneath, and the influence of a longer period of weathering, the analogy becomes very striking. Thus we may conceive this whole extent of country to have been submerged beneath the ocean for a long period; and that in its subsequent elevation it has been washed by the advancing and retiring waves, which have worn the deep indentations in the limestone cliffs, and broken up the northern edges of the strata.

Notwithstanding, however, that this operation would explain many of the phenomena presented, still there are others which it would leave unexplained. In those portions of the sea coast which I have had an opportunity of examining, the inlets and indentations are always broad towards the ocean, and narrowing as they recede. In many of our older valleys, however, we perceive a different form; the sides are nearly parallel for miles in extent, and they do not present the broad or trumpet-shaped mouths which are common to the coast inlets, or those in the face of our limestone terraces.

The valleys of Seneca, Cayuga and Crooked lakes, Canandaigua lake and others, are of nearly equal width from one extremity to the other, with nearly perpendicular banks above the water. It seems hardly possible that such channels could be excavated by the advancing and retiring waves, upon a coast which was gradually emerging from beneath an ocean.

* This cause has been explained by Mr. Hayes, in an article published in the American Journal of Science, Vol. 35, No. 1.

No theory of this kind, moreover, seems sufficient to account for the grooved and striated surfaces of the rocks in place, which hold a uniform direction, and which occur in all situations, and upon the highest and lowest points. In all situations which have been observed beyond the influence of deep valleys, these scorings or striæ have a uniform direction, or varying but a few degrees from N.N.E. and S.S.W.

The local origin of nearly all, and perhaps all the ancient drift of the district under consideration, can be shown by an examination of numerous sections upon the lake shore, in the river courses, and in artificial excavations which reach to the rocky strata. These sections, where made in situations beyond the reach of modern disturbing causes, show very clearly the conditions under which the superficial detritus has accumulated. The action of the present ocean upon cliffs and beds of rock extending beneath its surface, is nowhere more clearly represented than in the sections of detritus resting upon the stratified rocks of western New-York.

The shores of Lake Ontario offer some of the most instructive exhibitions of this kind, and indeed it might almost be considered a continuous section from one extremity of the district to the other. The following section on the east side of Irondequoit bay, illustrates in a perfect manner the general character of these superficial deposits.

158.

Section at Upton's quarry, Irondequoit bay.

7. The soil of sandy loam.
6. A coarse deposit of pebbles of the Medina sandstone below, with gravel and sand.
5. Stratum of pebbles and sand.
4. Stratum of sandstone pebbles, cemented into a conglomerate by oxide of iron and carbonate of lime.
3. Bed of fine sand.
2. Fragments and rolled masses of the sandstone below, with gravel and sand. This contains a few pebbles of the shaly, calcareous sandstone next on the north.
1. Medina sandstone. Shaly, with bands of green.

Numerous similar sections, varying in some unimportant details, might be given, all showing that the older deposit resting upon the red sandstone, is composed of fragments of that rock, more or less worn, with a small admixture of other materials. This red gravel of the lower deposit is always to be relied on, as indicating the immediate proximity of the sandstone. The following section, about seventy miles farther west, illustrates the same position, though the conditions seem not to have been as equal throughout as in the first.

159.

Section of the bank of Lake Ontario, town of Wilson, Niagara cou

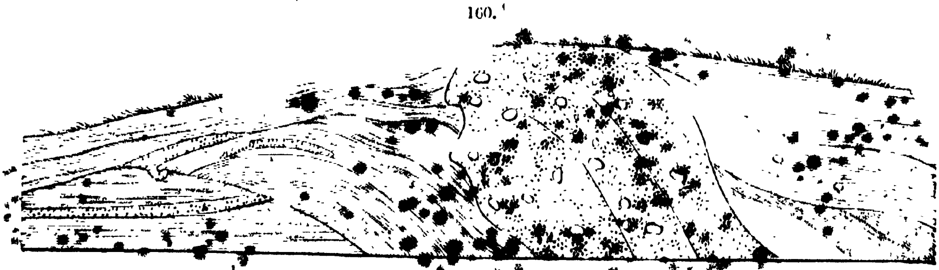
4. The soil of clayey loam, with clay below.
3. Gravel, clay and sand, of the neighboring rocks, folding over and passing beneath No. 2.
2. Blue clay and gravel. The pebbles are principally of the rocks of the Hudson-river group.
1. Red clay and gravel of the Medina sandstone.

The clay deposit of the surface is often succeeded by sand and sandy loam, as in Monroe county; and this sometimes rests upon the gravel, without the intervention of clay.

In most instances, there is evidence of the most perfect uniformity in the production of these deposits; and when they can be traced over so large an area, it is plain that the few apparent exceptions will be met by some other explanation. As before remarked, where these accumulations form hills and ridges, they do not always preserve the same regularity as in the widely distributed and more shallow deposits. This may have resulted, in some instances, from subsequent causes, or from the force of contending currents while the ocean covered the surface. In many instances, the sand is irregularly deposited; and at others, there appear to have been partial depositions and denudations during the period of its formation.

The following is a sketch by the late Dr. G. W. Boyd of a hill about two miles east of Rochester. The ridge has been excavated in an east and west direction, for the passage of a road, presenting a depth of thirty feet or more.

160.



1 & 2. Deposits of fine sand variously inclined, with a few layers of gravel.
3. Coarse gravel, with large boulders of limestone.
4. A subsequent deposit of [illegible], like Nos. 1 and 2.

There appear to have been several periods of deposition, where the laminæ do not coincide, and which are separated by stronger lines of division. The section is a perfect representation of the face of the hill: nearly all the strata dip towards the west, and the accumulation doubtless took place from this direction, from the heaping of the coarse gravel upon the fine sand.

The gravel consists principally of waterworn fragments of the Niagara limestone, on which the whole deposit rests, and of the sandstones and limestones on the north. There are some boulders of the limestone, from two to four feet in diameter, worn perfectly smooth, or often striated with shallow grooves; and from the fact that this is the subjacent rock, they have received their rounded forms and smooth surfaces from attrition near the spot where we now find them.

This character of the hills of the northern range of counties could be illustrated by numerous sections, showing the diagonal lamination, removal and re-deposition of deposits. Scarcely a hill can be excavated, where this kind of structure is not observed in a greater or less degree, and sometimes the whole deposit is in such confusion as to present no definable structure.

In the southern counties, after leaving the deeper valleys, the superficial detritus is less and differs in character from that in some of the more northern parts of the district. Its connection with the stratified rocks below is the same, and resting upon them we find an accumulation of fragments of variable dimensions, mixed with clay, gravel and rounded pebbles. The materials, however, bear less evidence of attrition than those farther north; and there are but few rounded pebbles. The "flat gravel" of the hills, and the "round gravel" of the deep valleys, has before been noticed. These terms serve to distinguish different degrees of attrition, as well as marking different portions of country. The origin of the mass is the same as in the northern part of the district, but it has been less subjected to subsequent operations, and may be regarded as presenting the primitive state of drift, or diluvium. It must be recollected also that in all these situations there are no primary boulders intermingled with the mass, though they are occasionally seen upon the surface. The materials of the northern stratified rocks of the district appear never to have been lifted to this elevated portion of the country, and are found only in the lower valleys.

I may here remark, that these investigations were commenced with a belief in certain views and theories regarding the production of drift; but as my observations progressed, the difficulty of reconciling the facts with these preconceived notions became constantly more apparent.

In conclusion, therefore, although some of the foregoing arguments may not appear quite satisfactory, or free from doubt, it must be remembered that long continued and extensive examinations are necessary to put us in possession of all the facts bearing upon the subject, while comparatively little time could be devoted to this department; and I have been unable to revisit localities, where, two, three, and even four years ago I noted circumstances and appearances, which at present, with the different views to which I have been led by multiplied observations, coincide with and confirm these inferences.

The theory usually inculcated in regard to the great body of drift covering the surface of the strata, is that it consists of granite and other materials of far northern origin which have been moved forward over the surface with resistless force, and, in their passage, uplifting, breaking and transporting the fragments of strata over which they pass. That blocks of granite, either enclosed in ice or moved by other means, have been the principal agents in effecting *diluvial* phenomena; that they have scored and grooved the rocks in their passage, and breaking up the strata, and mingling themselves with the mass, have been driven onward, carrying everything before them in one general *mêlée*. That such may have been the case in some instances, or in limited localities, cannot be denied; but that it ever has been over any great extent of country, will scarcely admit of proof.*

A glimpse of a more rational explanation has occasionally offered itself, and after an examination of my notes, and the numerous sections made on the spot, I have found, almost universally, that they correspond with the preceding sections and their explanation, viz. a bed of broken fragments, with worn pebbles resting upon the rock from which they are derived. The granite and other materials of a far northern origin rarely constitute a part; and I am not prepared to say that, in any instance where they do form a part, the deposit has not undergone some subsequent change.

If we adopt the views indicated by the facts here presented, it does not preclude the probability of deposits of purely northern origin (containing rocks of granite, gneiss, etc.) from resting directly upon any other stratified rock; for even allowing the earliest drift to have been formed by the wearing of the ocean and the breaking up of the strata by the action of waves, still all this may have been subsequently removed, and another deposit have taken its place. Such, doubtless, has often happened; and if a previous deposit is removed to make room for another, then we should naturally expect, in many instances, a mingling of the two.

Grooved, striated and polished rocks.

Intimately connected with the subject of the older drift is that of grooves, or striæ upon the surface of strata which lie immediately beneath. All the rocks of the Fourth District which are of a sufficient hardness to receive and retain such impressions, and which have since withstood the action of the weather, are more or less marked in this manner. From the Medina sandstone, at the level of Lake Ontario, to the summit of the conglomerate of the Carboniferous system, some of the strata in every group bear upon their surfaces these markings of former abrasion and the evidence of moving force. These, too, for the most part, bear a very uniform and decided direction, varying but a few degrees from N. 35° E. and S. 35° W. in their general course. Short and shallow striæ are abundant, which vary ten and fifteen degrees from this direction; but these have no continuous course, and apparently fall into the main direction after a few feet.

* In primary regions there are no other rocks than granite, gneiss and their associates; and consequently whatever may be the age, or by whatever means produced, the superficial deposits are charged with these masses.

These markings range from the slightest possible scratch to grooves of half an inch in width, and from one-eighth to one-fourth of an inch in depth. Such grooves could only have been made by some hard substance, moved with great force, and under great pressure, over the surface of the strata; for not only do we see the deep grooves and shallow striæ, but fragments are broken out as we approach a fissure in the stratum, as if crushed by some heavy body. Such phenomena, which are frequently witnessed, are illustrated in the following woodcut, where the lower side of the specimen, as shown in the cut, is broken off obliquely, so that the upper surface recedes six inches beyond the lower. This took place upon the southern edge of a mass at the crossing of a fissure. The mode of fracture indicates an immense weight, pressed upon the surface, but not a quick, heavy blow. The grooves follow, somewhat obliquely, the fractured slope, which was probably made near the close of the operation; for, in many instances, such surfaces are afterwards polished, but this one retains its freshness. There are in this specimen (and the same often occurs in others) two sets of striæ; one, being the prevailing direction, is as stated above, while the other is very nearly north and south.

Grooved and polished limestone, Lockport.

The outcropping edges of strata previously polished and grooved, are often overturned upon the rock, in place, by this force moving southward. Upon the surface from which the above specimen was selected, I have seen frequent examples of this kind; and in some instances the fragment is partially rounded, possessing the character of a boulder. At this locality the grooves are often large and deep, while in other places they are fine, and the surface is nearly polished. The materials resting above this rock are fine sand and sometimes clay; but in no place in the same neighborhood have I seen gravel, and only occasionally large fragments of the rock itself from the outcropping edges. A few miles farther south, however, there is a great accumulation of gravel, covering the strata.

At Rochester, on the other hand, the surface of the limestone is finely striated, and almost perfectly polished, by this abrading action. So evenly is the surface worn, that I have taken slabs a foot square, and laying the faces in contact, there is no perceptible difference in the planes. The material here resting upon the rock is fine sandy loam; and in another locality, a mile farther south, it is covered by coarse gravel of limestone and sandstone pebbles, with boulders of granite. These slabs are, for the most part, too smooth to be illustrated in an engraving, but can readily be understood from comparison to a partially polished slab of marble.

The surface of the Niagara limestone, which is covered with drift materials, is from two to seven miles wide, and extends the whole length of the district. In all localities where this rock has been exposed, I have observed these striæ, in greater or less perfection, but in no other place so fine, or with the surfaces so evenly polished, as at Rochester. The example of this rock alone, shows how universal has been the operation of this agent.*

The great force and powerful abrasive action is well illustrated in the accompanying plate, which is from a specimen obtained at Black Rock, from the surface of the Corniferous limestone, and is completely covered with these grooves and striæ. It presents some interesting phenomena, from the presence of little nodular concretions of hornstone, which, in some places, stand out from the general surface, having, from their harder nature, evidently acted as a barrier to the abrading force; and there is a long, elevated ridge of the stone, upon the southern side of these, which was thus protected, as a pebble or a fixed stone in a running stream allows the accumulation of sand or mud beyond it. In one or two examples these nodules of hornstone have been broken off, and fracturing below the surface, have left a depression, which is partially smoothed out in the same manner as the surface. There cannot be a more instructive exhibition of this abrading force than is here presented, where the different degrees of hardness in the two substances have fully illustrated their respective power in resisting the force applied. The surface, when free from these nodules, is not a perfect plane, but appears in broad undulations, with the elevations and depressions parallel to the striæ, and produced by the wearing of the surface. In this instance the direction of the grooves, with scarcely a single exception, is N. 35° E. and S. 35° W.†

On the banks of the Niagara river, and also at Lockport and elsewhere, I have, in some instances, found the direction of these grooves variable, though having the same general course. At Lockport, however, I was informed by Mr. Barrett that after clearing the earth from the rock, previous to excavating the Erie canal, one large groove was noticed, which was measured, and found to extend, without the least variation, more than one hundred feet.

It will be remarked that the direction of these grooves corresponds very nearly with the direction of the great excavating force, and the deep valleys of the lakes and rivers of the

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* I find in my notes the direction of the grooves at Rochester marked as N.N.E. and S.S.W. with some slight variations.

† See a communication on the subject of these grooved and polished surfaces, by George E. Hayes and R. W. Haskin, in the American Journal of Science.

western part of the State. Whether these are to be referred to the same origin, or as having been produced at the same period; or if the striæ only followed the previous direction of the valleys, may be a question not easily decided. I shall, however, show that in some instances, at least, they are connected with the excavation of large masses of the rocky strata.

The shore of Lake Erie, from Buffalo to the Pennsylvania line, in a southwesterly direction, coincides very nearly with the dip of the strata, presenting many interesting sections, as illustrated in Plates V. and VI. The rocky strata in vertical cliffs are succeeded by deposits of gravel, clay and loam; the lowest, as before remarked, consisting of fragments of the subjacent strata, but little worn, and intermingled with clay and gravel. Along this extensive line of natural section, there are some interesting exhibitions of the connection of these deposits of such widely distant geological epochs.

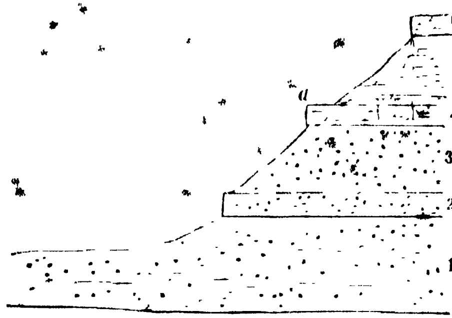
Sometimes the projecting edge of a stratum is uplifted, and the gravel and fragments pressed beneath it, elevating and sometimes overturning its edge, and loosening others some distance beyond. In this way, I have seen a stratum fractured and elevated at an angle of 30 or 45 degrees, imbedded in the drift which was pressed on from the northward. Stupendous operations of this kind have sometimes taken place, and immense masses of the strata have been elevated and moved forwards. The section, Plate VIII, is a correct representation of the cliff of Lake Erie, in Portland, Chautauque county, as it appeared in October, 1840. The section is explained upon the plate. The two upper strata are of the ordinary character of the deep loam and clayey gravel deposits along the lake shore. The rocky strata below have been uplifted, broken and contorted; the fragments intermingled with clay and gravel, and the same pressed beneath the strata, which otherwise appear to be in place. At some points the strata are completely broken up, and the fragments separated; in other places, they are simply shattered, without being otherwise much disturbed. In such cases they appear as if they had been subjected to violent oscillation, like ice when the water is agitated by wind; they are broken into short fragments, as seen in the whole of the central part of the section. Between *e* and *f*, the clay, gravel and fragments are folded and contorted, as if violently pressed forward from the north. It appears as if the whole mass above the shelf 1, 2, 3, had been uplifted and moved onward by some powerful force, which at the same time pressed the finer materials into all the interstices.

In several places where the strata are slightly separated, and the spaces filled with fragments, the surfaces are scored and striated precisely in the manner before described. It seems impossible that any other agent than what is here perceptible should have had access to these places, or aided in producing the result. The broken fragments insinuated between the layers, and the movement of the whole upper portion with its load of gravel and clay, seems sufficient to have produced the phenomena in question; and if in this case such causes are adequate to these results, why may not the same, under other conditions, produce the like, or more extended effects? The efficiency of the force cannot be doubted. In this instance, it only requires that a longer continued operation should have broken up the whole of these lifted strata, to have left a tolerably even surface, scored and striated like all the strata surfaces described. It requires simply the insinuation of sand and pebbles between the layers, and then that the upper one be made to move over the lower, to produce all the observed phenomena

In the softer shales, where the striæ are sometimes preserved, they are deeper than in the limestones and other hard rocks. In the black shale about Dunkirk harbor, all the grooves are broad and deep, compared with those of Black-Rock or Niagara, and there seems no other cause except the soft character of the shale.

There is a remarkable fact connected with these striated surfaces, which may be noticed here. The terrace at Lewiston is formed by the upper part of the Medina sandstone, the Clinton group, and the Niagara shale, capped by about twenty feet of limestone as already described. The following section illustrates the succession:

162.



1, 2 & 3. Medina sandstone. 4. Clinton group. 5. Shale of Niagara group. 6. Limestone of Niagara group.

The top of this terrace is three hundred and fifty feet above Lake Ontario, and more than two hundred feet above the plain about Lewiston. The projecting shelf of rock *a*, is the limestone of the Clinton group, about one hundred feet below the top of the Terrace. The surface of this projecting mass is deeply grooved and striated, the grooves having a general southern tendency, but more irregular than where they are seen upon the limestone on the top of the terrace; and at this place, the surfaces two hundred feet lower and one hundred feet higher are scored in like manner. We naturally inquire, what agency could produce this effect? Here is an abrupt elevation of one hundred feet above the striated surface; and it seems hardly possible that an island of ice, loaded with granite boulders, could have stranded upon this projecting shelf, and produced the scoring, and that at the same time others above and below could be made in like manner.

It may perhaps not be out of place here to consider a few facts connected with these striated and polished surfaces, in their relation to the theories of glacial and glacio-aqueous action, as the agencies in producing such phenomena, and others connected with superficial deposits. It will be borne in mind that the Fourth District, in its greatest elevation of about two thousand feet above tide water, descends to the level of Lake Ontario, two hundred and forty feet above tide, for the most part in a series of steps or terraces over the successive formations; the surfaces of these, from the highest to the lowest, are grooved and striated, and in the limestones often beautifully polished.

In the first place, we are unacquainted with any high land on the north, from which glaciers could originate to cover this entire surface. The relative levels, as well as the directions of the water courses, must also have been different, to have allowed of such effects from glaciers; for under present circumstances, we should hardly expect to find a glacier advancing from the valley of Lake Ontario, toward the southern margin of the State, and ascending nearly two thousand feet in one hundred miles. Even admitting the theory to be true, it is probable that the glaciers would originate among the mountains of Canada, or farther north among the primary rocks; and in this event, we might expect to meet intermingled with the earliest drift a considerable proportion of granite, and other pebbles and boulders of the older rocks, which is not the case. There is also another circumstance connected with glacial action, which deserves inquiry. The deep valleys were either excavated previously, at that period; or subsequently. If these were excavated previously, then the power which accomplished it was sufficient to produce all the striæ and grooves which we now find. It can hardly be supposed that these excavations were made at the time the glaciers were progressing southward; for no such power is attributed to them, and they usually follow the course of valleys previously formed. If we attribute these valleys to subsequent causes, then we have a power capable of obliterating all traces of glacial action.

Not being familiar with the views of M. Agassiz from his own writings, I may have an imperfect or erroneous opinion of his theory; but so far as I understand it, it seems inadequate to produce all the phenomena in question, and inapplicable to this portion of the country.

In regard to glacio-aqueous action, there are other considerations to be taken into view. Glaciers, loaded with fragments of rock, may have drifted from the base of mountains, and in passing over shallow portions of the ocean, have scored the surfaces of the strata; but in order to accomplish this, a peculiar condition of things is necessary. It requires that the surface be free from the accumulation of detritus, which in the ocean cannot be, except the elevated rocks; and we can never find any portion of country which has been for a considerable time submerged beneath the ocean, but is covered to a greater or less depth with superficial detritus. Again, it requires that the surface should be even; or that there should be an immense number of these bergs at all conceivable depths, to touch the varying elevation of the strata. And even under the most favorable circumstances, it requires that thousands and millions should have traversed the ocean, and stranded upon the bottom, in order to produce the wearing down, the polishing, and the myriads of small and large grooves and striæ which mark the surface of strata.

It is not pretended that more than a few masses of granite or other rocks can be attached to the bottom of an ice island, and therefore but few points could touch the bottom at one time; and if we reflect that they may often be as irregular and jagged in their outline beneath the surface as they are above it, then the points will be few indeed. If an ice island were to be stranded in the valley of Lake Ontario, supposing the whole country covered with water, it would require to be elevated three hundred feet to groove the Niagara limestone, and one hundred more to touch the surface of the next limestone above, and so on to the end of the series. This objection, however, can be met by supposing the country gradually rising from the water, and that the highest parts were first scored, and the lower ones afterwards. But if we take this view, we then make the admission that the great inequalities of the country were previously existing; and if these were made, we want no farther power to furnish the explanation we seek; for the same power which excavated a deep valley in a determinate direction, if more diffused in its operation, may have grooved and polished the strata over wide areas.

The countless numbers of inconceivably fine striæ upon the surfaces of the limestones, many of which are only visible by a magnifier, seem a strong objection to the theory that these phenomena have been produced by ice floes; and this fact of itself seems to me conclusive testimony against it. The lower surfaces of these icebergs are confessedly very irregular, and from the falling down of portions from above, the equilibrium is often destroyed, and the mass turns partially or entirely upside down. The fine striæ and polished surfaces are more like what is produced when one even surface is moved over another, having sand or gravel between the two; indeed, not very unlike the preliminary polishing of marble when the motion is all in one direction. It seems impossible that a mass of ice, with fragments of rock set in it, could have pressed so closely as to have produced such an effect.

The polishing and striating of surfaces of limestone and other rocks, no harder than the sandstones of the Fourth District, is, after all, no process which requires such tremendous force as is sometimes called into action; though if great force be applied, it would, doubtless, break up the strata, and still leave a striated surface below.*

Another objection to this view is in the oblique furrows, which often diverge from the regular course. Had all these been produced by fragments, like gravers, fixed in a mass of ice, no such furrows could have been made; and if we maintain that these were worn by loose masses on the surface, which were moved by contact with the ice, then they are as capable of making the same impressions if moved by any other force.

There is also another fact worthy of notice, which is that the vertical faces of joints, when much separated and nearly coinciding with the direction of these grooves, are polished or striated, in the same manner as the surfaces. Hundreds of instances can be observed near the outcropping edges of the Niagara limestone; but this is readily understood by any one who has observed the chinks and fissures in harder rocks along the sea shore, which are similarly polished by the washing in of sand and pebbles by the advancing and retiring waves.

* I have seen a quarry at Lockport, the entrance to which was along the surface of a stratum in the direction of the dip, the superior strata had been removed, and this surface left in its natural state. After drawing stone from the quarry, on the common stone-drag, for a few weeks, the surface of the stratum became worn smooth and striated, and in some places nearly polished. This was done merely by the fragments ground between the wood of the drag and the stratum below, as it moved over the surface. In this instance, there were few fragments or pebbles of any other rock than the limestone.

CHAPTER XIII.

Position and mode of transport of the great northern boulders.

The general contour of the surface of the Fourth District has been already described, and the limits of the successive terraces and plateaux are not more perfectly defined than is the distribution of granite boulders, particularly in the northern part. That portion occupied by the Medina sandstone, and forming the first plateau above Lake Ontario, is often plentifully covered with boulders. These usually lie upon the surface, and always upon the previously described deposits of drift. They are not evenly distributed, but often appear in immense numbers, scattered over several acres; while beyond this, for a greater distance, few are to be found. There appears to be no law regulating their distribution, though they are more abundant in the eastern than in the western part of the district.

In passing along the Ridge road from Wayne county to the Niagara river, these boulders may often be seen in immense numbers on the low ground just north of the ridge, as if they had been brought there while the water was limited by this barrier, and spread over the bottom in shallow water near the shore.

In higher situations, and just beneath the great limestone terrace, they again appear in abundance, as if this elevation prevented their farther advance to the south. Standing upon this high plateau and looking over the low ground on the north, the position of these boulder-fields can be distinctly traced. They are thickly scattered over spaces varying from a quarter of an acre to two or three acres, and sometimes even more; and these spots are separated from half a mile to two or three miles, with only a few stray ones between.

The broad plateau formed by the surface of the Niagara limestone and the Onondaga salt group, is sometimes thickly strewed by boulders of granite. The most abundant fields are in Wayne, and the eastern part of Monroe county; and going westward from the Genesee, they are less so, becoming extremely rare in Erie and Niagara counties. They occur here in the same manner as before described.

As we ascend the second limestone terrace, formed by the Helderberg range of limestones extending westward, boulders become perceptibly less numerous; they are irregularly scattered, and at few points present the thickly covered fields which we observe a few miles farther north. Very few ascend the slope formed by the passage of the Hamilton group to the rocks above; and in all the previous cases, they seem to have been brought on at intervals in great numbers, and their limits bounded by the different elevations of the surface.

As we pass southwards over the higher groups, boulders become exceedingly rare; and finally toward the southern margin of the State, they are rarely seen.

This approach to the southern limits of these northern masses corresponds with what is observed throughout the whole west, as far as the Mississippi. The drift containing northern boulders of granite is scarcely observable in the southern part of Ohio and Indiana; and I am informed by Mr. Lawrence, of Aurora, Ia., who has travelled much in that part of the country on both sides of the Ohio, that the valley of this river seems to be a limit to the northern boulders, and they rarely (if ever) appear upon the south of it. Such facts are of the highest interest, as enabling us to arrive at important conclusions regarding the means of transport of those huge blocks, which, over the whole continent, and even over the whole world, seem, at certain periods, to have poured down from the north in such immense numbers. Wherever any attention has been given to their southern extension, it has always been found confined within certain parallels, and we have no authentic account of northern boulders in intertropical regions.*

The condition of the boulders in the Fourth District, is the same generally with these masses over every part of the country where they have been noticed. Some of them bear evidence of much wearing, being actually striated upon the surface, and sometimes flattened on one side, as if held in that position while moved over a bottom of gravel or sand resting upon the strata beneath.† For the most part, however, they bear no evidence of attrition beyond what similar masses do a few miles from their parent rock, and thus offer no argument for their mode of transportation. I have met with many which are very angular, and with no appearance of attrition beyond what the weathering in their present situations would produce.‡ Even if these boulders were all rounded, it furnishes no argument that they were worn into this form during their transportation from their original beds to places where we now find them.

The process by which fragments of granite become rounded boulders, is illustrated by the desquamation which takes place in some granites, the weathering in place, and the attrition in mountain streams soon after leaving their native beds. In the mountainous region of

* In Virginia and North-Carolina, I have seen rounded masses of hard granite and greenstone lying upon the surface, and having much the appearance of boulders. In every case where I examined these, I found them to consist of masses which had become rounded from weathering in place, and were fragments of beds or veins of a hard rock in a surrounding softer mass which had disintegrated. Prof. Rogers says he has found pebbles of granite in Tennessee.

† I attach very little importance to the supposition that boulders of granite have been worn smooth and striated upon one side while fixed in a floating mass of ice, and in that way worn down while rubbing over a stony bottom. Some boulders of this kind, which I have seen, are less than a foot in thickness, and two feet in length. Now is it possible that such a boulder, having rounded edges, can be fixed in a mass of ice, so as to allow of such force being applied to it, without falling out, unless the pressure were constant? The beds of many of the streams in the granite regions of New-York are literally paved with boulders, which remain fixed in certain positions, while any fresh accumulation of stones and earth, with ice and water, pass over them, rendering the upper sides very smooth, while the lower may be little worn. Can such occurrences offer any explanation of this apparent polishing on one side by transportation?

‡ There is a mass of greenstone in the town of Riga, Monroe county, which bears no marks of having been broken artificially, the angles of which are as perfect and unworn as a fragment just precipitated from a mass of the rock in place. On the road to Nunda, south of Mount Morris, there is a similar fragment of greenstone, which weighs several tons, and still the angles are very little worn. Numerous other examples might be cited, offering the same evidence as these.

Northern New-York, I have seen examples where a slide or avalanche of snow and ice has brought down from a mountain side an immense number of fragments of the dark felspathic granite, freshly torn from the rock in place. These are precipitated into a narrow gorge, or the channel of a stream; succeeding floods bring down other fragments, which are rolled along with the previous ones; the water freezes, and, on breaking up in the spring with the melting snows from the higher grounds, forms an impetuous flood, which drives all before it in one general *mêlée*. In this way the angles are soon worn off, and every successive flood, or breaking up of ice and snow, helps to transport them farther down the stream, reducing their angles and their dimensions. In the beds of some of these streams, less than ten miles from their source, I have seen thousands of boulders of all dimensions from a pebble to the size of several tons. If these find their way to situations where they may be transported in floating ice, they are already perfectly rounded; and it is easy to conceive how those previously rounded in this way may be intermingled with angular fragments which have not been subjected to attrition, and both be deposited together.

Means of transport, conditions, etc. of the surface.

We have now to inquire by what means these blocks have been removed to their present position; and whether we have any other knowledge of the conditions of the surface at this period, which will enable us to decide, with any degree of probability, what agencies have operated.

From the fact already stated, that these masses for the most part lie upon the surface, though sometimes buried beneath the drift, we are led to the conclusion that they were not moved by any powerful flood, such as has sometimes been supposed; for, in this case, they would inevitably have been mixed with the loose materials of the surface which underlie them; and if a flood, with a force sufficient to transport these masses, had passed over the surface, the whole superficial deposit previously existing would have been swept off. Without the necessity of any farther reasoning in this place, we are led to adopt the opinions advanced by numerous writers, and supported by modern analogies, viz. the transportation of blocks of granite and other rocks enclosed in masses of ice.

In all situations where glaciers from mountain regions come down to the sea, they float off in large masses, and even great tracts, bearing with them the accumulated fragments of rock and earth which they have gathered up in their passage. River and lake ice may do the same at the breaking up of a northern winter; and in this manner large quantities of rocks and earth are annually transported many miles from their original position, to be deposited only when the iceberg shall be stranded upon some coast, or the bottom of a shallow sea; or, passing into a warmer climate, it is gradually melted, and precipitates its load to the bottom.

This subject is ably treated in Mr. Lyell's Principles of Geology, and in the concluding portion of Mr. Murchison's Silurian Researches.

It remains for us to inquire what were the conditions of this portion of the continent at the period in which these boulders were transported, and whether modern analogous conditions offer any evidences to lead to a belief that glaciers were formed on our northern mountains; that moving down to a sea then covering a large portion of the country, they floated off with their loads of earth and boulders, which have been precipitated over the whole of New-York.

When we examine these boulders, we are naturally led to ask, whether they are of the kind of rocks previously familiar to us in place, and if they can be referred to any known primary mountains; for if we can once fix their original locality, we are better prepared to offer explanations of their mode of transport. A large proportion of the boulders of Western New-York are of dark felspathic granite, and red granites like those of the northern part of the State. Some of other varieties occur, which are likewise referable to the same region. A few of crystalline limestone with serpentine have been found; and these are so precisely like a rock of that kind in St. Lawrence county, that we are inclined to refer to that place as its original home. A few boulders of specular iron ore have been found among the most extreme southwesterly materials of that kind; this is precisely like the ore from numerous points in St. Lawrence county. These are a few of the analogies which might be enumerated.

By casting the eye over the Geological map, it will be perceived that the northeastern portion of the State is occupied by a great central nucleus of Primary rocks, consisting of dark and reddish felspathic and other granites, crystalline limestones, etc.; this extends, though somewhat interruptedly, into Canada. The elevation of a large portion of this country is from two to four thousand feet above tide water, and many of the higher peaks approach to the elevation of five thousand feet above the level of the sea.

Admitting that the relative elevations between this part of the State and Western New-York have remained the same, the greater portion of the latter may have been submerged beneath the ocean, and still there would be large tracts of the former elevated two thousand feet above its level. If, under these circumstances, glaciers were formed upon the sides of these mountains, and descended to the sea, many of them would be carried forward by the oceanic current far into that part of the ocean which then occupied western New-York. Even the accumulations of snow and ice during winter, in the streams flowing from these islands, would, on the breaking up in spring, carry forward large quantities of loose stones. The same is shown by Capt. Bayfield to take place on the breaking up of the lakes and streams of the St. Lawrence valley at the present time; and we are warranted in supposing a more severe climate under the conditions suggested, as known by comparison in other latitudes.

From observations in the southern hemisphere, Mr. Darwin has shown that a larger proportional area of water is accompanied (probably as a consequence) by a more equable climate, the presence of tropical productions, and at the same time a low limit of perpetual snow, and therefore the descent of glaciers into the sea in latitudes as low as 46° 40'.* This reasoning he has illustrated by some beautiful comparisons between places in the southern hemisphere and different parts of Europe. These facts he has undertaken to apply to the explanation of the geological phenomena of the transportation of boulders and fragments of rock included in

* Darwin's Journal, quoted by Mr. Murchison, Silurian Researches, p. 512.

masses of ice. The facts observed, which establish the proposition of a low limit of perpetual frost, with a luxuriant vegetation, and islands covered with eternal snow, while the sea in the same latitude swarms 'with living creatures,' can be applied to this portion of the world as well as to Europe, and furnish us with the same arguments in explanation of the transport of boulders.

Let us now go back to the consideration of the condition of these boulders, and their relative situation to other superficial detritus, and we shall find that there can be no explanation offered of their mode of transportation, except during a time when the whole surface was covered by water. Had they been transported by a powerful current over the bottom, (which cannot be supposed from the inequalities of the surface,) all the older drift would have been removed at the same time, and instead of finding them as we now do mostly upon the surface, they would have been imbedded indiscriminately in the superficial detritus, and there would have been no means of recognizing the products of different periods.

In order to allow of a sufficient depth of water for the transport and deposition of these boulders in the places we now find them, it would require a depression of the country from five hundred to two thousand feet below its present level. This greatest depression would cover nearly all of the middle and southwestern portions of New-York, and the whole extent of country occupied by the Great lakes, a large portion of Canada and the Western States. Indeed, allowing the relative elevation of different portions to have remained the same, which as regards New-York is doubtless true, the whole of that portion of North America east of the Rocky mountains would be one great ocean, with numerous and thickly scattered islands. The mountain chains of New-England and New-York would form long ranges of islands rising from the ocean to two and three thousand feet above its level, their sides covered with perpetual snow and glaciers, and their bays terminated by cliffs of ice, from which detached masses floated off, bearing with them boulders and fragments of rock.* These would be transported in every possible direction by the ocean currents; and wherever the mass became stranded, or when it passed into warmer latitudes, its load of earth and rocks would be deposited.

To a certain extent, this view is corroborated by the dispersion of the boulders in New-York; for we find them on every side of the great primary nucleus before noticed, and those found many miles north of this point are undistinguishable from many of those at the south. Still it must be acknowledged that the greater number seem to have been transported southward, probably owing to the existence of a polar current as in the present ocean.† It is not only probable, but it can be demonstrated, that this dispersion of the boulders and fragments continued for a long period, and while the land was rising from the ocean, and the gradual

* See Darwin's Journal, page 291 et seq.

† I am informed by Dr. Emmons, that although there is no lithological difference in the transported blocks on the St. Lawrence at the north and northwest, as well as at the west and southwest, of the Great Primary region of New-York, still they diminish rather than become more numerous on approaching the base of these mountains, while the reverse is true when we attempt to trace their origin from the south.

elevation of some portions above water might produce counter currents; and finally, after the land had risen to within eight hundred or one thousand feet of its present elevation, the great valley of Lake Ontario would form a broad bay, communicating with the ocean through the valleys of the Mohawk and the Susquehannah, while the communication by the valley of the Mississippi was becoming closed. Even for a long period after this, the bay of Lake Ontario would communicate with the ocean by the valleys of the St. Lawrence and the Mohawk, while the valley of the Hudson formed a narrow strait, with numerous inlets and bays; the granite mountains of Northern New-York and of the Highlands, and the old red sandstone of the Catskills, rising to the height of from two thousand to four thousand feet above its level.

I have enumerated only those mountainous regions of New-York and New-England with which I am familiar. Of the elevated country in Canada, north of Lake Ontario and the St. Lawrence, too little is known to speak with certainty; but it is extremely probable that this also has furnished its share of the transported materials, which we now find in the valley of Lake Ontario and Western New-York. Farther west, there remains no doubt but the country on the north of the great lakes has furnished the boulders of Ohio, Indiana and Illinois; and as these mountains become more elevated toward the sources of the Mississippi and farther to the northwest, they have been the source of a much greater number of boulders over the country west of the Mississippi, than farther east.

We have also to inquire what collateral proof we have of this condition of the continent, besides the dispersion of the boulders. I have before alluded to the deposits of newer tertiary extending through the valleys of Lake Champlain and the St. Lawrence, which contain marine shells of species existing in the present ocean. Similar deposits, but without the shells, exist in the valleys of the Hudson and Lake Ontario. These have been subsequent to the great abrading and denuding agency which has excavated the valleys and scored the surface of the rocky strata, and previously to, or in part formed during the period of the transportation of the granitic boulders.

This Tertiary deposit on Lake Champlain is elevated in some parts nearly three hundred feet above the lake, which shows a depression of the present level, at the time of its formation, at least four hundred feet. This would be sufficient to raise the water of the ocean about one hundred and seventy feet above Lake Ontario, or nearly to the elevation of the ancient ridge bounding that lake.* The boulders of Primary rocks are distributed over the surface of this fossiliferous deposit, and in some places imbedded in it. In speaking of their occurrence in the tertiary of the St. Lawrence valley, Capt. Bayfield says, "They are found in the cliffs at different levels, not resting upon each other, but as if they had been dropped there at widely different times, during a long period, in which a quiet deposition of clay, sand and gravel had been going on, and in which the different genera of testacea had lived and died. Some of the shells are of course broken, and some of the valves are separated, as is the case in the bottom of the present sea; but many have both valves together, although they separate when taken up, because the ligament no longer exists. All idea of these shells together with the sand,

* The level of Lake Champlain is ninety-three feet above tide water.

clay and boulders) having been drifted together into their present positions, must be given up at once, when I state the fact, that the *Terebratulæ psittaceæ*, which you know are so fragile that the smallest stones would be sufficient to destroy them, if carried along with a moderate degree of violence by moving water, are found with their valves together, and their long and brittle teeth entire as when they were living."*

The inference of Capt. Bayfield, that "these numerous erratic blocks have been dropped from time to time, from ice floes, on the bed of the Tertiary sea," is substantiated by all the facts observed; and we have already shown from what sources these boulders may have been derived, at a period when large portions of the present continent were depressed beneath the ocean level, and when the conditions of climate were favorable to the production of large numbers of living creatures on the bottom of an ocean, in the vicinity of islands almost 'wholly covered with everlasting snow.'

It is unnecessary here to follow any farther these deductions. The deposits of newer tertiary along the New-England coast show, conclusively, that all this region was equally depressed with that of New-York; and the presence of boulders there may, to some extent, be accounted for in like manner.

The elevation of the tertiary of New-York, or New-England, is not sufficient to explain the transport of boulders to situations fifteen hundred or two thousand feet above tide water, if we admit the ocean to have been only at sufficient height to allow of that deposit. But having proof of the conditions necessary for the transportation of boulders at this period, shall we not be warranted in carrying backward these conditions to explain the means of transporting those found at higher elevations, when the sea covered a much larger proportion of the land; and when, perhaps, the climate was less favorable to the production of living beings on the bed of the ocean?

The facts stated seem very clearly to establish distinct and widely distant periods between the formation of the great body of the drift in Western New-York, and the erratic blocks or boulders. These products have often; and indeed almost always, been confounded with each other; and the whole accumulation of superficial detritus, except perhaps the finer alluvia along river banks, has been considered as the product of a single period. It will be seen, also, that the scoring and polishing of the rocks has taken place at a period long anterior to the transportation of these northern boulders, and that their passage over the surface has had little or no connection with this phenomenon.

The production of the local or older drift in the Fourth District was, probably, caused by the elevation of the great mountain chains on the north and east; which, by uplifting and disturbing the sedimentary rocks far to the south, gave origin to those partial dislocations and undulations which have been noticed. At the same time the violent movements thus produced elevated the edges of the strata, uplifting, overturning and pressing them forward, with their load of detritus, as represented in the section, Plate VIII. I might go farther into an explanation of similar phenomena, which are developed over the whole extent of

* Extract of a letter from Captain Bayfield, R. N. to Mr. Lyell, November, 1837. (See Appendix to Silurian Researches.)

Western New-York; but I have already devoted more space than was intended to this subject, upon which, although there are an immense collection of facts, there is yet no universal mode of explanation.

The great difficulty has been in the attempt to find some one cause which would satisfactorily account for the whole, while no attempt has been made to recognize the products of successive periods. The idea of a universal deluge, early inculcated, and strengthened by the arguments and facts brought forward to sustain the opinion, has led to the general belief that all superficial deposits were due to a single period, and to one agency. Geological phenomena are now studied without reference to preconceived opinions or interpretations, and by adopting more natural and rational explanations than otherwise could be done, we escape advocating numerous absurdities, without conflicting with religious opinions. No geologist, at the present time, can use the term *diluvium* in connection with the deluge of Scripture history, or refer the superficial detritus of a country to the same agency.

In many instances the relative position of the Great Boulder formation, and the more ancient drift, is well illustrated in the natural or artificial sections of these deposits. It must be acknowledged that there are often huge unworn fragments of the rocks of the district mingled with the granitic boulders, but these rarely extend many miles south of the outcropping edge of such masses. The following example is a section of a hill in the town of Victor, Ontario county, on the line of the railroad:

163.

Section of Drift and Boulder formation, Victor, Ontario county.

The lower deposit is of fine and coarse sand, with pebbles of the rocks of the district, distinctly stratified; this is succeeded by an unstratified deposit of coarser materials, consisting of large and small pebbles and boulders of granite, and other rocks with intermingled clay and sand. With this deposit are some large irregular fragments of limestone from the upper part of the Onondaga salt group, which have been transported only a few miles. It is evident that at the time this heterogeneous mass was brought upon the lower deposit, it suffered denudation to a considerable degree, the upper layer of sandy loam, with some of the coarser materials, having been removed on one side. Numerous similar deposits have been observed, and indeed they are among the most common appearances of the drift hills.

The hills covered with drift along the south side of the Ridge road, and upon the shore of Lake Ontario, exhibit very similar phenomena. Some of the bluffs on the lake shore present large accumulations of clay and gravel above the boulders.

FIG. 164.

Section of Drift and Boulder formation, Greece, Monroe county.

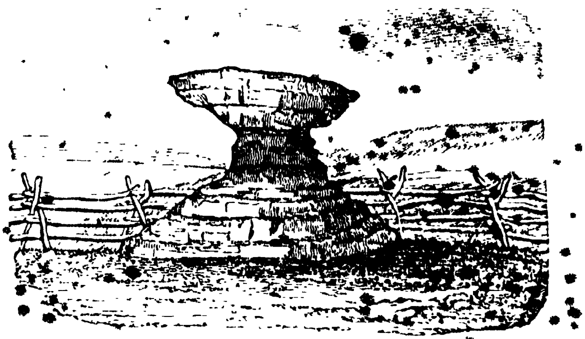
The illustration above is from a bluff in Monroe county, on the lake shore. The lower stratified deposit consists of gravel and loam, which is succeeded by a range of granitic boulders mingled with clay and gravel, and covered to the depth of several feet more with gravelly clay. The lower stratified deposit is evidently the product of a period distinct from that above, which presents no lines of stratification.

The bluff has been undermined by the action of the waves, and trees and stumps have been thrown, and often remain standing upright in the beach below; and on a cursory examination, many of them might be supposed to have grown there, so deeply imbedded and firmly are the roots fixed in the sand and pebbles.

Huge blocks of the Medina sandstone are sometimes found resting on the top of the Niagara limestone; these are scarcely worn, and appear to have been lifted from the upper outcropping edge of the mass, and dropped upon the limestone above. In like manner, numerous masses of the Niagara limestone are drifted forward, resting on the Onondaga salt group. Upon the terrace formed by the Corniferous limestone, we find great numbers of immense blocks of limestone from the upper part of the Onondaga salt group. This portion has been before described as an impure argillaceous limestone, in strata of ten or fifteen feet thickness. These masses frequently lie in their original position, as if the edge of the stratum had been enclosed in a mass of ice, which an advancing tide carried forward and dropped upon the bottom. The unequal hardness in different parts often causes them to be worn into fantastic shapes.

There were formerly several of these on the road from Caledonia to Batavia, but the following is the only one now remaining, which presents much of interest:

165.



Transported block of Hydraulic limestone, near Batavia, N. Y.

The upper and lower portions have resisted the action of the weather, while the central part has wasted away. There was formerly another one near this locality, but the upper part has since fallen down.*

In connection with this subject, may be noticed the direction of drift hills, as they occur in the eastern part of the district. In many places these hills have no definite direction, but all those north of the great valleys of Seneca and Cayuga lakes have a peculiar form and determinate direction. They are long, elevated ridges, rising abruptly on the north, and sloping gradually down to their southern termination. The ascent from the south is almost imperceptible, and often scarcely noticed, till one observes himself on an elevation of fifty or sixty feet above the valleys on either side. I have been informed by the engineers in this part of the country, that a line may be run for a long distance, upon the summits of these hills, having a direction N. 10° E.; and from numerous observations, this appears to be the prevailing direction.

It will also be seen that this direction corresponds very closely with that of Seneca and Cayuga lakes. The form of the hills is precisely such as would be made by a powerful current passing southward through these valleys, piling up the coarser materials at the northern extremity, and moving the finer ones farther on, until they were in some measure protected by this barrier before they were deposited. It is quite evident that this took place after the formation of the valleys, and probably at the period of, or subsequent to the boulder deposit. The materials are often mingled in the greatest confusion, though there seems to have been subsequently an equilibrium of the currents; for there is in many places a regular deposit of fine sand, and in the valleys one of clay covering the coarser products.

* May it not be possible that some operation of this kind may produce the "rocking stones," which are such a marvel? If the mass wearing away be thin, and those above and below are unaffected by weather, the one may be very nicely poised upon the other as the matter between is slowly removed.

166.

Alluvial hills and terraces on the Conhocton valley, as seen from Liberty corners. From a sketch by Mrs. Hall.

CHAPTER XIV.

MODERN SUPERFICIAL DEPOSITS.

After the period of the superficial deposits just described, and when the surface had become permanently elevated above the ocean, its inequalities would give origin to broad lakes and rivers, discharging themselves into the surrounding sea. By any irregular motion attending the farther elevation of the land, and even from the accumulation of water alone, the barriers of these lakes might be broken down, their beds deepened, and vast quantities of detritus carried to the lower plains, or into lakes or rivers at a lower elevation. That such has been the condition of the whole of New-York, will admit of demonstrative proof, and the details of the various modifications of this modern period would occupy many chapters. In many instances it requires much careful examination to separate the products of this period from those of previous ones, and also to recognize the different ages of modern deposits; for these again are, among themselves, referable to distinct epochs. We can only select a few well defined examples, and such as are produced by causes that will at once be recognized; leaving a consideration of the whole subject, and the various and successive changes, to some future opportunity.

There are numerous points where the accumulation of superficial detritus is local in its character, and very circumscribed in its limits. These deposits often consist of an intermixture of the older drift, with boulders which have been removed by the change in the course of a river, the bursting of a lake, or some other phenomenon of the kind. They are recognized by numerous characters; but a general distinctive feature is that of containing materials of both northern and southern origin, confusedly intermingled. They often rest upon previously formed superficial detritus, and are distinguished by position, as well as by the character of the materials. Several cases of this kind have been enumerated in the Annual Reports; and many others might be added to the list, were it necessary to increase the number for the sake of illustration.

In passing along the margins of the broad valleys, such as the Genesee and others, we find, opposite the mouth of every stream or deep ravine entering the valley, a mound of greater or less extent, and undistinguishable, upon the surface, from the surrounding deposits of similar nature. Occasionally, however, the bursting of a cloud, or a powerful spring flood, reveals to us the mode of those formations, in the production of mounds of earth, pebbles and fragments of rock which are swept down by the resistless torrent, and heaped up as the stream emerges into the broader valley. The more ancient deposits of this kind often cover many acres, and, from all the analogies, we must suppose that they were formed in the same manner as recent ones of the kind. Sometimes, however, it appears as if a lake may have burst its barriers upon the high ground, and the waters suddenly discharging, have carried forward this immense mass of materials. These deposits often occur opposite the inlet of ravines in which no water flows at the present time.

In many of the river valleys the accumulation of materials indicates the whole to have been occupied by a deep lake, and that the fine sand and loam has been brought down by streams, and spread over the bottom. Terraces are often left at successive points, indicating the stages of recession in the waters occupying these lakes, as the outlet has been lowered.

In the valley of the Conhocton, opposite the junction of the valley of the Canandaigua lake, there are several successive terraces, as represented in the woodcut at the head of the chapter. It would appear that at the same time in which the current was flowing down the valley of the Conhocton, a still more powerful current, probably loaded with detritus, came in by the valley from the north, and was carried against the south side, when these materials were deposited in the eddy current, while the stream turned its course to the east.

Along the courses of nearly all the streams and rivers, we find evidences of their having once stood at a higher elevation than at present. These evidences consist in long terraces of pebbles and sand, often successively repeated; and from being continuous, and at the same elevation for long distances, no farther facts are required to indicate their nature. It would require too much space to describe all the examples of this kind which have been examined. A few of the more extensive and important cases will be noticed.

The deep depression known as the Genesee valley, extends from Rochester, southward, as far as Dansville. Following the same direction we find, after rising several hundred feet, that this valley communicates with the valley of the Canisteo river, and thence with the Chemung and Susquehannah. The Genesee river, beyond Portage, flows in a valley more than five hundred feet above the same, after leaving the gorge at Mount-Morris. The northern part of this valley, from Rochester to Dansville, maintains nearly the same elevation throughout, or with a gradual descent to the north. It is one of the most ancient valleys of excavation; and its sloping sides, covered with superficial accumulations to the height of 600 or 800 feet above its base, show an immense period of time to have elapsed since its formation. Long subsequent to its formation it has been partially filled with water, having a barrier on the north, and extending over the whole plain of the "*Genesee flats*," and south as far as Dansville, in one great shallow lake. At the same time the valleys south of Dansville and south of Mount-Morris, by way of Gashaqua creek, were discharging their waters into this lake. With these streams was brought down a large quantity of coarse and fine materials, which we now find about Dansville, and below the junction of the Cashaqua creek, while the great extent of the valley is spread over with a fine sandy loam. The materials are precisely like those which are carried into modern lakes, by their tributaries; and when they are filled nearly to the surface, a growth of vegetation ensues, changing as the whole becomes drained.

An examination of this deep deposit, on the Genesee flats, shows conclusively that it has been made in a lake, such as described, with a current passing through it from south to north. The deposit was evidently carried forward in that direction, as indicated by the lines of lamination. The coarser materials, at the points mentioned near the embouchures of the streams into this lake, are, in considerable proportion, of southern origin.*

The former outlet of this valley appears to have been by the Irondequoit; but this becoming obstructed with the vast accumulations of superficial detritus, it sought another course, and excavated a channel by way of Rochester, which, as it has been worn down, has gradually drained the lake, leaving the present flats as its ancient bed.

The valley of the Genesee south of Portage seems to have been in a similar condition with that portion on the north, except that from the proximity of the hills on either side, a larger proportion of coarse materials has been distributed over the bottom. At the junction of the Angelica creek with this valley, there is the clearest evidence of its condition at that period. From the direction at which that valley joins the valley of the Genesee, the stream flowing in would extend across to the western side, depositing its coarser materials, while the finer sediment of clay and sand would be deposited in the eddy formed by the junction of the two streams. Accordingly we find below the junction of this stream an extensive deposit of sand, loam and clay, chiefly of the former; and its extent is marked in some degree by the growth of evergreen timber. [illegible]

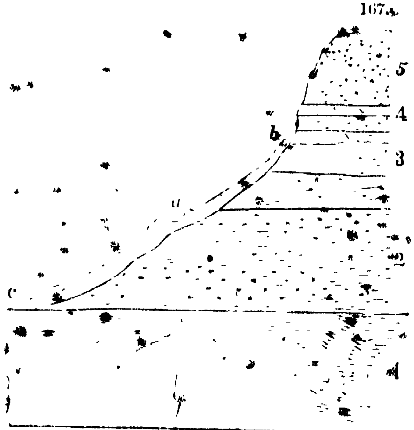
* As an example of this kind, may be noticed the accumulation of gravel and [illegible], resting on regularly stratified clay, at Squakie hill, near Mount-Morris. The excavation of the Genesee Valley canal has exposed a deep section at this place, showing the lower deposit of fine clay horizontally stratified, and succeeded by a stratum of coarse pebbles and gravel, and above this loose sand and gravel the [illegible] of rocks on the south. This example shows an inundation of these materials after the deposition of clay and loam forming the Genesee flats.

In the vicinity of Portage village, we find an immense deposit of coarse sand and gravel, piled upon an older deposit of sand and clay; showing, subsequent to the period of the ancient drift, and after the great deposits of clay and sand following it — indeed apparently subsequent to the boulder period — a condition of things producing this immense local accumulation. The lower deposit is regularly stratified, and consists in part of materials of northern origin. This appears to have been partially excavated, and another deposit spread over it, of materials from the south, consisting of flat masses of sandstone and scarcely worn pebbles, with loam and gravel.* It is entirely distinct from the formation below, and proceeded from a long subsequent operation. It will be farther alluded to in connection with the recent production of valleys and river channels.

The excavation of the Genesee Valley canal has given an opportunity of examining these deposits in a very satisfactory manner, and many facts have been brought to light. The surface alone, or the natural banks of the river, offer no opportunities of investigation.

In the broad indentation on the eastern side of the river, opposite the middle falls, the canal passes along the slope of the hill, which rises nearly two hundred feet higher. The lowest deposit excavated at this point consists of alternating layers of clay and quicksand, which, about one hundred feet lower, rest upon the rocks of the Portage group, as illustrated in the following section:

167.



Section of the hill at Portage tunnel.

1. Shales and sandstones of the Portage group.
2 & 3. Regularly stratified deposit of clay and quicksand.
4. Materials similar to those below, with fragments of trunks of trees in the lower part.
5. Gravel and sand, having a large proportion of its materials of southern origin.
a b, c. A superficial deposit, formed by the undermining of the hill above.
a. The point at which the Genesee Valley canal is carried around the hill.

* See Annual Report of 1840, pp. 439 and 440.

This deposit of clay and quicksand extends about one hundred feet above the level of the canal, where it is succeeded by sand and gravel. For more than two hundred feet from the bottom, the mass consists of alternating layers of sand from two to eighteen inches, with layers of clay of half an inch to two inches, each becoming thicker as we approach the upper part, where the quicksand layers are fifteen and twenty feet.

The upper layer, of fifteen feet thickness, becomes perfectly saturated with water, and is termed *liquid quicksand*; and this is succeeded by the deposit of coarse sand and gravel, which is of subsequent origin, containing materials from the rocks of the south, mingled with some of the older drift deposits which have been broken up. Through this the water percolates, saturating the mass below, and giving it the character of quicksand.

Fragments of the trunks of trees have been found in this deposit, in a layer of clay about thirty-five feet below the gravel.*

The whole of the lower deposit, consisting of regularly alternating layers of clay and sand, was evidently deposited in a quiet lake, while the subsequent one of gravel and coarse sand was brought on by some powerful inundation from the south. The fragments of wood are doubtless such as were drifted from the higher grounds into this lake, and sinking to the bottom, were covered by the subsequent sediment.

In several similar situations, bones of the mastodon have been found, and consequently referred to the period of the drift. These facts, however, offer no arguments in favor of such an hypothesis; for in all instances which occur in Western New-York, there is the strongest evidence of their having been transported from their original situation, and mingled with the more modern fluviatile or lake deposits.

Another circumstance to be noticed in connection with this section, is a superficial deposit (*a*, *b*, *c*) of about ten feet in depth, covering the whole slope, from the base of the gravel hill to the bank of the river. This surface deposit is composed of the ruins of the gravel hill, with the clay and sand below. From the constant oozing of water from the lower deposit, it undermines that above, which falling, carries with it something of those below, the whole constituting a moving mass, saturated with water. Its nature only became fully understood upon the excavation of the canal, when all that part above commenced sliding down, completely destroying the work. Farther examination proved that the whole hill side, for ten feet in depth, was in motion towards the river, and of course no excavation or fixture could be made permanent on such a foundation. In proof of this, and that such, for a long period, has been its condition, we find that the oaks which grow upon the hill, towards the top, have slidden down to the rocky margin of the river, where they stand among the hemlocks and cedars, sometimes upright, but often leaning in various directions.

* I am indebted to Col. Elisha Johnson, of Hornby Lodge, Portage, for numerous facts relating to this section, as well as for specimens of the wood, which was dug out under his direction. This wood has been examined by Prof. Bailey, of West-Point; but from its condition, he has been unable to decide its nature.

The whole surface, for half a mile, is saturated with water, and springs gush out at every step. We see very plainly how fallacious would be any reasoning as to the nature of these deposits from what appears upon the surface.

A similar modern deposition at Goat island, on the Niagara, will be described, in connection with the falls and river channel. Numerous local deposits of this character, of greater or less extent, can be found in nearly all the ancient valleys of the Fourth District, but it would occupy too much space to describe them. They are often, and generally due to similar causes with those above detailed. It appears as if, after the elevation of this region from beneath the sea, extensive lakes were left upon some of the higher grounds occupying broad depressions; and that these have frequently burst their barriers, producing local depositions of gravel and coarse sand along their outlets or in the valleys below.

CHAPTER XV.

LAKE RIDGES.

Ridge roads of Lake Ontario and Lake Erie—Terraced hills—Modern lake ridges and beaches.

One of the most interesting of the superficial deposits of the district is the "Lake Ridge,"* which, from Sodus in Wayne county, with some trifling exceptions, is a travelled highway, nearly as far as the Niagara river. Beyond this it can be traced quite to the head of Lake Ontario; and I have been informed that it exists upon the northern side of the lake. Throughout its whole extent in New-York this ridge is well defined, except from slight interruptions caused by the passage of streams. It bears all the marks of having been the boundary of a large body of water, and of having been produced in the same manner as the elevated beaches bordering the ocean or our larger lakes. The ridge follows the general course of Lake Ontario; being, at its nearest point, about three miles distant; and at its greatest, perhaps less than eight miles.

In some places it is strongly defined, descending toward the lake twenty or thirty, and even fifty feet, in a moderate slope. Its seaward side is usually covered with coarse gravel, and often with large pebbles, resembling the shingle of the sea beaches. The top is generally of coarse sand and gravel, though sometimes of fine sand, as if blown up by the wind, similar to modern beaches, when the coarser materials are thus left as the waves deposit them, while as the finer parts become dry they are carried to a higher elevation. It is sometimes so contracted upon the top as to offer only space for a broad carriage road, and again expands to a width of two or three hundred feet, being scarcely defined on the inland side. It is far from uniform in height, and in passing the distance of a mile inequalities of several feet may be perceived; still this feature is only an exception, and when the road is tolerably direct, a traveller may be seen as far as the eye can reach. Neither is this a single continuous ridge, but often divided into several, running parallel to each other, and again uniting in one. All these deviations in height, breadth, continuation, etc. only the more forcibly impress one with the idea of its analogy to existing beaches, where we observe the same inequalities. In looking from the ridge toward the lake, the uniform surface of the country and gentle slope

* The term *lake ridge* is used to distinguish it from the terrace formed by the outcropping edge of the Niagara limestone, which is known as the "Mountain Ridge."

remind one very strongly of the high sea beaches of pebbles and sand bounding many of our Atlantic bays, where, when the tide is down, he can see over an extent of miles of almost level sand and mud.*

If any thing were wanting in the external appearance of this ridge to convince the observer of the mode of its formation, every excavation made into it proves conclusively its origin. Fragments of wood, shells, etc. are found in digging wells, and cutting channels to drain the marshes on the southern side. I have not had an opportunity of seeing any of these shells, but have no doubt of their existence. In the town of Cambria, Niagara county, I was fortunate enough to find a recent excavation entirely across the ridge, cutting down to the level of the country on the south. The lowest deposit is a coarse sand or gravel, and upon this a regular deposit of silt and thin fragments of wood. Some of the latter, which are branches or roots of trees, have in parts entirely lost their woody structure, have become brittle, with a close grain and dark resinous shining fracture, and present, in fact, an appearance more like highly bituminous coal than any other substance. In some parts again the woody structure is more perfectly preserved, but still presents an appearance like lignite. The layer of vegetable matter is evenly spread, as if deposited from water, and afterwards covered with fine sand; to this succeeds coarse sand and gravel.

This example leaves no doubt of the mode of formation, if indeed any proof of the kind were wanting. I have been informed of numerous similar instances, though no other has fallen under my own observation.

In its eastern extension in the town of Sodus, this ridge ceases to be well defined. It will be observed that this point comes within the range of the valleys of Cayuga and Seneca lakes; and I have before remarked, that all the drift hills have a direction toward these valleys. The present level of Seneca lake is somewhat above the Ridge road, and that of Cayuga lake is below it.

At the time when the water of this lake or bay was at a higher elevation, it doubtless communicated with the valleys of Seneca and Cayuga lakes, and even discharged southward through these valleys, as indicated by the direction of the hills before alluded to. At a subsequent period there have been deep bays and marshes along the margin of Lake Ontario, which are still represented in the eastern part of Wayne county. These, with the water discharging into the lake from the higher grounds, prevented the formation of any distinct ridge; and still farther east through the valley of the Oswego river, Lake Ontario, at the time of the formation of this ridge, must have communicated with the Cayuga lake.

The interruptions in the continuity of the ridge, from the passage of small streams, are numerous throughout its whole extent. Many of these streams were doubtless discharging their waters into the lake at the time of the formation of this ridge, and have thus kept an open

* To the geological reader it will require no attempt to prove this the ancient beach of Lake Ontario, or a body of water, perhaps an arm of the ocean, which once stood at this elevation; such occurrences are well known elsewhere, but there are many persons in western New-York, and some grave critics among the number, who prefer to explain this by supposing some stupendous uplifting of the strata in this line from Sodus bay to Niagara river.

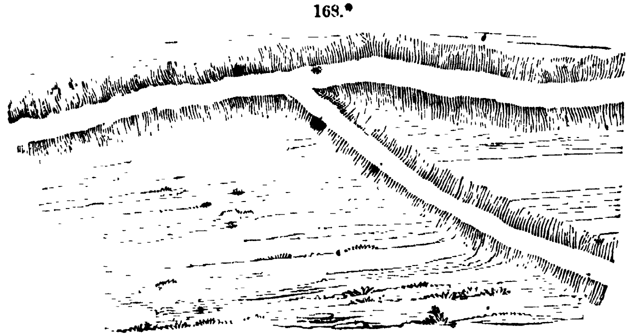
passage; others have been closed up during its deposition, and formed little ponds upon the inland side, which, subsequently becoming powerful, have burst through the barrier, and carried away large portions of it. The original elevation and extent of many of these ponds on the south side of the ridge is still distinctly marked, although there is now but an insignificant rivulet flowing in their channels.

The most important interruption in its course is at the entrance of the Eighteen-mile creek, in Niagara county. In passing from the east, we find, before reaching the creek, that it bends around to the south, showing that a bay extended inland along the course of the stream. After this there is no well defined ridge for four miles westward, where it again commences, and continues without interruption nearly to Lewiston. All these facts are highly interesting, as showing its analogy to modern beaches along the lake shore, and the effects of streams flowing in from the higher grounds.

In the town of Cambria, Niagara county, this ridge divides, or perhaps, more properly, we find a ridge diverging from the main one, and pursuing a northwesterly course for several miles, when it becomes merged in the general surrounding level. The main ridge, in the mean time, pursues its regular course, apparently uninfluenced by this diverging one.

The following diagram illustrates the position of these ridges:

168.*



The smaller one is known as the "Little ridge," from being less than the other; it is a single low well-defined ridge sloping uniformly on both sides, the country around being nearly level.†

* See note under Modern lake ridges, page 356.

† This feature of sloping on both sides, has been urged as an objection to the main ridge having been formed by the lake, as beaches are supposed to slope only seaward. Such, however, is not true either of lake or sea beaches, where they are formed before low or level ground, there is always a ridge sloping inland, as well as seaward, and elevated in proportion to the force of the waves and its position with regard to accumulation of materials. I could cite an example on Massachusetts bay, where the sea has thrown up a beach for the distance of two miles, and from twenty to forty feet above its own level, completely damming out a large marsh about its own elevation. The water from this marsh finds its way into the bay by a circuit of ten or fifteen miles. Precisely similar were the operations in the formation of this ridge; and analogous operations, only upon a smaller scale, are going on along the present lake shore.

The elevation of this ridge above Lake Ontario has been variously estimated from one hundred to two hundred feet. In 1838, through the kindness of Mr. Barrett, I obtained the elevation of the ridge north of Lockport, which is about one hundred and sixty feet above Lake Ontario; and very recently, Mr. Fay, the resident engineer at Lockport, has obligingly furnished me with the following levels:

The Ridge road, opposite Lockport, is below bottom of canal	106 feet.
Opposite Middleport, Niagara county	79 "
Opposite Albion, Orleans county	76 "
Opposite Brockport, Monroe county	76 "

The bottom of the canal at Lockport is 264 feet above Lake Ontario, giving the elevation of the Ridge road above the lake	158 feet.
At Middleport	185 "
At Albion and Brockport	188 " *

The bottom of the canal at Brockport is about two feet lower than at Lockport. The difference in the elevation of the Ridge road at these places is readily accounted for. The point opposite Lockport is where the ridge declines toward the Eighteen-mile creek, and is plainly much lower than the same a mile farther east. Middleport is ten miles east of Lockport, and the difference between the elevation at this place and the others still farther east is little more than the difference in the elevation of the bottom of the canal.

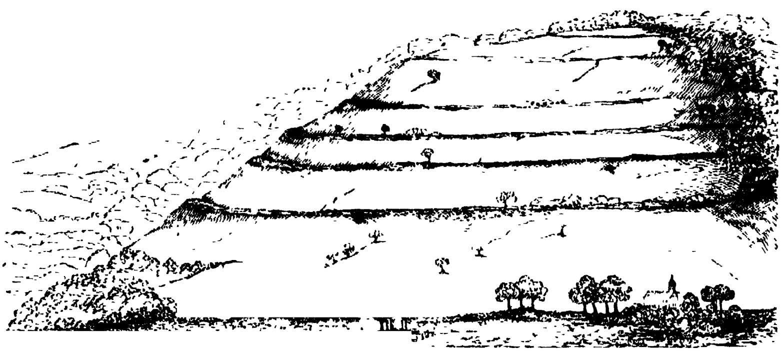
There is a similar ridge along the country on the east of Lake Erie, commencing south of Silver creek, and continuing beyond the limits of the State. The description of the ridge along Lake Ontario applies equally to this, except that the country east of it is higher, and therefore the ridge is less distinct, forming a terrace, from which one descends over pebbles and shingle to the lower ground towards the lake. I have not been able to learn that remains of shells or wood have been found beneath this ridge, as on Lake Ontario.

It is said that this ridge can be traced through Ohio; and the Geologists of Michigan inform me that a similar ridge likewise exists in that State, bordering both Lake Erie and Michigan. The elevation is about one hundred and fifty feet above the lake level, and fresh-water shells, with fragments of decayed wood, have been dug from beneath it.

* The three last observations embrace a distance of thirty miles, in which there is only three feet of difference in the elevation of the ridge. In Wayne county, Dr. Boyd (Annual Report of 1838) has estimated the elevation of the ridge at two hundred feet. I have had no opportunity of ascertaining by direct measurement whether this be correct; and even allowing it to be at that height, it varies but twelve feet from two observations in Monroe and Orleans counties.

Terraced Hills.

169.



Sketch of the hill on the west side of Seneca lake valley, at Jefferson.

Besides the well-defined ridges, which can only have been made by the water of the lakes or ocean remaining at this elevation for a considerable length of time, we often find a series of terraces which appear to have been produced by the rapidly subsiding water. In the illustration above is presented a series of distinct terraces, the surface of each with a few large pebbles upon it. Those represented are exceedingly uniform, and below the lowest are several others less distinct. I had at first supposed them due to the alternating hard and soft layers of rock; but the surface is so deeply covered with drift as scarcely to allow any influence from the strata beneath, even if the alternations were as regular as here represented, which is not true.

The sketch is of the hill at Jefferson, at the head of Seneca lake, taken from the opposite, more than a mile distant. When standing upon the hill sketched, and looking upon the opposite side of the valley, there appears a similar series of steps or terraces, though not so distinctly defined. Many similar appearances have been observed, but after the country becomes cultivated, they are soon obliterated. The ascent from Lake Erie in many places presents these terraces often well defined, and, by careful examination, they may afford some clue to its successive drainage previous to the period when the well-defined ridge before alluded to was formed.

The contemplation of these monuments of the former elevation of the water, and the marks of its gradual subsidence, lead the mind back to periods when the conditions of the surface, and the proportions of land and water, were very different from the present. If the relative elevations of the surface in New-York have remained the same from that period to the present, then the greater portion of the middle and eastern parts of the State would have been covered with water. At the same period, there must have been a communication between the waters of this great valley and the Mississippi, and with the ocean through both that valley and the

St. Lawrence and Hudson. These may have been successive stages in the subsidence of the waters, under the condition supposed, during which the northern mountains formed groups of islands, from which masses of ice with boulders were drifted over the surrounding sea, and deposited at various elevations. This supposition seems not improbable, nor would it be surprising if some of the remains of shells found in the ridge of Lake Ontario should prove to be marine, thus in a measure identifying it with the period of the tertiary of the St Lawrence and Champlain valleys.

The elevations of the different levels of this former ocean may, hereafter, prove of the highest interest, in connection with the theory of the distribution of boulders. The fields of boulders between Lake Ontario and the ridge were evidently dropped upon its bed in the most quiet manner. The thin deposit of older drift appears not to have been disturbed, and it lies evenly spread over the strata, till we approach the ancient shore, where the waves had sufficient power to pile up all the loose materials in one long ridge.

From the fact that no other well defined ridge exists between this one and the present lake, it seems that the elevation of the land was rapid; for, had there been a cessation for any considerable time, the waves would have thrown up another ridge of the kind, which does not appear in New-York.

The existence of these ridges, and others at higher elevations, though less prominetly defined, give us sufficient proof of the existence of water at different elevations, and of its gradual subsidence. These evidences have given origin to the theory of an ancient inland sea, which formerly spread over a large portion of the territory east of the Rocky mountains, and was limited by the great primary regions of New-England on the east. Subsequently, and at successive periods, this sea reduced its barriers, and eventually discharged itself by the valleys of the St. Lawrence, the Hudson and the Susquehannah, draining an immense area. This view seems very plausible, and there are numerous facts to sustain the conclusion, but still there are objections which appear to me insurmountable.

The evidences of the former elevation of the inland waters remain, principally, in the ridges and terraces of superficial materials. These are accumulated in valleys, and upon their sides, showing them to be of subsequent origin to the formation of the river channels and lake-basins. All the great outlets being apparently of the the same date as the valleys alluded to, it follows that this inland sea, if existing at all, had only to excavate its outlets through the superficial detritus. From all the testimony in the case, it appears more probable that these marks of the ancient limits, which are everywhere visible, resulted from the partial submergence of our continent after the present character of surface had been impressed upon it, or from the action of water during its later elevation. These ridges are the lines of successive emergence, and they are more or less strongly marked as they remained for a longer or shorter time the limit of the water.

Mr. Roy, civil engineer at Toronto, Canada, has examined these ancient sea beaches with much care; and has thus been able to establish several lines, at successive elevations, between the level of Lake Ontario and the height of 1000 feet above the ocean. From these facts, he maintains the existence of an inland sea, covering all that portion of country below 1000 feet above tide water, and that it has been successively drained to points corresponding with the following elevations, which I have taken from a plan constructed by him.* At some of these points the water remained long stationary, while in others only for a very short time, the duration probably depending on the facility with which the barrier at the outlet was reduced.

	Above the level of Lake Ontario. FEET.	*Above the level of the sea.* FEET.
O	762	996
L	680	914
G	420	654
E	344	518
D	308	542
C	280	514
B	208	442
A	108	352
Level of Lake Ontario,		234†

This theory, when connected with so many authentic observations, impressed me very favorably; but subsequent observations have not been sufficient to convince me of its truth; yet my examinations not having been especially directed to the subject, I may have overlooked important facts. The fact, however, which is demonstrable, that the great valleys of the Champlain, and St. Lawrence and Hudson, were excavated previous to a submergence of the land, and the formation of extensive tertiary deposits, likewise proves that the ocean, at this period, would occupy a large portion of the valley of Lake Ontario, and even, perhaps, of higher lake valleys. These are circumstances to be taken into the account in estimating the probability of the existence of such a sea.

Modern Lake Ridges and Beaches.

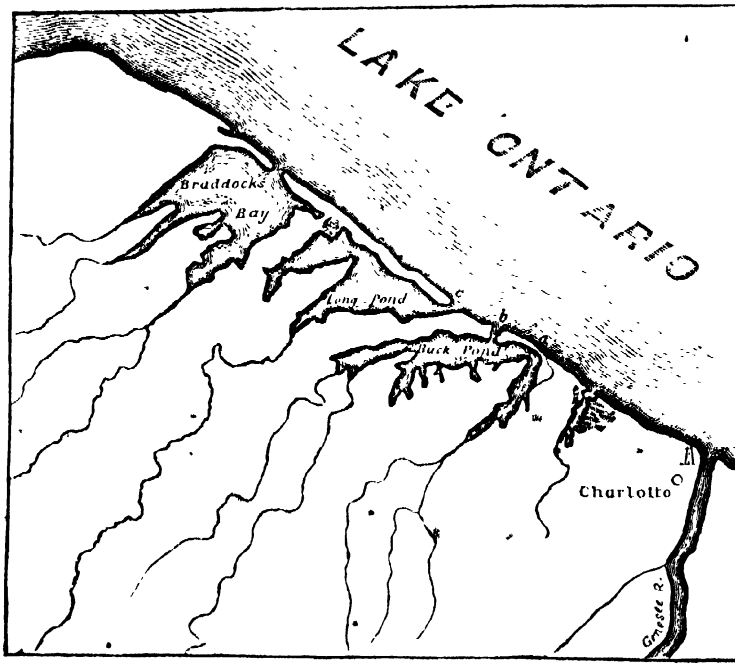
Connected with this subject is that of the modern beaches and ridges along Lake Ontario. These are such as may be formed in the space a few weeks or months, or even during a single storm. Some have stood for ages, and others are the sport of the changing winds and the fluctuating level of the lake.

Those which I have examined more particularly, are in Monroe county, and a few of these will serve to illustrate the character of the whole. The following map, including a small portion of Monroe county west of the Genesee river, will render these remarks better understood:

* The views of Mr Roy, have, I believe, been made public in some communications to the Geological Society of London; but I have not seen the publication, and my information is derived from his communications to myself.

† The elevation here given is three feet higher than that usually given by engineers in the United States.

170.

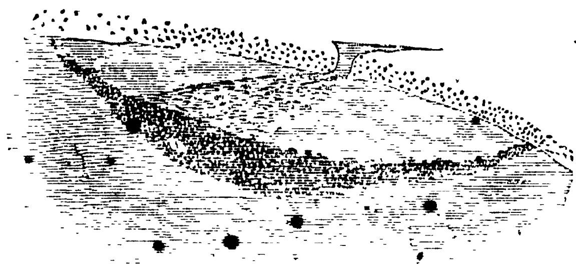


In passing westward from the Genesee, and approaching the outlet of Little pond, we come upon a raised beach of shingle, about fifty feet wide, and extending a quarter of a mile, separating the marsh from the lake. This slopes on both sides, and is a miniature representation of the Ridge road. The outlet through this beach is not more than ten feet wide, and during a storm is frequently closed. The action of the waves upon a bluff a little east of this has been very great during the few years past. Since 1838, a portion, several rods in width and three hundred in length, with a height of twenty feet, has been entirely removed. The coarser materials are deposited in long lines of shingle beach, while the finer parts are carried to a greater distance. Notwithstanding, also, that these beaches appear so permanent, a northeast gale will, in a few hours, remove them entirely, and deposit the materials in some other situation several miles distant. In this way the outlets of streams are dammed up, and remain until the accumulated water is sufficient to open a channel. Under these circumstances, two or more of these ponds become united in one, overflowing the marshes and low grounds bordering them.

At the time of my examinations, the outlets of Round pond, Buck pond and Long pond were all united in one. The point *a* in the map, which was the original outlet of this pond, was entirely closed, and a long beach of sand and pebbles extended to *b*, the present outlet, and continued beyond it for some distance. The outlet of Long pond, as marked in the map, did not then exist.* The channel at *b* being the passage for the accumulated waters of all these ponds, was very deep and rapid, being impassable for a horse. At the same time, from near the point *a* there extended a sand-bar, obliquely, into the lake, crossing the line of the channel, and beyond it turning toward the other shore. The water on this bar was comparatively shallow, being generally less than two feet, and never exceeding three feet. By following the course of this, I was able to drive safely across the outlet and gain the shore on the opposite side, which would have been impossible by any other course.

The following diagram of the bar and beach will serve to shew its situation:

171.



This bar is formed by the influence of two forces: the waves washing in, which carry forward the sand and deposit it in long beaches; and the opposing power of the steady current, which neutralizes that of the waves, and the sand thus falls down in a broad curve. The force of the current is principally expended in opposing the waves of the lake, and becoming diffused, it flows quietly out over the bar. This continues while there is no more than ordinary force in the waves; but on the occurrence of a violent northeast wind, the whole of this bar, with perhaps ten times as great an amount of matter, is driven upon the beach, closing the outlet. This remains so long as the wind continues, but as soon as it subsides, and the water in the ponds is able to force a passage through the beach, the old order of things is resumed, to be again subverted and again renewed. Such, simply, is the operation of one stream, as it has existed for the last four or five years; and such would be the history of hundreds of large and small streams along the lake shore.†

* This map is copied from Burr's county maps, published in 1829, which was probably correct at that time.

† By comparing this sandbar with the illustration page 350, we find that it bears the same relation to the beach that the "little ridge" does to the main ridge. If we suppose the Niagara to have been flowing into the lake at the period when it stood at the elevation of the Ridge road, may not the little ridge have been a bar, formed in the same manner as this miniature representation, by the opposing force of the river current and the advancing waves of the lake? That ridge, several miles in extent, bears no greater proportion to the power of the stream than does this insignificant sandbar to the outlet of these ponds. In reasoning *a priori*, we should infer that the beach would be destroyed under such circumstances; but such is not true, in fact, as we see by this instance and numerous others. These ridges are not always curved so much as represented in the drawing, and are often nearly parallel with the beach.

What a chapter does this simple process open in the former history of our great lakes, or in the present history of these and of the ocean where large rivers are flowing in! How many bars of sand and mud may be thrown down at the mouths of rivers which are beyond the reach of waves, and which only become known when the coast is elevated! By the gradual and constant rising of a portion of the continent, a series of such ridges may be formed, each of which will be at a lower level than the preceding one, and which, when the whole is elevated, would present an interesting series of parallel roads and ridges, as we may see to some extent in the ancient lake ridge, and along the present lake shore. May it not be possible that some of those ridges which have been identified as ancient *moraines*, are ridges which have been formed in this or a similar manner?

The beach before alluded to, between the lake and these ponds, is nearly a mile long before coming to the outlet; from fifty to one hundred feet wide, and generally not more than five or six feet above the lake. For the last few years it has been wearing away, and the roots of large trees growing upon it are becoming exposed, and some of the trees themselves are thrown down.

Farther westward, and along the distance between *b* and *c* (see map above), the space between the lake and the marsh is five or six hundred feet wide. This is occupied by three distinct ridges, running parallel with each other and with the lake. Near the western extremity, these three ridges divide into four, but continue equally well marked. Their summits are from six to eight or ten feet above the lake, and the valleys between them are from four to six feet lower than the tops of the ridges. The materials of which they are composed are similar to the recent lake beaches, consisting of pebbles and sand covered with a light sandy loam. They are overgrown with large trees of oak, elm, beech and button-wood, which shows their antiquity. Their form is distinct and well-marked, while the cause which gave rise to them more than a hundred years since is still active, producing other similar ones before our eyes. These associations carry us back to the time when the great ridge was washed by the lake; when the same causes were in action over a more extended surface, to produce that striking feature, which cannot fail to convince us of the former elevation of waters in the valley of Lake Ontario.

I might go on to illustrate the condition of the beaches and outlets farther west, but these few examples are applicable to the whole. The ridge or beach west of Long pond is undivided, and in many places from ten to twenty feet high, showing that a variation of a few feet in height can be no objection to the mode of formation. These ponds and marshes, which are now only covered with *Sparganium* and some coarse water plants, are rapidly becoming dry; and the process by which several are drained in one outlet, by keeping open the channel from the greater force of water, will tend more certainly to produce the result. During the time that these outlets remain closed, the water within the ponds is raised above the level of the lake without, and at the same time the mud and silt is brought in and deposited upon the bottom; by this process, we see in what manner those marshes now below the level of the lake will be raised above it.

The closing of the outlets of some of these streams is owing to the diminished quantity of water flowing into the lake by their channels. This arises from causes before explained, and which are constantly operating. For many years previous to 1835, the lakes were all at a lower elevation, and this allowed the formation of bars and beaches at the outlet of streams which before opened by a deep channel into the lake.

Some of the bays along Lake Ontario formerly admitted vessels for several miles, while at the present time they are partially or entirely closed. The beach formed at the mouth of Irondequoit bay has a narrow opening of three feet deep, while formerly it was a quarter of a mile farther east, and of a depth sufficient to admit sloops which took in freights at the head of the bay three miles distant. This bay is so situated, that it receives the abraded materials of the banks of the lake, both from the east and west. It is one mile and a quarter wide, gradually narrowing southward; and it is separated from the lake by a sandbar or beach from fifty to two hundred feet wide, and rising from three to twenty feet high. The greater part of this beach has accumulated within the last fifty years. At that distance of time, it was very low, and scarcely covered with grass; it is now overgrown in some places with large trees. The sand and silt brought down by the stream into this bay are gradually filling it up, and eventually it will become a marsh, with the stream winding through it to the lake.

The Twelve-mile creek, in Niagara county, presents a somewhat similar case. After the junction of the two branches, it runs in a deep broad channel nearly parallel to the lake shore for some distance, and its outlet is entirely closed with a beach of sand and pebbles. When the water accumulates so as to render the stream impassable, a channel is cut through the beach, which, from the greater flow of water, is kept open for a few days, when it again closes. The water in this channel, for two miles from the lake, is thirty feet deep, and vessels formerly entered here and loaded at that distance from the lake. We have here a repetition of the same circumstances as at Irondequoit bay. The diminution in the quantity of water has doubtless been one great reason for the closing of the outlet; for had it been greater, the outlet would have been kept open.

These are a few of the simple operations which, some centuries hence, will leave all this marshy region dry land, bounded by long ridges, the ancient beaches of the lake, through which the diminished streams will have made their way as in the ancient ridge which is now some miles distant from the lake. The same will eventually take place in all the lakes, though the process is so slow as to be scarcely perceptible. But we are to remember that the operations of nature are the same, and the causes never cease; so that if from analogy we prove that all this change has taken place, then by the continued existence of the same causes, we can anticipate, in a partial degree, what is still to result where the same materials are the subject of the experiment.

CHAPTER XVI.

Muck swamps—Lake marl, and tufa or travertine—Discoloration of sands and clays by percolating water.

The accumulations of calcareous marl and tufa or travertine, are among the most interesting and important of the modern formations. The early condition of the surface; the existence of large lakes, and their mode of drainage, has been before alluded to. In much more recent periods, and within the limits of human recollection, other changes, perhaps not as extensive, but of the same nature, have been going on. Small lakes are gradually drained by the deepening of their outlets, or filled up by the accumulation of sediment brought in by their tributaries. The effect becomes the same in both cases: as the water grows shallow, a growth of vegetation, fitted for the condition, springs up on the bottom; the plants are at first few, but the accumulation of mud and silt around these prepares the bottom for a stronger growth; and, finally, it becomes covered with the marsh grasses, *Sparganium* and the like. Mosses and shrubs sometimes succeed this, and finally larger trees, till the whole becomes overgrown with forest.

The luxuriant vegetation which thus year after year decays, and is accumulated upon the bottom, forms a thick bed of muck. In the Fourth District its condition is not that of peat, it being loose and friable, and crumbling to pieces when dry.

Many of these muck swamps are very extensive, and of the utmost importance to the farmer as a source of manure for his crops. In the southern counties, where vegetable manure is much needed, there are large tracts which could be drained at a moderate expense, and which would prove an invaluable acquisition to the inhabitants; for not only will they yield a constant supply of manure, but they are even more productive than the higher grounds, which are cultivated, while these are neglected. Along the south side of the Ridge road, and upon the borders of Lake Ontario, there are also extensive swamps and marshes, which, even in the natural course of things, are becoming redeemed from this condition.

The Cayuga marshes present an area of sixty thousand acres, which are almost useless in their present condition, but which may be reclaimed, and become some of the most valuable tracts in Western New-York. Even the growth and destruction of vegetable matter, and the accumulation of mud and silt, will eventually redeem this tract, though by artificial means it would be much sooner accomplished. This immense area has once evidently been a portion of the lake, and deeply covered with water. The outlet of Seneca lake has deposited here the debris of the strata it passes through, as well as much that has been brought in by other sources. The consequence has been a gradual filling up of the lake, until vegetation has taken root upon the bottom, and produced by its decomposition the extensive deposit of muck which covers the whole. There are similar deposits at the head of all these lakes, and in some cases considerable tracts have been reclaimed.

Lake Marl and Tufa.

In nearly all situations the muck swamps are underlaid by a deposit of calcareous marl. This is usually very finely pulverulent, and, though cohering when wet, is very friable when dry. When this calcareous deposit is made upon the surface, or in situations exposed to the air, it becomes a tufa or travertine, often preserving, in a most beautiful manner, the impressions of twigs and leaves, etc., so perfect that the species may be determined.

This marl is derived from two sources, one being the limestone rocks themselves, and the other the calcareous particles distributed through the superficial detritus, the origin of which is still the limestone formations. The drift materials being composed, in a large proportion, of the debris of the rocks of the district, calcareous matter is widely diffused. This is not only a constant fertilizing agent in the soil, but, from the action of rains upon the surface, and the passage of the water through these superficial deposits, the calcareous matter is dissolved and carried forward into some lower situations, where it accumulates in the bottom of the small lakes and marshes. By this process, extensive beds of marl are formed in portions of the district remote from any limestone formation of the older rocks. These deposits occur in the southern counties, wherever the drift from the northern part of the district has accumulated. In situations above the reach of this influence, the soil has too little calcareous matter to produce any such deposits, and consequently the elevated swamps in the southern counties are mostly destitute of it. This, however, is not universally the case; for the bed of Casadaga lake, and the marshes around it, contain deposits of marl.

Some of the most extensive formations of this kind in the district are made upon the Onondaga salt group, and are deposited from the copious springs which rise along its southern margin. By referring to the head of *Springs*, under Corniferous limestone, it will be seen that there is a large surface drained through the fissures of that rock, and that this water flows out in the form of springs, on the north side of the terrace formed by it.

These deposits of marl usually rest upon a bed of clay or sand, and are succeeded by muck. In the greater number of localities its formation has long since come to an end, but in others it is still in progress. In many of the springs issuing from the rocks, its daily deposition can be observed; it incrusts all the vegetables growing in the stream, and, in favorable situations, forms deposits of considerable extent. The tufa is used for building stone; being soft, when first removed from its bed, it is easily cut, or hewn into blocks of convenient size. These, after drying, become comparatively hard, and form a durable material. There are, however, but few situations where there is a quantity sufficient to allow of its being used in this manner.

In the bottoms of all the lakes in the northern and middle parts of the district, the *Chara* abounds, as it also does in the beds of streams, where the water is charged with calcareous matter. By dredging along the bottom, it may be brought up in large quantities, and the same takes place after high winds. The prevalence of a high south wind is sufficient to strew the shores of Seneca and Cayuga lakes with this vegetable. It is always incrusted with, indeed apparently almost changed to, carbonate of lime. It is at first green, but by exposure soon becomes white, and crumbles to powder in the hand.

In the outlet of the Caledonia spring this vegetable grows so rapidly, and so abundantly, that it chokes up the mill-races, and requires to be constantly removed. The presence of carbonate of lime seems favorable to its growth; for in other similar situations, where this is absent, it does not flourish.

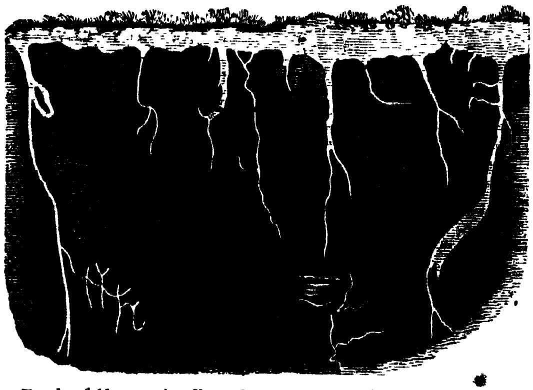
In the greater number of the marl beds the remains of fluviatile testacea are very abundant, though it is only in a few situations where they have formed any large proportion of the deposit. The shells appear to have flourished in immense numbers, probably from the facility with which they obtained calcareous matter, and other favorable circumstances; but still it is plain that the formations of this kind are generally due to calcareous springs, or to the percolation of rain water through the surrounding rocks, which, from its excess of carbonic acid, dissolves the calcareous particles in the soil or the harder strata.

The shells occurring in these deposits are all of recent species, and indeed the same may often be found, still living, in great numbers, in the marshes above the marl. The *Limnea jugularis*, *Planorbis bicarinata* and two or three other species, *Valvata tricarinata*, and *Cyclas similis*, are among the most abundant species.

Discoloration of sands and clays from the percolation of water.

The discoloration of sand and clay beneath muck swamps, or vegetable deposits of any kind, is deserving of notice as sometimes leading to important conclusions. The green lines and patches in the Medina sandstone have been attributed to the deoxidation of the iron, from the presence of carbonaceous matter. The same is noticed in the Old and New red sandstones, and indeed in all rocks colored by oxide of iron. In the superficial deposits, the presence of free carbonic acid renders the water capable of dissolving and removing the coloring matter, forming deposits of the hydrous peroxide of iron. This takes place with great facility in muck swamps, or where there is a deposit of vegetable matter above the soil. In this way we are to account for the white gravel and sand found in swamps and bog meadows. In some cases the change is only partial, and in others there seems a change from a lower to a higher state of oxidation.

We usually find two kinds of clay noticed; the blue and yellow, the latter succeeding the former, and generally supposed to be a subsequent deposition. This may perhaps be true in many localities; but in Western New-York, not only the clays, but the other superficial deposits often take their color from the effect of the percolation of water, which probably changes the state of oxidation in the coloring matter. The surface deposits have originally been of the same blue color as those beneath, and this change takes place after sufficient exposure. This may be made apparent by the following illustration:



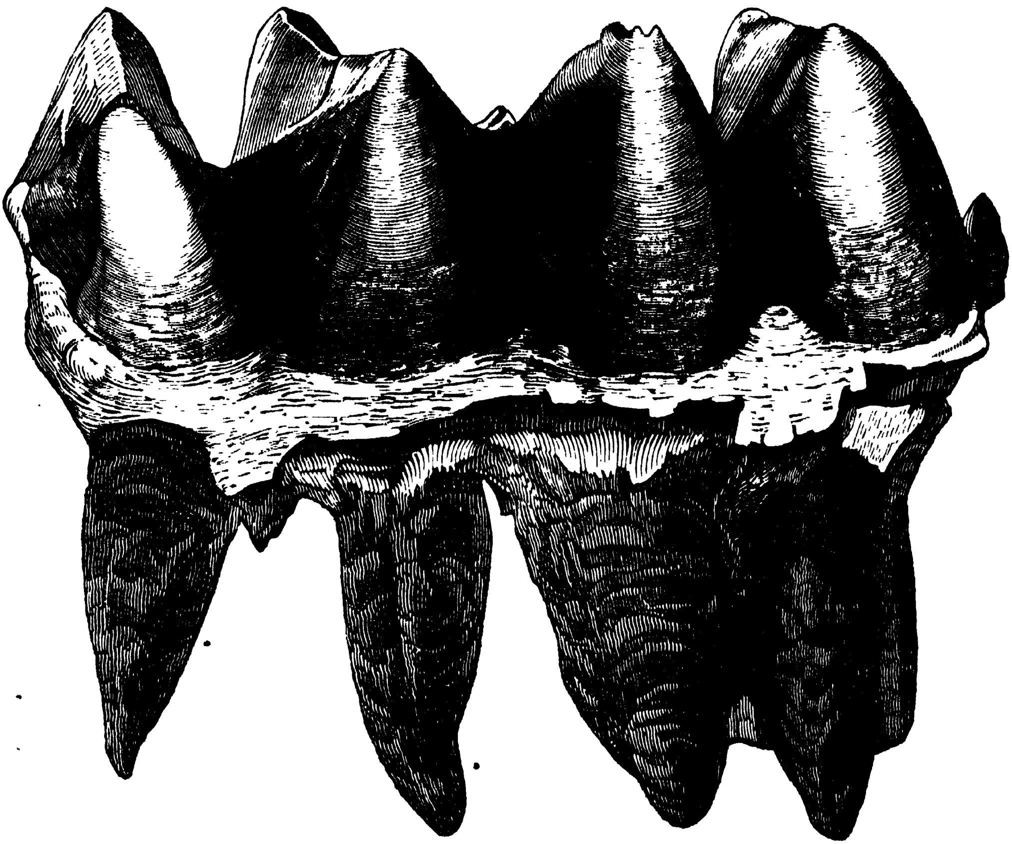
Bank of blue and yellow clay, Dunkirk, Chautauque county.

The lower deposit is a blue clay, with small pebbles or gravel sparingly intermixed; the upper part is a yellowish brown clay, with veins of the same penetrating the blue clay in the manner represented in the woodcut. The upper part is distinctly mingled with gravel, as well as the veins, while the blue appears a more pure clay; but this appearance is fallacious, for on examining the blue portion, it is found to resemble the upper precisely, except in color. Farther examination also proves that these veins are merely apparent, being caused by the discoloration of the blue clay from the percolation of water. The water sometimes penetrates laterally, and produces beautiful ramifications of the yellowish veins. In this example the process is perceptible, and the passage of water along these lines can be witnessed at any time. In many other cases the cause is not so apparent, though in a large number of instances I have been able to detect the same agency, attended with similar results.

This is a subject well worthy of attention, not only among superficial deposits, but among the older rocks; for these have often been near the surface or above water before their induration. How far it may explain the change or alteration of color in successive strata, or the apparent veins of segregation in some of our rocks, I am not now prepared to decide; but I have seen numerous examples apparently due to changes of this kind, which have operated before the strata became fully consolidated.

In the clays, it of course happens that the yellowish deposits are subsequent to the blue, and they are often more pervious to water from an intermixture of sand; but the limit of the change in color will be found at the depth to which surface water penetrates. The lower clays are the more purely argillaceous, and therefore less pervious to water; consequently this portion of the deposit retains its color, while the more sandy parts are rapidly changed.

173.



Molar tooth of Mastodon maximus. Geneseo, Livingston county.

CHAPTER XVII.

Fossil Bones of Quadrupeds.

Fossil bones of the Mastodon have been found in numerous localities throughout the district, and, since the relative period of their existence is one of much interest, it seems desirable to ascertain the comparative date of the formation in which they are imbedded. These remains are not only distributed throughout the Fourth District, but have been found in all that part of the State west of the Hudson river and south of the valley of the Mohawk. But two localities have been noticed on the east side of the Hudson, within New-York. In New-England the remains of this animal are comparatively rare, and their occurrence has been recorded in only a few localities.* This rarity, when contrasted with the numerous localities in Western New-York, and the still greater number in the Western States, shows that the animal found a more congenial condition of the surface, or climate, at the west than among the primary regions of New-England and New-York.

The following are the localities which have been recorded, or have fallen under my own observation within the Fourth District:

1. In the town of Perrinton, in the bank of a small stream, in gravel and sand. A tusk and several teeth were found at this place, which are now in the Rochester Museum.

2. In 1817, some remains were found in Rochester, in a hollow or water course.†

3. In 1838, during the excavation of the Genesee Valley canal, at its junction with Sophia-street in the city of Rochester, a tusk, some bones of the head, several ribs, parts of two vertebræ, and some portion of the pelvis were found, intermingled with gravel and covered by clay and loam, and above these a deposit of shell marl. These bones are now in the State Collection. The tusk is said to have been nine feet long, but was nearly destroyed by the workmen before removing it from the clay. A portion of a tibia was also found, which is in the Rochester Museum.

4. During the excavation of the Erie canal at Holley in Orleans county, a large molar tooth was found in a swamp near the village.‡

5. A molar tooth was found in digging a mill-race at Niagara falls, several feet below the surface. The deposit in which it occurs is a fine gravel and loam containing fresh-water shells, and is evidently a fluviatile deposit.

6. In a small muck swamp in Stafford, Genesee county, a small molar tooth was found several years since. Its situation was beneath the muck, and upon a deposit of clay and sand. A large quantity of hair-like confervæ, of a dun brown color, occurs in this locality; and so much does it resemble hair, that a close examination is required to satisfy one's self of its true nature.

7. In 1841, a molar tooth, weighing two pounds, was found in a bed of marl three miles south of Le Roy.

8. At Geneseo in Livingston county, several years since, a large number of bones and three teeth were found in a swamp beneath a deposit of muck, intermingled with a sandy calcareous marl. A single tooth, in the possession of C. H. Bryan, Esq. of Geneseo, is the only known remaining specimen of this collection. The figure at the head of the chapter is from this fossil.

9. At Hinsdale, Cattaraugus county, a tusk, with some horns of deer, were found sixteen feet beneath the surface, in gravel and sand.

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* See Hitchcock's Geological Report, page 402. † See New-York Fauna, Vol. 1, Part 1, p. 103.

‡ For this information I am indebted to Col. Elisha Johnson of Rochester, having seen no published notice of it.

10. At Jamestown, Chautauque county, a tooth of a mastodon was found several feet beneath the surface, in gravel. Dr. Emmons has in his possession a tooth from the same neighborhood, said to have been found in a bank of clay. Dr. De Kay refers this specimen to the *American Stag*.

The localities enumerated are all that are known as occurring in the Fourth District. The different positions in which these remains are said to have been found, will probably all admit of one explanation.

Notwithstanding the numerous localities which have been examined, and the great numbers of bones disinterred, there still seems to exist among many a doubt as to the period of their existence upon the earth. Their bones are said to be found in the diluvial or drift, thus identifying them with that period which, from all testimony, seems to have been one of general submergence beneath an ocean, and we have no knowledge of a previous condition of the surface fitted for their existence. It is doubtless true that these bones often occur imbedded in gravel and sand of the nature of the ordinary drift; but in such instances it can usually be shown that they have been transported, and that the deposit in which they occur is one of very modern origin.

In all situations where these remains appear to have been left undisturbed, they are associated with the most recent deposits, proving that the animal has existed upon the surface since the present condition of things prevailed.

In speaking of this subject, Dr. De Kay remarks, that "The geological period at which this huge animal existed, has occasioned much attention. It must have been among the most recently extinct of all quadrupeds, unless we except some species whose generic types still exist on this continent. Rejecting as altogether fabulous the pretended discovery of the stomach of this animal, with its contents, consisting of reeds, twigs and grass, as detailed by Barton (*Med. and Phys. Jour.*, Vol 3, p. 23), it has certainly been discovered in positions indicating that the animal perished and left its bones on or near the surface where they are now found. Cuvier states that the mastodons discovered near the Great Osage river were almost all found in a vertical position, as if the animals had merely sunk in the mud (*Oss. Foss.*, Ed. alt. Vol. 1, pp. 217, 222). Since that time, many others have been found in swamps, a short distance beneath the surface, (frequently some of the bones appearing above the soil.) in an erect position; conveying the perfect impression that the animal (probably in search of its food) had wandered into a swamp, and unable to extricate himself, had died on the spot. Such an incident doubtless occurred to the animal whose remains we assisted to disinter, some years ago, at Long Branch, New-Jersey. He was in a natural vertical position, his body supported by the turf soil or black earth, and his feet resting upon a gravelly bottom. The occurrence of the bones of other animals not yet extinct, in company with those of the mastodon, is not a conclusive evidence of their contemporaneous existence; but we cannot deny that it furnishes strong reasons for believing them to have been of a very recent date. We think it highly probable that the mastodon was alive in this country at a period when its surface was not materially different from its actual state, and that he may have existed cotemporaneously with man."*

Of the very recent existence of this animal, there can be no doubt; the marl beds and muck swamps where these remains occur are the most recent of all superficial accumulations (indeed they are now forming), and the surface had arrived at its present condition generally before these began to be formed. Any great change, such as the submergence of the land, would obliterate these deposits, and mingle their contents with the surrounding drift. That they are of very recent formation, is also proved from their usually resting on the drift, being the latest deposits in shallow lakes after the final deposition of the sand and clay and the elevation of the continent.

The situation of the bones in the Fourth District offers no exception to the general rule, but rather confirms it in all instances. In the first named locality in Perrinton, the deposit of gravel and sand is a recent one, made by the stream on which it occurs.

In the third instance, the bones were somewhat mingled with pebbles, and a portion were lying against the side of a large boulder; but the deposit covering them was evidently of very modern origin, containing fluviatile shells. The surface for some distance around had evidently been a lake, which was subsequently filled up, and became a swamp; and finally, since the settlement of the country, this swamp has been reclaimed.

In the fourth instance, the tooth was in the bottom of a muck deposit, and above the gravel. At Niagara falls the deposit is a very modern one, containing shells of recent species, and evidently of the same age as Goat island, which is elsewhere described. The tooth was probably drifted by the current into the situation in which it was found, and therefore furnishes no knowledge of the period of its existence, but proves the deposition at that place to have been subsequent to the destruction of the mastodon.

The specimen at Stafford, in the bottom of a muck swamp, was probably part of the remains of an animal which had perished here, and had never suffered transportation.

In the case at Geneseo, where the bones were said to be imbedded in gravel, it is proved to have been a shell marl.†

The deposit of gravel and sand in which the remains of mastodon and deer were found in Cattaraugus county, is one of very recent origin, having been made from the ruins of the drift, by the stream along which it occurs.

The same is doubtless true of the formation at Jamestown, as there are some extensive deposits of recent origin at the outlet of Chautauque lake; but I have not examined this locality.

It appears, therefore, from a consideration of all the facts, that the apparent instances of

* New-York Fauna, Vol. 1, Part 1, p. 105.

† While Mr. Lyell was in this part of the country, being desirous to ascertain the truth among conflicting statements, he procured an excavation to be made at the spot where the bones were originally found. Some fragments of bones were obtained, mixed with marl and freshwater shells, leaving no doubt of the position of the animal, which doubtless perished on the spot where these remains occur.

bones imbedded in drift are accounted for upon other principles, at least so far as regards the western part of New-York. The most probable explanation appears to be, that a marl lake has been suddenly drained, and its contents, mixed with gravel, sand and boulders, transported to a distance, where the whole was left as a deposit resembling the ordinary drift.

I might mention two other localities which I have visited; one at Coeymans, and the other at Greenville in Greene county, where the bones were imbedded in a freshwater marl, or rested upon the clay beneath the marl. There is here no possibility of their having been transported; and the inference of Dr. De Kay, that these animals perished while in search of food in swamps, seems substantiated by the position of their bones.

It has been noticed as a remarkable fact, that the bones of other animals have rarely been found with those of the mastodon; and of this, the circumstances just mentioned may perhaps offer some explanation. If the nature of the animal induced it to search for food in such situations as we find their bones, those that sunk in the mud, or died there, would be preserved; while other animals, having no inducement to go into those places, would leave no evidence of their existence. The bones of other animals, and even those of the mastodon, when left in situations exposed to atmospheric influences, and as a prey to smaller gnawing animals, would be destroyed, and no vestige of them would remain. This we know to be true, from the fact that although the country has been long inhabited by great numbers of moose, deer, bears, wolves, and a variety of smaller animals, yet rarely any of their remains are found; it is only in situations favorable to their preservation that they occur; and the same is true of the mastodon. It thus appears probable that the remains of this animal which we find are but a moiety of the hundreds and perhaps thousands which died in other situations, and left no record of their existence.*

From all the facts observed, it seems not very improbable that the mastodon has lived since the continent was inhabited by man. In the earlier condition of the surface, it was probably better fitted to sustain these animals; the kinds of food they required grew more abundantly, the nature of the surface was adapted to their habits. Subsequently this state of things became changed, and small portions only may have afforded them the required kind of nourishment; under these circumstances they have become extinct; not suddenly, as has sometimes been conjectured, but gradually as the conditions of the surface became incompatible with their existence. In this respect doubtless their mode of extermination resembled that of some other animals which have disappeared, and are disappearing from the earth. In the latter, the influence of man has had a large share in the process; while in the former, we are not aware of any such influence, unless we give credit to the aboriginal traditions.

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* Mr. Williams, one of the assistant engineers, has informed me, that at the summit level of the Genesee Valley canal near New-Hudson, four miles from Cuba, several deer's horns and the horn of an elk were found twelve feet below the surface, in a muck deposit. In the same situation, a piece of wood, gnawed by beavers, was also found. These are all remains of existing animals, but the position is the same as that in which the bones of the mastodon are found.

174.

Lower falls at Portage, from the west bank of the river. From a sketch by Mrs. Hall.

CHAPTER XVIII.

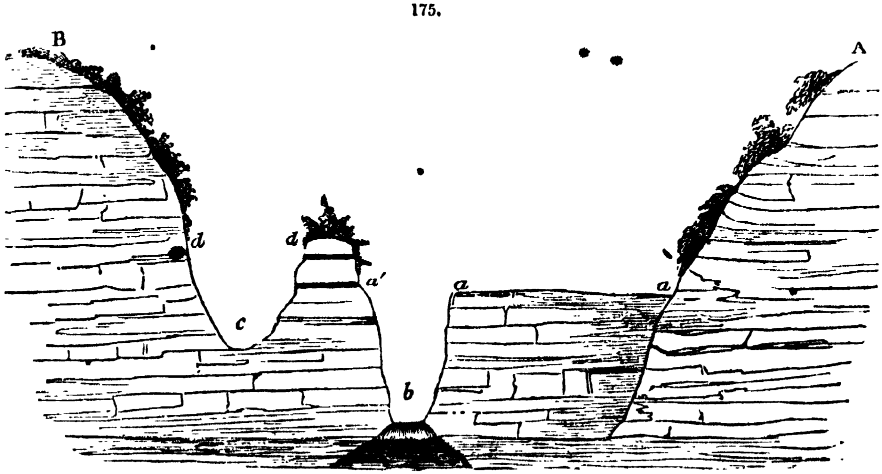
Modern action of rivers—Freezing of water in river channels.

The numerous examples which we have in the Fourth District, of rivers flowing in deep narrow gorges, naturally prompts the inquiry whether the present streams can have formed the channels in which they now flow? Fully to answer this question would lead to the consideration of numerous circumstances, and open a wide field of inquiry. Every river and smaller stream, even the most insignificant, will furnish facts for illustrating the subject. Although we may find these modern operations upon a much smaller scale than in the mountainous regions of Northern New-York, still the effects are everywhere visible. The trees standing upon the very margin of a stream falling over a rocky stratum, or upon the edge of a cliff with their roots projecting more than half over the precipice, or even the tree itself prostrated and held suspended only by a few fibres which penetrate the soil beyond the chasm, are eloquent monuments of the changes wrought by time upon the rocky cliffs and deep river gorges. These show that nature in all her operations is constant and unremitting, and that the least perceptible change within the memory of man becomes a vast incomprehensible amount during the millions of ages through which the earth has arrived at its present condition. If a river channel can be widened and deepened to the amount of a few inches within the recollection of any individual, may not a gorge of one or two hundred feet be formed by the same process? Our theories of modern operations make provision for wide sweeping deluges, for immense excavating waves, for hemispheres of ice, the upheaval of mountain chains, and the transportation of ice floes from frozen islands in our own latitudes; but we have almost forgotten the quiet operation of running streams, and the freezing of water in fissures of hardened rocks.

In the first place we may consider a few of these effects which are known to us, and afterwards compare them with similar ones which may have resulted from the same causes. By this method we shall be able to prove that rivers have worn their channels not only through preëxisting beds of modern detritus, but also through the barriers of solid rocks.

The sketch at the head of the chapter represents the lower falls of the Genesee at Portage. The bed of the stream is bounded on either side by cliffs three hundred feet high. Upon the left bank is a table of rock, which was formerly the river bed; and upon the right is a small conical island of rock, between which and the table on the other side, the stream now flows. Within the memory of the oldest observers, the river flowed almost wholly over this table rock, and the isolated mass was joined with the right bank of the river. The following diagram will enable the reader fully to comprehend its present and former condition:

175.



A, B, represents the width of the chasm at the top.

a, *a* The platform or bed of the stream, over which the water was originally precipitated ninety-six feet to the level of the river below the falls. This platform *a a* was formerly continuous to *a'*.

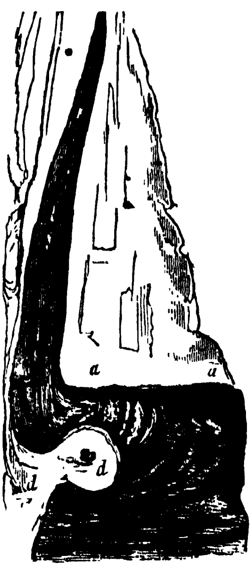
b. The narrow channel of recent excavation.

d, *d*, and *c*. A recent gorge, separating the small island from the main bank.

This table or platform is composed of a firm sandstone less than two feet thick, resting on softer strata beneath. A slight depression had been worn between *a* and *a′*, over which a larger portion of water flowed than over the space between *a* and *a*. This depression increased in depth by the wearing action of the water and the effects of freezing, so that long since, the great body of water has flowed through this recent channel. During freshets, and at the breaking up of the ice in the spring, the narrow channel on the right is filled, and it then flows over the table above to the depth of a few inches.

The following ground plan of the river at this place will illustrate its condition at the period before the projecting mass of rock was worn through:

176.



a, *a*. The table or platform, which originally extended across the whole width of the river's bed.

d, *d*. An elevated projecting mass of rock, standing in the direct course of the current.

The first operation by which this change was effected, seems to have been a deflection of the current to the right side, caused by a bend in the river above. This force diminished towards the edge of the fall, and the projecting portion of the cliff *d*, *d*, was thus protected for a long time, until the channel on the right side, becoming deepened, drew off nearly all the water in that direction, when it was gradually worn through. When first known, this isolated mass was joined to the main cliff; and when subsequently a passage was formed at *c*, the upper part still remained connected with it. This arch was afterwards broken down by the action of freezing water and its own weight, leaving it in its present condition.

The principal modern effect illustrated in this example, is the formation of the narrow channel on the eastern side of the river bed, which now extends back from the fall about one-eighth of a mile, being in its greatest depth about eighty feet, and nearly the same in width. For the whole of this distance it forms a violent rapid, and the action of water and ice is constantly tending to increase its dimensions. Within five years, the period of my own observation, it has been deepened in some places five or six feet, and its southern termination has extended several rods. Except during freshets, or the breaking up of winter, the water does not flow through the channel c of diagram No. 175, and consequently the wearing action has nearly ceased in that direction. The stream, however, is directed against the little island seen in the sketch, and will eventually remove it, making for itself a direct channel to the gorge below.*

If all the changes here described have taken place within the last forty years—if a river of the power of the Genesee has in one place excavated a channel of these dimensions—what results may we not ascribe to similar action in larger bodies of water? It is not too much to say that the deep gorge from Portage to Mount-Morris has been worn in the same way, or that the chasm of Niagara, from the falls to Lewiston, has been excavated by the stream now flowing in its bed. In making these estimates we are not to count time by years, but by ages; and there is abundant testimony that years beyond our comprehension have passed since the surface of the earth assumed its present form, and since the rivers began to flow in their present courses.

I have cited this case as an example, because it is one well known, and where observations have been repeatedly made; and because, within the last five years, I have examined it several times, and each time with a conviction of the changes that were in progress. The breaking up of the ice every spring removes large masses of rock at the head of this channel, and these, with others, are carried forward through the gorge, with a force that tears up its bed and sides. The table above, which was formerly the bed of the river, will, in a few years, become covered with soil and vegetation; strong grass and willows have taken root in the fissures, and these collecting about them a little earth, giving a soil for the support of the other plants, the evidences of its original condition will be lost. A century hence some incredulous observer may stand on the edge of this table rock, then covered with shrubs and trees, and deny that the insignificant stream flowing in its bed can have excavated this deep chasm. An observer of similar dispositions may now stand upon the margin of the great gorge of the Genesee at Portage, and say that it is impossible for this river to have worn it to the depth of three hundred and fifty feet, and with a breadth of six hundred feet. But the Genesee was once a more powerful stream, and it has flowed in its present direction longer than we are usually accustomed to consider as the age of the world.

The consideration of this small portion of the channel of the Genesee leads us to the examination of the whole of that deep gorge extending from Portage to Mount-Morris. The greater portion of the channel for this distance, so different from that in which the river flows, either to the north or south, requires a different explanation of the mode of its formation. The river flowing northward from its source through the valley south of Portage, then bends around to the

* For a knowledge of the early condition of this fall, and many of its successive changes, I am indebted to my friend Colonel Johnson of Hornby Lodge, who explored this part of the country in 1808. Col. Williams, an early settler in this region, gave me a very similar account of its condition when first known to him.

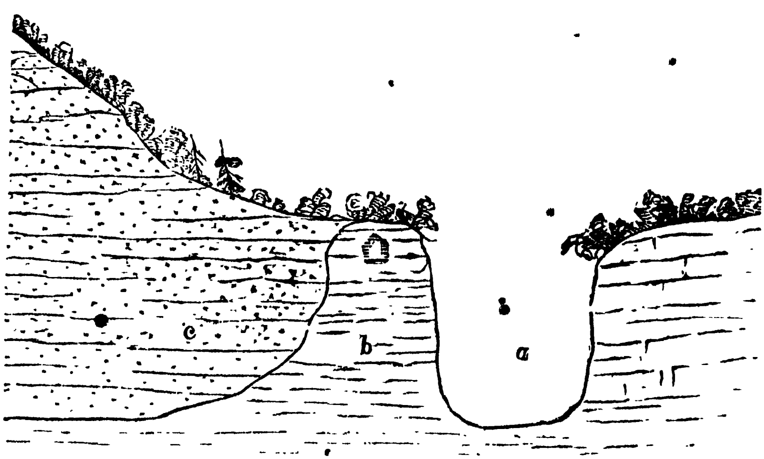
left, and pursuing, for a short distance, an almost opposite direction, again gradually assumes a northerly course; but here, instead of the alluvial bottom of a broad valley, with sloping sides, it flows through a deep narrow gorge, and in the space of less than two miles precipitates itself over three falls, descending about four hundred feet.

It is to be recollected that in all the narrow portions of this gorge the cliffs are nearly or quite perpendicular, the chasm is narrow, and there is no deposition of drift or alluvium in its bottom. The bed of the stream presents a vast accumulation of fragments, fallen from the sides of the chasm, and there are few or no rocks of foreign origin. From the very aspect of this kind of channel, when compared with the broad deep valleys, we would at once decide, that it is of more recent origin.

In examining the country north of Portage, in the direction of the river, on the south, we find a valley filled with an accumulation of sand and gravel. This has been sounded, in many places, to such a depth, and over an extent so great as to authorize the conclusion that it was an ancient valley which received these deposits. The uppermost of these is very modern, as was before shown (page 345), and doubtless made after the river was formed; indeed, probably after it had followed this channel for some length of time. The inundation of gravel and sand closed this former valley, and the Genesee on the south became a lake. It then took a course westward, over the lowest barrier, which appears to have been in the direction of its present course Here it has formed for itself a channel in the rocky strata, worn in some places to the depth of three hundred and fifty feet.

The following diagram shows the respective positions of the ancient valley, now filled, and the present river channel:

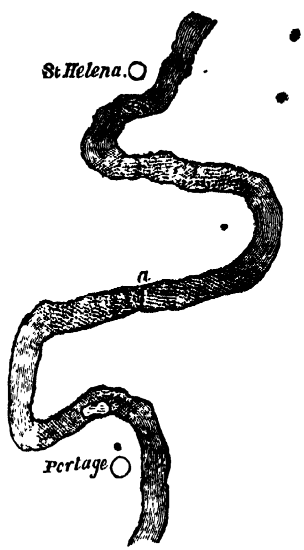
177.



a. Present channel of the Genesee.
c. Ancient channel, filled with modern detritus.
b. Strata of shale and sandstone of Portage group.

Whatever may have been the causes which closed the old channel, there can remain no doubt of the mode in which the new one was formed. We can think of no other cause than the action of the stream itself, that would excavate such a channel, with vertical walls, and in a direction so devious. If it were of the age, and formed by the same means as the majority of valleys, it would be broader in proportion to its depth, and its sides and bottom present some deposits of drift. Where the stream emerges into an old valley on the north, near Rogers' bridge, after making this circuit, a distance one-third as great, direct from Portage, would have brought the stream through the old valley filled with drift. Between Rogers' bridge and St. Helena the direct route is filled with drift, while the river channel is a narrow deep gorge, making a circuit of three miles. Again, for three miles before reaching Mount-Morris, the same devious course is pursued, and the banks are almost equally precipitous, though, from being shales, they are less abrupt. In all these instances the banks bear the marks of a freshness of excavation not to be mistaken. It is emphatically a modern channel.

178.



The accompanying illustration represents the course of the river from Portage to St. Helena; a direct line between the two places would have passed in an ancient valley, while all the deviations are through rocky strata, and in deep gorges.

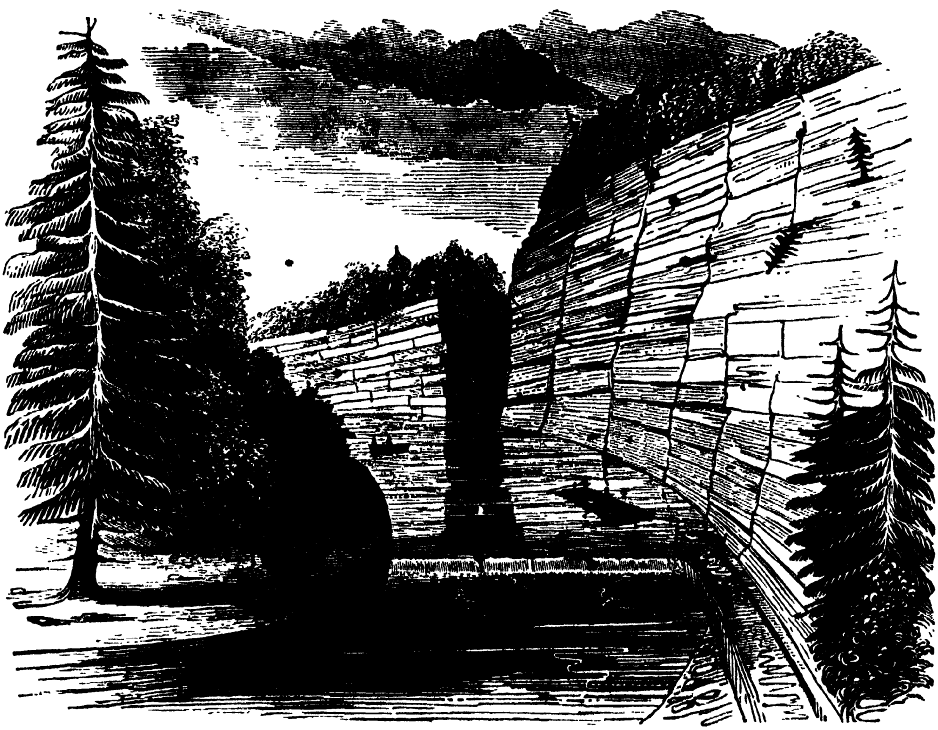
a. Position of the lower falls of Portage.

This example is sufficient to enable us to understand how a river, when obstructed in one direction, will excavate a channel in another; and even, though the obstruction be only loose materials, it often finds an easier course by wearing down hard rocks than by removing gravel and sand; making a circuitous route through solid strata, while a more direct one would have been through a superficial deposit.

Nearly every stream flowing from the south, over strata of this age, presents the same features, in a greater or less degree. A hundred examples can be cited where there is demonstrative proof of the recent effects of streams upon their beds; examples such as will make us hesitate before we decide that such effects as deep gorges can not be formed by running streams.

The few lateral streams that flow into the Genesee, in its course through these gorges, give evidence of the same recent origin in the channel. The streams either fall over the vertical edge of the cliff, having worn it back to some little extent; or they come in through lateral channels, with vertical sides, scarcely disturbing the continuity of the cliff, any more than if a deep cutting had been excavated by artificial means. The appearance of both the main channel and the lateral one, respectively attest their modern origin.

179.



Entrance of Wolf creek into the Genesee above St. Helena. From a sketch by Mr. E. N. Horsford.

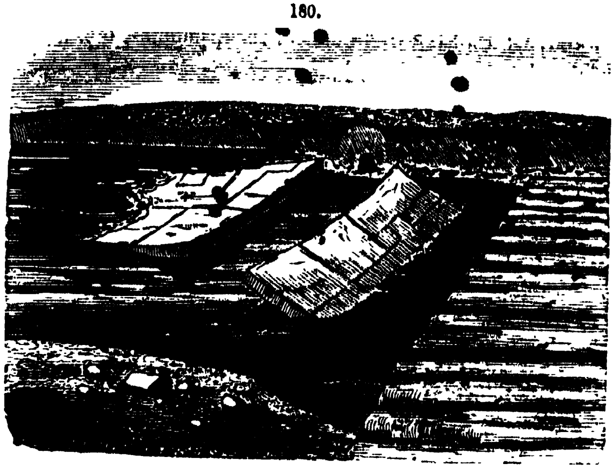
The entrance of Wolf creek into the Genesee offers a good example in point. The lateral channel is, at its entrance, a square cut gorge of nearly two hundred feet deep. Farther from the river, however, the stream appears to have flowed in the bottom of an ancient shallow valley, before it excavated the present gorge. Such is doubtless the fact in other instances, where there has been a sufficient depression upon the surface to give direction to the water, after which it has cut its own channel far into the strata beneath.

Action of freezing water in deepening river channels.

The manner in which streams deepen their channels, particularly in the rocks of the southern counties, is illustrated at every step. The rocks, consisting of alternations of hard and soft materials, are readily influenced by the freezing of water; and the bed of any stream can scarcely be examined, but the strata will be found elevated in the centre, and dipping toward each side. Sometimes the elevation is on one side, and the dip towards the other. This takes place by the water first finding its way through a fissure beneath the stratum, where it freezes and elevates the rock; loose earth and pebbles find their way into this enlarged fissure, and beneath the stratum; during the succeeding winter, a larger quantity of water freezes beneath it, and elevates it still more. If the breaking up in spring does not remove it, the next winter will be sufficient, and then the whole is carried onward, with ice, stumps, trunks of trees, etc., till it finds some level place in the bed of the stream, where the whole rests for a period, to have the same operations renewed.

The following illustration is a sketch from the bed of the south branch of the Cattaraugus creek. A thick stratum has been elevated by the freezing of the water, till its edges are above the surface. This sketch was taken two years since, and probably the whole is now replaced by others.

180.



This mode of operation is constant; and no sooner is one portion removed, than another is lifted up, to follow in the same manner. In the thick-bedded limestones, its effects are less rapid; but even here the influence is perceptible, and occasionally large blocks are loosened and carried down the stream.

Potholes—Effects of artificial dams.

These evidences of running water exist in several places in the Fourth District; but in all that I have seen, they are near the margin of some stream, and in a situation easily accounted for by supposing the water at a higher elevation. In the rapids at Rochester, small potholes are formed in the limestone, and also in the sandstone and shales of Portage on the same river. In the bed of the river at the Rapids above Niagara falls, large and deep potholes are formed. These probably exist over the whole extent of the rapids, as they are visible in all accessible places. On the western side of Goat island, there are remains of some of these in situations higher than the water usually flows, proving therefore that the elevation is less, and that at the time they were made, the margin of the fall was farther north than at present.

Potholes similar to these are frequently worn in rapids below artificial dams. Mr. Wilder, of Hoosick-falls, informs me, that on turning the water to repair a dam which had been standing twelve years, potholes of four feet in diameter, and several feet deep, were found in the sloping rock below. Dr. Ambler, of Ogdensburgh, informs me of still more important effects produced by the falling of water over dams. The dam at Brownville, Jefferson county, which was erected forty or fifty years since, in a narrow place in the river, bounded by perpendicular walls of limestone, and flowing over a bed of the same, had a perpendicular fall of twelve or fifteen feet. From the time of its erection till 1841, when it was carried off by a freshet, the falling water, with all the fragments of rock, pebbles, etc. had been wearing upon the limestone bed of the river, and had produced a cavity or pothole estimated at fifty or sixty feet in depth. Sawmill logs of fourteen feet in length, passing over this dam, would plunge beneath the water, disappear for a considerable time, and on coming to the surface, would rise more than half their length above water. From this circumstance it was considered that the depth of sixty feet was not too great an estimate. The rock is of hard grey and black limestone of the Black river and Trenton limestone formations.

In another case, of the dam at Ogdensburgh on the Oswegatchie, with a fall of twelve feet, the water has removed large slabs of limestone of a foot thick, and from ten to twenty feet in diameter, and carried them several rods down the stream.

Neither are these isolated instances. I could extract pages from my note books, showing the modern effects of running and falling water, freezing, etc.; but examples enough have already been presented.

181.

Taghannuc falls, Tompkins county. From a sketch by Mrs. Hall.

CHAPTER XIX.

Waterfalls.

The numerous and picturesque waterfalls of the western part of the State are intimately connected with the modern action of rivers and streams, in excavating and deepening their channels. That every fall of water is receding by wearing back its bed, will admit of demonstrative proof, wherever observations have been continued for any length of time. Even the short period of four or five years has been sufficient to show, in many instances, a constant, gradual recession, varying with the quantity of water and the nature of the rock. The greatest amount of water does not always, however, appear to be attended with the most rapid recession; for where the stream is so small as to be entirely frozen during winter, the effects of ice on the strata seem even more efficient than the wearing of water. The loosening of masses near the edge, at least, enables the water afterwards to remove them with greater facility.

Where we find these falls upon streams half a mile from their junction with a large lake, it is difficult to conceive how they have once commenced their operation on its margin, and we are readily disposed to admit any hypothesis that will account for the previous excavation of a lateral valley to this distance from the main one. Where these channels expand rapidly toward their outlets, and slope gradually upward, it seems a fair inference that some agency other than the wearing of the stream has had a share in producing its present condition; but where we find a regular chasm with perpendicular and nearly parallel sides, with a fall of water at its extremity, we are compelled, from all analogy, to admit that the stream has been the agent producing it.

In the sketch at the head of the chapter, there seems originally to have been a broad shallow depression, in which the stream commenced flowing towards the lake. In its passage, it first produced a series of falls and rapids, but finally receded so as to form but a single fall. This is caused by the higher strata being so much harder than those below, that a firm table is formed of these, while those below are undermined. At the present time the fall is about a mile from the lake shore, and one hundred and ninety feet in perpendicular height, being the highest fall in the State. The water is precipitated into a deep chasm, with cliffs on either side of three hundred feet in height. The stream becomes almost lost in spray before reaching the bottom, where it is gathered in a circular pool, from which it flows over the rocky bottom to the lake. The fall is usually approached from the lake, and it forms one of the most romantic and picturesque scenes in the whole of Western New-York. The stream, insignificant as it appears, is nevertheless during freshets of great power, carrying forward huge slabs, which are piled up below the fall in a manner such as we are accustomed to attribute only to the agency of more mighty streams.

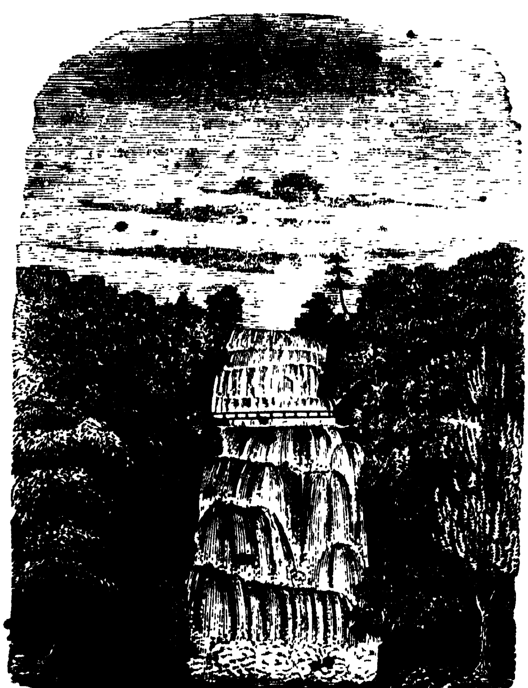
Although there may have been originally an indentation at this point, from the valley of Cayuga lake, yet there seems conclusive evidence that the stream has been the chief agent in producing this immense chasm. The numerous seams freely admit the water, which during winter is frozen, and thus from the whole face of the cliff immense quantities are detached. In this way the upper portion is left projecting beyond the lower, till it is broken off, and falls down. The first process is constant; and during an interval between my visits to this place, I observed that a mass of fragments, scarcely less than fifty tons, had fallen down. This is doubtless but a small part of what is annually separated by freezing water, and the more quiet operation of moisture and air during the milder season.*

* The lower of the two more prominent arenaceous strata, about half way up the cliff, is the one presenting the fine casts of striæ, alluded to in the description of these under Portage group. Beautiful specimens may be obtained at this place after the falling of a mass, or by approaching the stratum at some accessible point. Many of the strata in the channel of the stream above the fall present these casts in great perfection.

This mode of operation will explain the cause of recession in a great number of instances. Where, however, the water is in such quantity as to preserve a temperature above freezing, as in the outlets of some of the lakes, the recession is slower; the chief agents in effecting the destruction of the rock being the wearing action of water, and the effects of air and moisture.

It may be natural to suppose, that if these streams commenced their operation at the same period, and upon similar rocks, that they would have *worn back* the strata to the same distance. The fact, however, is, that the falls are at extremely unequal distances from the main valleys into which they flow. This may, in part at least, be accounted for from the circumstances of a different proportion of water and a greater or less height of fall, as well also as many other minor causes which may have operated to vary the amount of recession. Along the Seneca and Cayuga lakes there are many examples of falls over the same strata, at almost equal distances from the lake. About one mile north of the Taghannuc falls, there is another fall of water over somewhat similar strata; but here are no indestructible layers near the summit to act as a table rock, and the whole elevation is worn down in a continuous slope, with some narrow projections formed by thin arenaceous strata. Had there been, near the top, a thick stratum, capable of sustaining the water, we might have had a fall similar to the one in the illustration.

182.



Hector falls, Tompkins county. From a sketch by Mrs. Hall.

Where there are frequent alternations of argillaceous and arenaceous strata, a series of falls and rapids are produced; but, in such cases, the total amount of wearing action is far less. The sketch above is an example of this kind, where the fall has scarcely receded from the lake shore. A slight indentation only is produced in the abruptly sloping bank of the lake, and the same outline is preserved as if, on either side, it were stripped of its earthy covering. The strata here are principally arenaceous, and offer little facility for rapid wearing away; while at Lodi falls, a few miles farther north, where the principal part of the rock excavated is shale, the fall is now about one mile from the lake. It is impossible to say, with certainty, that these streams began their operations at the same time; though, if such had been the case, they would never have receded at the same rate.

183.

Entrance of the Canascrowlie into the Cattaraugus creek.

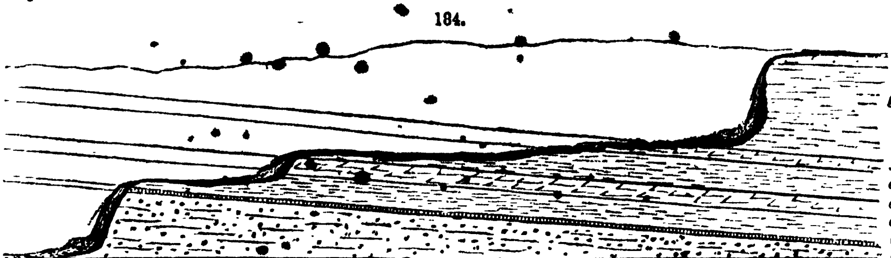
In the more recently excavated channels we find the streams falling over the very edge of the cliff, having produced no perceptible recession in the margin of the fall. The sketch above is an example of this kind, where the Canaserowlie unites with the south branch of the Cattaraugus creek. The channel of this latter stream is one of very modern excavation, as might be shown from numerous facts, similar to those in relation to the Genesee about Portage. The cliffs are almost vertical, to the height of one or two hundred feet, and the gorge is narrow, presenting no deposits of drift. Its course is devious, however, and it sometimes enters an ancient valley, presenting a very different aspect from the recent one.

A series of observations, for one or two centuries, will enable us to speculate with some degree of certainty regarding the probable rate of recession in waterfalls. But the observations require to be made at different points; upon streams of different magnitude; on falls of different elevations, and upon those falling over different kinds of rocks. The rate of recession in one fall will be an unsafe guide for estimating that of all others. Accurate maps of the country, with monuments placed in situations where observations may be made, are the only means by which this knowledge can be gained; and when the inhabitants feel sufficient interest in the operations of nature to establish and preserve such monuments, we shall be able to arrive at important conclusions regarding the periods which have elapsed since these streams began to wear their channels. Even with our present knowledge, these speculations are not always unprofitable; they lead us to take into consideration numerous influences which ordinarily escape observation, and we often find that hasty conclusions are essentially modified, or often changed, by the consideration of new facts.

The different rates of recession in waterfalls is shown when the successive rocks are of different degrees of hardness, producing a series of falls. This happens where the highest are more destructible than the lower, and by this means the upper fall outruns the others. The Genesee river at Rochester presents an example of this kind, where the Medina sandstone, the rocks of the Clinton group, and the Niagara group, have each produced a distinct fall. This, at one period, was doubtless a single cascade; but the upper shale wearing away faster than the rocks below, allowed the fall to travel rapidly southward till it came to the limestone surmounting the shale, where its progress was somewhat arrested. At the present time it seems probable that the lower fall is receding faster than the upper, which is thus protected.

The following diagram illustrates the position of these falls, and the rocks over which the water passes:

184.



1, 2, 3. Upper, middle and lower falls.

a, b. Medina sandstone.
c, d, e, f. Shales and limestones of the Clinton group.
g. Shale of Niagara group.
h. Limestone of Niagara group.

The upper fall is now upon the northern edge of the limestone, which increases in thickness for two miles south, being a medium of constantly augmenting resistance; while the Medina sandstone and the limestone of the Clinton group, are no thicker and no more difficult to wear away than they have been for centuries past. Thus it is plain, that under otherwise equal circumstances, the lower falls will advance upon the upper, until the whole will become one. It will not then, however, be of the height of all these; for the long rapid between the upper fall, and the present place of the lower one, will be nearly as much descent as the fall at present.

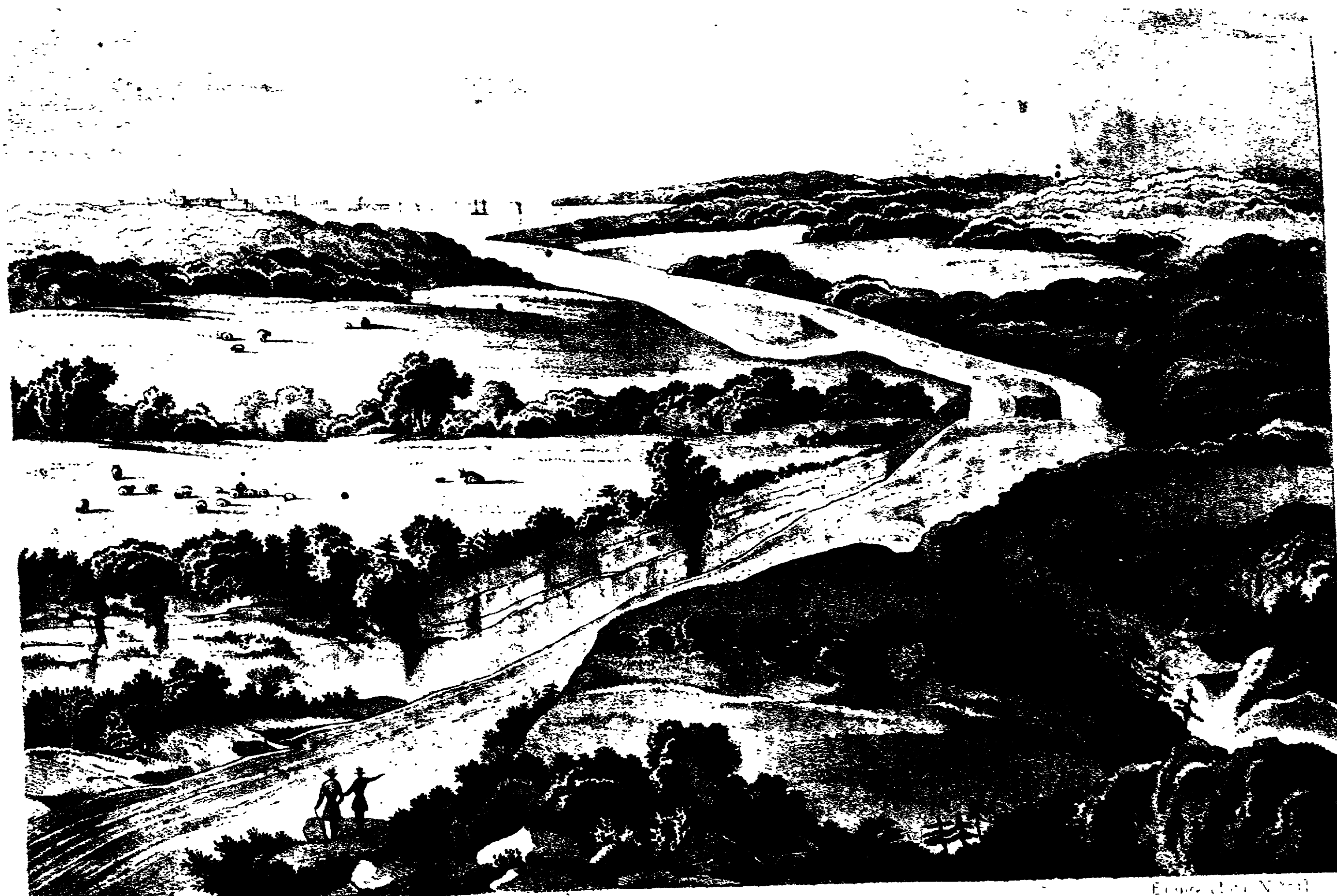
These speculations are offered, not with a view to any practical bearing, but to correct an erroneous impression which arises from the first view of these falls. Since there are now three falls, and since we suppose there was a period when only one existed, it is natural to infer that the same cause that first produced a separation would continue to operate to perpetuate the same condition. This would doubtless be true so long as the nature of the strata remained the same; but it is equally evident that any change in these will change all the other conditions.

185.

Lower falls of the Genesee at Rochester. From a sketch by Mrs. HALL.

The lower fall at Rochester has evidently receded but very slowly for a long period; the broad expansion in the river below evidently indicates that the falling water and eddying currents have done their work upon the cliffs for many centuries. Still within a short period the stream has excavated the rock deeper upon the west side, and during the dry season nearly all the water flows in that direction. This will eventually wear a narrow channel like the lower fall at Portage, leaving a platform the original bed of the stream on the east side.

This locality offers a good exhibition of the succession of the strata. The Medina sandstone rises to the top of the falls, and is succeeded by the Clinton group, and this again by the shale of the Niagara group. The layer of limestone containing the *Pentamerus oblongus* is here one of the most prominent and interesting portions of the mass, while in the succeeding shales occur the fossils figured under the Niagara group; thus presenting a succession of the strata, scarcely so well exposed in any part of the district.



[illegible] FALLS,

And the surrounding Country.

CHAPTER XX.

Niagara Falls, its past, present and prospective condition.

Among the phenomena of waterfalls and river gorges, the Cataract of Niagara is justly regarded as holding the first rank, and as standing an index in the path of time, by which the influence of numberless ages upon the surface of our planet may be recorded. Its present, its former and its prospective conditions have engaged the investigation and speculation of many philosophers. The possible consequences of its entire reduction, and the drainage of the upper lakes, have excited the wonder and the apprehensions of many. The estimated time of its recession has sprinkled grey hairs among the fresh locks of the young and blooming earth, and alarmed those who would consider her still youthful in years.

But amid all these speculations, Niagara still remains; the thunder of its cataract still reverberates through its deep chasms, and its ocean of waters still rolls on as, unknown to the white man, it rolled a thousand years ago. When we come to the investigation of facts, we find that, except to travellers and the aborigines, Niagara was unknown until within the last fifty years; and that even during this time no accurate observations have been made, no monument erected to determine whether the falls are retrograding or not. The testimony of living witnesses and historical evidence unite in confirming the opinion that the water is wearing away the rock, and that the outline of the falls has changed. From these general observations, it has been estimated that they have receded at the rate of about forty feet in fifty years. Without pretending to question the accuracy of this or any other estimate of the kind, or to establish any rate of retrogression in the falls, we may examine its present, and from numerous facts infer its past condition; and from these we are entitled to draw an inference for the future, though without specifying time.

Both in relation to the former condition and to the future recession of the falls, we may regard the problem as undecided with respect to time. So many disturbing causes are constantly presenting themselves, that, although the great principles may be regarded as established, still it is impossible to calculate accurately the effect of these minor influences. The recession of every mile changes the whole aspect: new elements are brought into operation; the nature of the strata varies; the relative height of certain portions, and the elevation of the whole cascade is altered; and we have had time to observe only one of the phases, and to reason from that to the future, before the condition is changed, and we must take into the account new influences, which the previous changes have called into operation.

The great difference in elevation between Lake Ontario and Lake Erie, and the occurrence of the Cataract of Niagara, form one of the most striking features in the topography of Western New-York. The difference in elevation of the upper great lakes is comparatively small; they being nearly in the range of the strike of the strata, while the passage from Lake Erie to Lake Ontario is directly across the line of dip.* Lake Erie is three hundred and thirty-four feet above Lake Ontario, and the greater part of the descent from one to the other is overcome by the rapids and falls of the Niagara river in the space of one mile.

The series of limestones forming the Helderberg mountains in the eastern part of New-York, extend westward throughout the whole length of the State, gradually diminishing from the thinning out of some of the members; and crossing the Niagara at the outlet of Lake Erie, they extend far westward into Canada, and form, for many miles, the southern shore of Lake Huron, and the eastern shore of Lake Michigan. This limestone dips to the south, passing beneath the water, and forming to some extent the bed of Lake Erie. It forms the second great terrace south of Lake Ontario, over the outcropping edge of which, on the north, we descend to a low, level country, underlaid by the shales and marls of the Onondaga salt group, which extends for fifteen or eighteen miles. Beyond this point there is a gradual and almost imperceptible ascent for seven or eight miles, when we come to the edge of the first great terrace overlooking the present valley of Lake Ontario. From this we plunge down for two hundred and fifty feet, over the outcropping edges of various strata, which here terminate abruptly, to the low table land bordering the lake. From the base of this escarpment, the plateau, on which Lewiston and Queenston stand, slopes almost imperceptibly to the level of the lake, which is seven miles distant, and one hundred and twenty feet lower.

A great portion of the country for twenty miles north of the southern terrace is so low and level, that a rise in the river for thirty feet would inundate an extent of many miles on both sides.† The ascent from this low country toward the north is very gradual; but when we arrive at the edge of the great terrace above Lewiston, the elevation is thirty-eight feet above Lake Erie. The accompanying section from Lake Erie to Ontario, presents an outline of this portion of the country.

This great terrace and escarpment, through which the Niagara makes its way into the valley of Lake Ontario, is known in New-York as the *Mountain Ridge*, and in Canada as *Queenston Heights*. It continues to the westward of Niagara river, curving around the head of Lake Ontario, and thence trending westerly, some of its members extend beyond the Mississippi river. To the eastward, it is distinctly traceable as far as the Genesee river; beyond which, it merges in the general level, and the rocks forming it disappear almost entirely, from thinning out, before reaching the Hudson river. The abrupt termination of these various strata upon the face of the escarpment, prove conclusively the extent and effect of denuding agency upon

* The geological positions of Lake Superior and Lake Ontario, the highest and the lowest of this chain of lakes, correspond very nearly with each other.

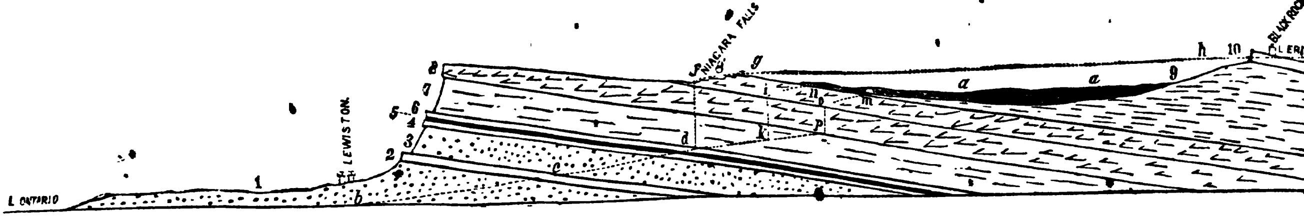
† By means of the dam at Black-Rock, the water is taken from Lake Erie into the Erie canal, and carried through the Tonawanda creek, descending the terrace at Lockport by a cutting of less than thirty feet.

this part of the surface. The basin of Ontario, on the north of this terrace, has evidently been excavated from the sedimentary strata; the limit of the force, and the extent of the lake basin, being the line of this escarpment.

It is quite unnecessary, in the present instance, to controvert the opinion which has been advanced, of a dislocation of the strata, by which those forming the terrace have been elevated to their present position. They are continuously exposed both on the north and south of the escarpment, and it is very plain that no such change has taken place. The accompanying section, and also the section, Plate IV., illustrate the order of succession among the strata.

Here, instead of any evidence of disturbance in the strata, we find the most unequivocal proofs of denuding action, which has entirely removed the materials once forming the continuation of these strata on the north. It will be seen that the strata, consisting of alternating hard and soft beds, offer great facilities for the operation of any excavating force. The action of water would thus undermine the harder beds, leaving them to fall by their own weight, while the softer materials were removed. The manner in which this denudation was effected, and the period of its occurrence, have already been noticed; and by the same means we are able to account for this and other extensive lines of escarpment, where the succession of strata presents a very different structure and ability to endure abrasion. In the same way we are to account for the broad valleys in other situations, and the numerous gorges in the edge of this escarpment. These are of little extent, scarcely reaching beyond a quarter of a mile, and usually less; they present broad expanded openings on the north, and are very similar to the indentations upon lines of seacoast.

186.



Section of the strata along the Niagara river, from Lake Ontario to Lake Erie.

EXPLANATION OF THE SECTION.

1. Red shaly sandstone and marl, seen in the bank of the river at Lewiston, and extending to Lake Ontario.
2. Grey quartzose sandstone.
3. Red shaly sandstone like No. 1, with thin courses of sandstone near the top.
4. Grey and mottled sandstone, constituting, with those below, the Medina sandstone.
5. A thin mass of green shale.
6. Compact grey limestone, which, with No. 5, constitutes the Clinton group at this place.
7. Soft argillo-calcareous shale. Niagara shale.
8. Limestone—compact and geodiferous. Niagara limestone.

8'. The upper thin-bedded portions of the Niagara limestone.

9. Onondaga salt group, including the hydraulic limestone, or beds of passage to the next rock.
10. Onondaga and Corniferous limestones, being all the limestones of the Helderberg division which continue so far westward.

a, *a*. Alluviatile deposit in the depression south of the Rapids, probably similar to the fluviatile deposit of Goat island.

b, *c*, *d*, *f*, *g*, *h*. The dotted line represents the present surface of the river from Lewiston to Lake Erie.

d, *f*. The perpendicular fall, over the Niagara limestone and shale.

f, *g*. The rapids, fifty-two feet, over the upper thin-bedded portion of the Niagara limestone.

c. The whirlpool.

k, *i*, *n*. The position of the falls and rapids after a recession of one mile.

p, *o*, *m*. The position of the falls and rapids after a recession of two miles.

The strata 1, 2, 3, 4, 5, 6, 7 and 8, forming the escarpment at Lewiston as represented in the section, are those through which the gorge of the Niagara is excavated; all that portion above the dotted line *b*, *c*, *d*, as well as the depth of the river, being removed for a length of seven miles and a width of twelve hundred to two thousand feet. These rocks dip gradually to the south, and all below Nos. 6, 7 and 8 disappear beneath the level of the river before reaching the falls.

The limestone which forms the summit of the terrace at Lewiston, and which at its margin is not more than twenty feet thick, gradually increases from the addition of higher layers, till at the Falls it has acquired a thickness of one hundred and sixty-four feet.* This limestone, about one mile south of the Falls, disappears beneath the surface, and is succeeded by a soft marl of a bluish or greenish-grey color. This formation, which is the Onondaga salt group, occupies all the level country from two miles south of the Falls, to Black-Rock, a distance of fifteen miles by the course of the river. To this succeeds the limestone terrace before described, on the north of Lake Erie.

The Onondaga salt group occupying this great breadth of country, and forming an important item in any calculation regarding the future recession of the falls, had never been noticed by any one till the publication of the Annual Reports of 1838. In all previous accounts the distance from the Falls to Lake Erie was regarded as underlaid by limestone, and the limestone of Black-Rock was represented as resting upon the Niagara limestone.

The Niagara river, from Lake Erie to its emergence into the low country at Lewiston, has excavated a channel through the rocks represented in the section. The current, for the first two miles after leaving the lake, is very rapid; after which it flows on more gently, the channel gradually widening as far as Grand island, where it divides, the greater quantity of water flowing on the west side of this island. Farther down, the river expands to a width of two or three miles, and presents all the appearance of a quiet lake, with small, low islands. The descent from Black-Rock to the head of the rapids is only fifteen feet. Approaching these rapids the river narrows and the current becomes more violent, and, for about one mile before reaching the grand cascade, rushes on, with inconceivable velocity, over a declivity of fifty-two feet, to the edge of the chasm, where it is precipitated into a gulf one hundred and sixty feet below.†

The gorge through which the Niagara river now flows presents almost perpendicular walls, with a talus at the bottom, formed by the falling of some of the higher strata. The outlet of this chasm is scarcely wider than elsewhere along its course. In some places the channel is less than two hundred yards across, and again is expanded to twice that width. The breadth

* Eighty feet only are visible at the Falls; its whole thickness was ascertained by levelling to Porter's quarry, a mile east of the river.

† The birdseye view, facing page 383, conveys a very good impression of the face of the country, and the course of the river from Lake Erie to Lewiston. A representation of the course of the river by this method was given by Mr. Robert Bakewell, jr., and published in Loudon's Magazine of Natural History for March, 1830. This one was constructed without having Mr. Bakewell's view before me, and the artist finished his work without seeing it. The idea of thus representing it was doubtless original with Mr. Bakewell; but the same mode, to a certain extent, was adopted by Father Hennepin in his sketch which is given in this chapter.

of the chasm at the top is nearly twice as great as that of the stream below. The declivity of the bed of the river, from the falls to Lewiston, is one hundred and four feet, or nearly fifteen feet in the mile.*

At one place, about a mile below the falls, and where the channel is narrowest, the stream glides with comparative stillness; while below this, where the channel is broader, it is driven along with great velocity. Again, below the whirlpool the surface of the river is more smooth, and the current more gentle, though the channel is narrower than above. These appearances, which have seemed inexplicable upon the common theory, and which have been used as arguments against the recession of the falls, have their cause in the geological structure of the place. Below the whirlpool there are no hard rocks in the bed of the river; consequently the channel is deeper, and the water is more quiet than where such rocks exist. At the whirlpool, and above that place, the hard sandstone No. 2 is at and near the level of the river, and consequently the channel is not worn so deep. Again, after this hard mass has dipped beneath the surface, the bed of the river is excavated in softer rocks; hence the narrow channel and smooth water a mile below the falls. Near the falls, the higher beds of sandstone, and the limestone of the Clinton group, approach the level of the river, and thus cause a wider, shallow channel, and more tumultuous water. Such I conceive to be the explanation of the variable width of the chasm, and the greater or less violence of the water.

In the course of this gorge, there is a single exception to the parallel sides and nearly vertical cliffs; this is upon the west bank of the river, at the whirlpool, as can be seen by referring to the plate. Standing upon the east bank of the river, it appears like a depression worn by the eddying current, which is partially obstructed in its course by the sandstone No. 2. Not having made particular examinations upon the Canada side of the river, I had overlooked the true cause of this indentation, till during the summer of 1841, while in company with Mr. Lyell, we examined this place, and found it to be an ancient gorge filled with drift, except a narrow ravine through which a small stream flows into the river. In the channel of this stream, near the river, there are one or two places where the rocks are exposed, proving this gorge to be less deeply excavated than that in which the Niagara now flows. The ravine may be traced for nearly two miles in a northwest direction, where it comes out to the general level of the surrounding country. From the point of its termination, and following the same direction for about one mile, we again commence descending through another deep gorge, which terminates upon the plateau at the base of the escarpment at St. Davids, four miles west of Queenston. It will be perceived by referring to the map, that the course of the river before coming to the whirlpool, if continued, would lead in the direction of St. Davids. From this fact it has been inferred that there is a continuous ancient gorge filled with drift, from the whirlpool to this place. This inference seems substantiated by facts; for upon the

* A considerable declivity is required in the bed of such a stream, in order to give it power to remove obstacles which are constantly impeding its course. In any stream excavating its own channel, the declivity of its bed will be, in some degree, proportioned to the weight of the fallen masses which it has to remove; and if its channel be in soft shale, the descent will be very gradual, while the intercalation of harder strata increases the descent according to their proportion.

elevated ground just before commencing the descent to St. Davids, upon the estate of the late Governor Maitland, a well was dug to the depth of 150 or 160 feet, and the whole distance in gravel and sand. This proves at least that the limestone has been deeply excavated, and leaves no doubt in my mind of the continuity of this ancient gorge. This remarkable fact has been cited as an objection to the opinion that the Niagara formed its own channel; but still I hope to be able to show that its existence is equally an objection to the opinion that the gorge of the Niagara was produced by the action of the sea.

This ancient ravine appears to be filled with drift, of the period of the oldest drift of the district; consequently we infer that it was one of the earliest effects produced by that denuding agency which excavated all the great valleys of Western New-York. If this be true, it became filled with drift before we have any evidence of any part of this region being above the ocean, or of the Niagara river having an existence; therefore we have no ground for supposing that it was ever the channel of this or any other river. If, on the other hand, we assume that the present gorge of the Niagara was excavated by the ocean, and that the river has but cleared out the drift, then we are bound to show that it resembles other gorges, which there is every reason to believe that the ocean did excavate. The opening of the gorge at St. Davids, towards Lake Ontario, presents a width of two miles where no rock is to be found in the line of the escarpment; while that of the Niagara at Lewiston presents a width of fifteen hundred, or perhaps two thousand feet. Allowing this ancient gorge to be continuous as far as the whirlpool, we find it to have diminished to a width less than the present river channel. In this we see no analogy to the present channel of the Niagara, which, though variable in width, is scarcely wider at its opening on the north than in some other parts of its course. If we suppose that the undermining action of the ocean or an elevated lake aided in excavating this channel, then also we must suppose that it would at the same time have removed the drift from this ancient one; and if we suppose them both of the same age, or produced by the same cause, then we should expect to find them similar in character, which is not true. The existence of this ancient ravine, so different in character from the present channel, indicates a different origin; and as it corresponds with those gorges or indentations in coast lines, we infer that it was due to similar causes; while that of Niagara, corresponding with all modern river channels, or those which we know to have been formed by streams now flowing in them, we infer that it, too, had a similar origin.

It might appear more rational to conclude, that if the Niagara commenced excavating its own channel, it would more readily find a way through the drift filling this ancient gorge, than through a solid wall of rock; but this objection can be met by numerous examples, where old channels have been closed by modern accumulations, and the stream has excavated a new one through rocky strata. Such a case has already been illustrated in the passage of the Genesee from Portage to Mount-Morris: in this example, the facts are incontrovertible; and whether the Genesee ever occupied the ancient valley which is now filled with drift, does not affect the conclusion; we see it leaving an ancient valley, through which it has flowed for many miles, and entering a narrow gorge in the rocks of Portage, making a circuit of two or three miles, when, by the ancient channel filled with sand and gravel, the same point would have been gained in less than half the distance. Similar examples may be found in Seneca and Cayuga lakes; the outlet of the former, instead of pursuing its course through an ancient valley to Lake Ontario, turns to the eastward, and excavates a channel through the limestone and gypsum beds between that lake and Cayuga.

Numerous similar examples might be cited, were it necessary, in order to account for the fact that the Niagara did not take the course by the ancient ravine to St. Davids. In any case it only requires that the superficial deposit should be higher than the rocky strata, and that the water once be directed in that course, and it will wear itself a channel sooner than remove the other deposit.

In consideration of the argument that the channel of the Niagara has been worn by the action of the sea, it may be necessary to offer some analogous examples. In all ravines, or indentations, excavated in the face of sea cliffs, whether aided by a stream flowing in or not, we find a broad or trumpet-mouthed opening toward the sea, and they recede abruptly to a termination. They never present a long, narrow ravine of equal width; and where of a length at all approaching that of Niagara, they have an opening many times broader than this at Lewiston. Numerous examples of ravines formed in this manner might be mentioned, but none of these resemble Niagara. In such instances they are broad enough to allow the stream to flow in the bottom, leaving waterworn materials along the sides, monuments of the abrading action of the waves. In the Niagara chasm there are no boulders, pebbles or gravel. The river occupies the whole width at the bottom, except a talus on either side, formed by angular fragments fallen from above.

The valley of the Genesee, from Rochester to Dansville, offers a good example of a channel excavated by the action of the sea during the emergence of land; but this valley is broad, and partially filled with drift; the sides sloping gradually, and for the most part, deeply covered with transported materials.

The small amount of wearing, or the recession of a fall, accomplished by a stream during the period of our observation, might incline us to doubt the possibility of any body of water having excavated its channel backwards for a length of seven miles, and to a depth of from three to five hundred feet. But if the period of one life be sufficient to admit of observation proving the *smallest amount of recession*, then it is only requisite that we should carry on the process for an indefinite period, to accomplish the utmost that we require; or that we extend backward our imagination regarding time, in order to demonstrate what is already accomplished. Now it is proved that within the recorded observations of persons residing in the vicinity of Niagara, that the falls have receded within their recollection. Therefore, if we are able to prove that this ravine could not have been excavated by the sea, during the emergence of the land, we have only this mode of operation left to account for its formation.

It is barely possible that there may have been a fissure in the present course of this river, which gave the first direction to the stream; but I have not been able to find any farther evidence than what has already been given on this subject. I have remarked that the surface of the limestone declines to the eastward, and I have been informed by Mr. Roy that it also declines to the westward from Queenston. Such being the case, it is possible there may have been a rent in this situation previous to the period when the river began to flow in that direction. From all that appears along the present river course, there was probably an ancient shallow valley extending in the direction of the present Niagara, which gave the first direction to the waters. This will be made apparent by the following transverse section of the river valley, which shows that the present square cut gorge is in the bottom of a previously formed valley. Along the whole course of the river this gradual ascent from the edge of the gorge is manifest, and, together with other circumstances, is evidently of the origin we infer.

187.

From analogous facts, which have before been stated, we learn that it only requires an elevation of drift or other superficial deposits greater than the rocky strata, in order to give the water this direction, and cause it to excavate a new channel. In the present case it only requires the depression before noticed, whether in the superficial deposit or in the rock, to give the river that course; and, when it had once commenced flowing, no power would divert it. Even if we suppose the channel to have been previously in any other direction, if it became obstructed, the water would seek the lowest point along the terrace. In the present instance this appears to have been in the direction of Lewiston, and here the water commenced its work of excavation, cutting down the higher strata, and rapidly undermining and removing those below. It is only necessary to refer to the accompanying section, in order to discover what materials the river had to work upon at this period.

It is impossible that there could ever have been a perpendicular fall of the whole height of the cliff at Lewiston, for the limestone at the top, being so much thinner than at the present falls, would soon be broken down by the pressure of the immense body of water precipitated over its edge upon the shale below. It may even be doubted whether the shale would be excavated fast enough to form a perpendicular fall, and it is probable that the water would be projected over a declivity of the upper shale (No. 7), to the limestone below, which, together with the higher layers of the sandstone, would form the crest of a second fall. From this, again, the water would be precipitated as far as the sandstone (No. 2), where a third fall would be formed. Thus, instead of a single fall of three hundred and fifty feet, we should have the whole height divided into three falls, at some distance from each other. In consequence of the thinness of the upper limestone, that fall would recede faster than either of those below it; and the middle faster than the lower one. Even under these circumstances, the wearing action would go on much faster than at present. Finally, however, the recession would become less and less rapid, from the thickening of the limestone above; and from this cause, the two lower falls having only the same resistance to overcome as at first, would gradually approach the upper, till the whole become one.*

At the same time there are other circumstances to be taken into consideration, and among the most important of these are the dip of the strata and the ascent of the bed of the stream; both together tending to bring the strata down to the level of the water as we progress southward. This fact has also an important bearing upon the rate of recession; for while a hard mass remains at a considerable height above water, with a soft one below, the excavation of the softer one and undermining of the upper hard one, tends to the recession much more rapidly than if the whole were of uniform character. Thus it must have been that the fall over the sandstone (No. 2), receded much more rapidly while there was a considerable thickness of shale below, than when it approached the level of the water. This would happen after the falls had retreated about three miles, or nearly to the whirlpool. At this point the recession would go on very slowly for a long period; for this hard mass, being at the level of the water, would effectually suspend the undermining process. Even at the present time this rock may be seen stretching into the river, from either side, beyond the others, and at the point where it crosses, producing a descent of eight or ten feet within a few rods.

After this long and almost stationary period at the whirlpool, the recession would again go on more rapidly; soft materials being presented at the river level to be excavated by the force of the falling water, which would thus undermine the harder mass above.

When the cascade had receded to near its present position, another pause, similar to that at the whirlpool, would occur, from the approach of the higher layers of sandstone (No. 4), and the hard limestone (No. 6), to the surface of the water. There are various proofs of this halting, both in the form of the chasm below the present fall, and from the fact that the higher layers of sandstone still remain in place; for it is seen that having passed a few feet beneath the water at the cascade, it supports the large fragments of the upper limestone which have fallen down.

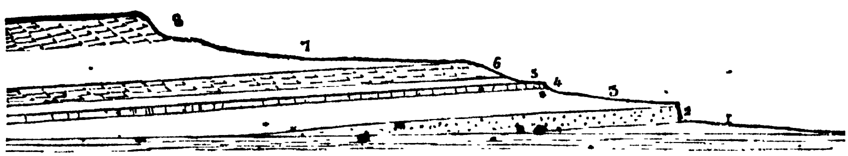
The conclusion then, seems inevitable, that the river has been the great agent in excavating its own channel, from near the escarpment between Lewiston and Queenston, to the present position of the cataract; that the recession has been aided by the character of the rocks, presenting alternate hard and soft strata; and that the descent was overcome, not by one perpendicular fall, but by several. In support of this latter assertion, a single analogous case will furnish stronger evidence than a long argument. The course of the Oak-orchard creek,

* See diagram on explanation of the falls of the Genesee, page 391.

in Orleans county, is over the same strata, and exhibits the succession of falls and rapids, precisely in the manner I have just enumerated. The quantity of water, however, in this stream, is too small to produce any thing like a degree of recession to compare with the Niagara river.

The following diagram will explain these remarks by showing the present position of the falls and rapids along the stream; the numbering corresponds to that upon the Niagara section, page 386:

169.



Section along the Oak-orchard creek.

1. Lower part of Medina sandstone. 2. Quartzose sandstone. 3. Alternating, shaly and hard sandstone. 4. Greyband; termination of the Medina sandstone. 5. Green shale of Clinton group. 6. Limestone of Clinton group. 7. Niagara shale. 8. Niagara limestone; falls at Shelby.

The same views have already been explained and illustrated, in relation to the falls on Genesee river; but the quartzose sandstone (No. 2) of the Niagara section does not extend so far eastward, and, therefore, it forms no item in the calculation at that place. The hard limestone layer (No. 6), or one filling the place of that at Niagara, has retreated a quarter of a mile farther up the river, where it forms a fall of twenty-five feet. This recession of the limestone, beyond the sandstone, is owing to a mass of green shale below it, twenty-three feet thick, while at Niagara the same shale is but four feet thick. From this place to the upper fall, about a mile and a half distant, we have a rapid stream. This fall is one hundred and ten feet high, and over precisely the same rocks as the Niagara fall at present, viz. Nos. 7 and 8 of section, the Niagara shale and limestone. The limestone at the top of the fall is much thinner than that at Niagara, in consequence of the less recession into the mass, as well as from being thinner as a whole. We have here a case precisely analogous to Niagara, as I have supposed its former condition.

Had the quantity of water flowing down the Genesee been equal to the Niagara, the upper fall would have been excavated farther backward, and the lower fall, in all probability, entirely obliterated, presenting a rapid current from the upper fall to the present site of the Rochester landing. There appears here positive proof that there never has been so large a body of water passing down the Genesee as down the Niagara, and the concurring testimony is to the effect that the wearing action has been far less. The recession of the lower falls at Rochester would add little or nothing to the height of the upper; for the ascent of the river bed, and the dip of the strata, would cause the disappearance of the whole beneath the water, before reaching that point.

In support of the hypothesis that falls do retrograde, we may adduce sufficient evidence. Observations, during the last five years, upon the waterfalls of Western New-York, have furnished positive evidence of their recession. Among these may be noticed the falls on Jacock's run, near Geneseo, and Fall brook, a few miles farther south, both of which have evidently receded, from the undermining of the platform over which the water is precipitated. The amount during this time is very small, but quite sufficient to be appreciated.

Lateral streams flowing into ravines or river courses, furnish the most palpable evidence of the excavating power of water. The channel of Wolf creek, which comes into the Genesee through a perpendicular wall of rock, is a good example of this kind, where the evidence is conclusive that the excavating power is alone due to the stream. The junction of a small stream with the Genesee, on the west side, below Rochester, furnishes another example of this power. This stream has cut its channel through soft shale for fifty feet or more, a bed of limestone eighteen feet thick, a bed of shale of equal thickness, and below this another bed of limestone nearly equal to the upper one. Many more examples of a similar kind might be named, on the Seneca and Cayuga lakes, and their valleys continued to the south.

All the historical evidence that we possess upon the subject proves the falls to have receded; and, although there have been no monuments established, yet the representations of early travellers, when compared with the present condition of the falls, proves that a change has taken place, though we cannot be certain of its precise amount.

The oldest authentic historical account of the falls which I have seen is that of Father Louis Hennepin, who travelled in this country in 1678.* The accompanying view of the falls is a fac simile of that published in his travels, and though rude and fanciful, it is, in many points of view, highly interesting and important.

It represents a projecting rock upon the west side of the river, which turned a part of the water across the main fall, as seen in the sketch. This fact is of great interest as showing one important change which has taken place within the historical era; for in regard to a portion of the water being projected from west to east, forming a cross fall, there seems no doubt, as it is particularly described. In chapter LXX. he says, "From the end, then, of this island it is that these two great falls of water, as also the third, but now mentioned, throw themselves, after a most surprising manner, down into a dreadful gulph six hundred foot and more in depth. I have already said that the waters which discharge themselves at the cascade to the east, fall with lesser force; whereas those to the west tumble all at once, making two cascades; one moderate, the other violent and strong, which at last make a kind of crotchet or square figure, falling from south to north and west to east." The northwestern

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* This work is entitled "A New Discovery of a Vast Country in America, extending above four thousand miles, between New-France and New-Mexico; with a description of the Great Lakes, Cataracts, Rivers, Plants and Animals; also, the Manners, Customs and Languages of the several Native Indians; and the advantages of commerce with these different nations, &c." Dedicated to His Most Excellent Majesty, William III. King of Great Britain, &c. By F. Louis Hennepin. London, 1698. This work was first published in Utrecht in 1697.

My attention was called to this book and view of Niagara falls by JOSEPH W. INGRAHAM, of Boston, who has given much attention to collecting the historical accounts of Niagara falls.

[illegible]

by Father Louis Hennepin, 1698.

[illegible]

end of Goat island is also represented as extending perpendicularly to the water; and though we can hardly credit this, we can conceive how such an error may have been committed, when the spot was inaccessible.

In 1750, Kalm, a Danish naturalist, visited the falls, and his description and view is published in the Gentleman's Magazine in 1751. His general description corresponds with that of Father Hennepin, though there was at that time no third cascade. The period of his visit was seventy-two years after that of F. Hennepin, and he distinctly alludes to the projecting rock, which forced the water out of its direct course, causing it to fall across the great fall. He speaks of this rock having fallen down a few years previous, and in his view of the falls the spot is indicated. In this interval of seventy years we find that the recorded observations of these two travellers prove precisely the same kind of change to have taken place, as we suppose to have occurred previously, and which has subsequently altered the outline and position of the falls.

We have not space here to introduce all the subsequent accounts of Niagara falls which have been published, neither would they furnish us with arguments bearing upon their recession.

In 1824,* Prof. Eaton gave a section of the rocks from Lewiston to Lake Erie, which, with the omission of the Onondaga salt group, corresponds with subsequent observations. This is the first account of the falls which I have seen where the geological structure of the place is given.

In the 28th Vol. of the American Journal of Science and Arts, Prof. H. D. Rogers has given a very full description of the falls, and the geology of the surrounding country, together with his views regarding the formation of the chasm of the Niagara, and the future recession of the cataract.

Mr. Hayes, in his paper on the geology and topography of Western New-York,† has presented many interesting facts and speculations relating to the falls and the production of this chasm, as well as the fluviatile deposit of Goat island and the eastern shore.

We have now to consider another class of phenomena, which aid us in our conclusions regarding the recession of Niagara, proving at least that the water has extended much farther in the direction of Lewiston before the present gorge was excavated. The nature of this evidence I pointed out in my report on the Fourth Geological District of New-York, in 1838, pages 271, 272, and 273. At that time, I was not aware that the same phenomena had before been noticed, though I have since learned that the existence of freshwater deposits on Goat island was known some years previous. Whether the important inference had been deduced from this fact or not, I do not know.

Goat island stands upon the top of the precipice separating the two falls; it is formed by the accumulation of gravel, sand, and clay, upon the surface of the limestone, and is evidently

* Geological and Agricultural Survey of the District adjoining the Erie Canal, Part I. page 149.

† Am. Jour. Science and Arts, Vol. XXXV. No. 1.

a portion of a once much more extensive deposit. Upon the southern side of this island, where there is an escarpment, the thickness of the superficial deposit is about twenty-five feet. The upper half consists of coarse gravel and sand, with abundance of fresh water shells of the genera Unio, Cyclas, Limnea, Planorbis, Valvata, and Melania; the same, both in genera and species, as those now inhabiting the river and lakes. The occurrence of these shells, in this situation, about forty feet higher than the top of the fall, proves the existence of a river or lake at an elevation sufficient to allow of such a deposition, for this accumulation of shells and gravel bears all the evidence of a fluviatile deposit. It is equally evident that this deposit could not have been made while the falls were in their present position.

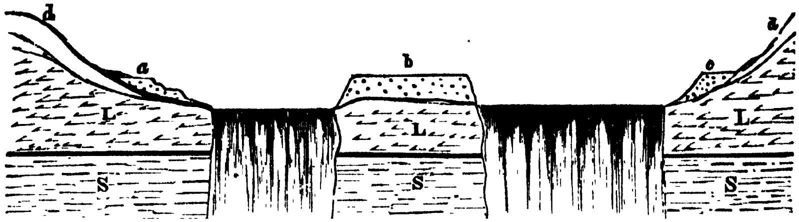
During a reëxamination of this place in 1841, in company with Mr. Lyell, we discovered the Cyclas, Valvata, &c. in a terrace, upon the east side of the river, of the same elevation as Goat island. It was at this place, and in the same deposit, that a Mastodon's tooth was found eleven feet below the surface. Farther northward, and more than half a mile north of Goat island, in another excavation, we discovered similar shells. At the same time we noticed the continuation of this terrace as far as the whirlpool. Since that time I have levelled the whole distance from the falls to the whirlpool, and find the elevations at the two places to correspond. Shells are even more abundant in this terrace at the whirlpool than at the falls.* Farther north than this point, I have made no examinations for freshwater shells.

Upon the west side of the river there is a similar terrace, which is mentioned by Mr. Hayes as also containing freshwater shells,† in common with that on the east side. Now, in order to find a barrier on the north sufficient to elevate the water so as to make this deposit, it would require to extend it far towards Lewiston. Furthermore, it is evident that the deposits forming these banks or terraces, on either side of the river, and that of Goat island, were not made in this form, but are parts of a once much more extensive formation, which has been removed by the waters of the river. During the time of its deposition the river must have occupied this ancient valley, which extended toward Lewiston, finding a barrier much nearer the edge of the terrace than the whirlpool. In the bed of this expanded river or lake, much as it now is above the rapids, this deposit was made, probably covering the whole extent. From the subsequent recession and drainage, the margins only have remained, together with Goat island, indicating its former extent. The position of this fluviatile deposit, which is subsequent to the ancient drift, may be illustrated in the following diagram:

* See accompanying map and elevations. Mr. Lyell informs me that in a second visit to the falls in the spring of 1842, he found freshwater shells at the Whirlpool.

† Am. Journal of Science and Arts, Vol. XXXV. No. 1.

189.



a. The terrace with shells on the eastern side.
b. Goat island.
c. The terrace on the Canada side.
d. The ancient drift.
L. Limestone.
S. Shale.

From the present position of the remains of this deposit, there can be no doubt but it was once continuous, the greater part of it having subsequently been removed. The mode of its formation can be well illustrated by referring to fig. 186, *a*, *a*, which is intended to represent what is now going on in the broad expansion of the river above the rapids. This fluviatile deposit is made by materials brought down by the current, and doubtless mingled with a large accumulation of shells of *Unio*, *Melania*, *Anculotus*, &c. as these shells are abundant above the falls, and large numbers of the shells of Uniones are constantly brought down the rapids during the summer season.

The single terrace containing shells is not the only one; on the eastern side, at lower elevations, there are in succession three others (as seen by the acompanying topographical map of the falls), which seem to be remains of the deposit in the river bed, as it successively excavated its barrier on the north, and receded towards its present position. For the greater part of the distance from the falls to Black-Rock, on the eastern side there is a terrace or bank a few feet higher than the river, which may have originally limited its waters when it stood at the level indicated by the freshwater deposit of Goat island. Near Black-Rock, and bordering the valley of the Tonawanda, there is a terrace some twenty feet higher, which appears to have been the boundary of the river or lake at a still earlier period; but with these we have, at present, nothing to do. The existence of the fluviatile deposit of Goat island, and at the same level on the eastern side of the river, requires for its elucidation the existence of water standing at a level somewhat higher, in order to allow of the deposit being made in the bed of the stream. To accomplish this, a barrier is required further north than the Whirlpool, and about the height of the surface of limestone between this and Lewiston. The occurrence of successive terraces below this one, proves that the drainage to the present point was not effected suddenly.

There is another fact which should be noticed, as proving the existence of a current from south to north, during the deposition of the materials forming Goat island. The pebbles, at least large numbers of them, are of the limestone of Black-Rock, and the harder layers of the Onondaga salt group, like the rock in place at the upper end of Grand island. The surface of the rock, on which the deposit forming Goat island is made, is smoothed and scratched, as are the surrounding surfaces, both in the rapids and on either bank of the river. The deposit is of greatest thickness towards the fall, and thins entirely out at its southeastern extremity. In some places the lowest part of this deposit is of clay, which has been subsequently covered by gravel and sand, containing the freshwater shells. This proves the first condition to have been that of a quiet lake, while subsequently a current, transporting pebbles and sand, passed over the same bed, leaving the coarse deposit.

There is another indentation on the eastern bank of the Niagara, below the Whirlpool. This has been cited as a case where the small stream coming in, is insufficient to account for such an excavation.* It occurs at the junction of Bloody run and the river, and bears the strongest evidence of having been produced by the common agents, frost and water. The wearing action of the stream alone is probably insufficient to produce this short ravine, which extends a few rods back from the margin of the river bank; but when we take into consideration the fact, that the water penetrates all the fissures of the rock, and then, during fall and winter, expands by freezing, we shall find means of explaining the mode of operation. At the falls, the recession is by the undermining and breaking down of the upper masses; the action of frost is not to be taken into consideration, as the water, probably, never freezes in the fissures behind the fall. Now I consider it as an established fact, that small streams, which freeze during winter, will excavate their beds more rapidly in proportion than large bodies of water which never freeze. It appears to me that the indentation at Bloody run is not greater than might be expected to have taken place while the main channel receded to its present position.

Whatever facts and arguments may be advanced to prove the existence of phenomena indicating the former action of the sea in excavating the Niagara channel, and whatever objections may be advanced for or against other theories, I am fully convinced, from the facts presented, that the existence of the falls and the Niagara river, in their present position, is of very recent date geologically.

We come now to consider the future recession of Niagara falls, and its consequences. This is a subject on which many speculations have been hazarded, but no one appears to have undertaken the calculation with a full knowledge of the geology of the district, or to have taken into account the many disturbing influences. At the present time, the cliff over which the water is precipitated, is nearly equally divided between thick-bedded limestone and soft disintegrating shale. It is by the action of the spray from the falling water upon the shale, undermining and leaving the limestone unsupported, which falls down by its own weight, that the falls recede from their present position. Now if we believe the statements of those who have resided at the falls, the recession has been about fifty yards within the last forty years; but from all the data I have been able to obtain, this appears to be much too great an estimate; indeed, it is extremely questionable if the fall has receded as many feet within that time. The central portion of the Horseshoe fall recedes more rapidly than any other part, for here the greatest force of the river is exerted. We know, likewise, from the testimony

* Am. Journal of Science, Vol. XXXV. No. 1.

of all residents at this place, that the American fall is becoming more curved in its outline, whereas formerly it was nearly in a straight line. The successive descent of large masses of limestone, and the still continued overhanging of the table rock, prove very conclusively the unremitting action of water and air upon the shale below.

In the absence of established landmarks, we are compelled to leave the rate of recession unsettled for the present. The accompanying trigonometrical map of the falls will furnish the means of doing this, by the monuments which have been established, and which may be considered as permanent points of reference for the future.

Leaving out of view the time or rate of recession, we have sufficient data to establish with certainty the future changes which will supervene, allowing the recession to go on as it is now doing. The lower half of the rock at the cascade, or about eighty feet, is of soft shale, the limestone above being of equal thickness; higher still is about sixty feet of thin-bedded limestone, forming the rapids. These different rocks are represented in the section as 7, 8 and 8′, respectively. Now these beds dip to the south at the rate of about twenty-five feet in the mile, and the declivity of the bed of the river is about fifteen feet in the mile from the falls to Lewiston. It follows, therefore, that as the falls recede, there will be a less amount of shale above water, owing to the dip; and to this must be added the amount of declivity in the river bed, both together making forty feet. So that when the fall has receded one mile, the surface of the water will stand at *k*, of section page 386, or a point in the shale half way between the present surface of the water and the bottom of the limestone. Going on at this rate for another mile would take away from the fall forty feet more of the shale, so that the surface of the river would then stand at *p*, or the base of the limestone.

The cataract would then have a solid wall of limestone to wear down, the river beneath protecting, in a great measure, the undermining action upon the shale. During this time, and at the end of the first mile, the falls would have arrived at the present site of the commencement of the rapids, and thus about sixty feet more of limestone would be added to the height; unless from its thin-bedded character it continued to recede faster, and thus remain a rapid. In this case, there would be a fall of one hundred and forty feet at the end of the first mile (*i*, *k*); and one of one hundred feet (*o*, *p*) at the end of the second mile.

At this period, then, we are to contemplate the cataract of Niagara as having receded two miles, the shale having disappeared beneath the river, and the cascade presenting a solid wall of limestone one hundred feet high, and a rapid of forty or fifty feet (*o*, *m*) beyond. The recession will then go on very gradually; and so soon as masses from this cliff have fallen down to fill up the river bed, as they inevitably will in a great measure, then the base will be protected so effectually that little influence will be exerted by the force of the water. Eventually, however, the cliff will be broken down, and huge fragments piled up below, until the cataract will be nearly lost amid them. This state of things will continue for a long time, the height gradually diminishing, till the river has cut its way back for two miles further, when there will be no thick-bedded limestone above water, and the higher beds will form a rapid as before.

This point of meeting between the surface of the river below the fall and the top of the thick-bedded limestone, will be about one hundred feet lower than the top of the present cascade; and as there will be forty feet of rapids in the thin-bedded limestone within a short space, as there now is, it follows that there will be added to the descent of the river beyond the rapids, one hundred feet more than at present, as the surface of the limestone has dipped to that amount. The whole fall in the river at that time, from Lake Erie to the point of junction between the limestone and water below the rapids (*h*, *o*), will be about one hundred and sixty feet. The distance between this point and the outlet of Lake Erie is occupied by nearly uniform soft layers; and after a partial wearing down of the limestone forming the rapids, the descent will be equally distributed over the whole extent of sixteen miles, giving a uniform declivity of about ten feet in the mile, or one-third less than the present declivity in the bed of the river from the Falls to Lewiston. From the nature of the bed of the river for sixteen miles below Lake Erie, it may be doubted whether this rapid descent along the whole distance would be continued; for the stream, having no heavy blocks of rock to remove, would keep its channel clear with a far less declivity; and should this prove the case here, we might still have a fall of a few feet, at the outlet of Lake Erie, over the limestone succeeding the salt group.

Whether such a fall would occur, depends on the solution of the problem regarding the required declivity in the bed of the river below Lake Erie. Whichever way it may occur, it will make no material difference in the great result, which will be either a continuous rapid stream from Lake Erie to Lewiston, or a rapid stream with a low fall at the outlet of Erie. If present causes continue to operate as now, such will be the consummation of the grand cataract of Niagara.

It is unnecessary here to follow on this recession gradually from the outlet of Lake Erie to the final drainage of a portion of its waters. The views which have been entertained of the sudden drainage of this or any of the upper lakes, and a deluging of the country on the north and east are no longer considered as tenable by any one; and even if Lake Erie could be drained suddenly, it would cause no deluge of any importance. If the whole lake were at once placed upon Lake Ontario, it would only elevate its surface by about one hundred and fifty feet, so that its extent would not exceed the limits of the ancient lake ridge, and the outlet would still be the valley of the St. Lawrence.

Thus far the country supplying water to the upper lakes has been but little changed by the hand of cultivation; the primeval forests still clothe the surface, and evaporation, to a great extent, is prevented. This cannot always remain so; the advancing settlements will yet penetrate even to the wilderness bordering Lake Superior, and the opening of the surface to the influence of the sun's rays will greatly diminish the supply of water flowing into its tributaries. These causes will sensibly diminish the quantity passing down the natural outlet; and the mighty Niagara is destined to be, at certain seasons, but a diminutive representative of its former grandeur.

But this event, though a certain result of existing causes, must still be inconceivably distant; and Niagara, for thousands of years, will continue to be the *Thunder of Waters*, whose magnificence no pen can describe, no pencil can express; which to be appreciated must be seen in its vast tumultuous waves, as they sweep down the rapids and are hurled into the immense chasm below, and heard in its voice of thunder, which drowns all other voices, and reverberates in one perpetual roar of sound and echo.

NOTE.—The quantity of water flowing down the Niagara river has been variously estimated by different observers.

Mr. Dwight estimates the amount at	361,392,742	cubic feet per minute.
Mr. Darby,	27,878,400	" "
Mr. Pickens,	3,087,533	" "
Mr. Barrett,	19,500,000	" "

The last estimate is from three different observations made at Black Rock during the high water of 1838 and 1839. The extremes of all the observations did not vary more than 20,000 feet per minute.

Mr. Barrett informs me that the quantity of water taken out by the different canals is as follows:

Erie canal, 30,000 cubic feet per minute.
Welland canal,* 7000 cubic feet per minute.
Illinois canal, from 5000 to 10,000 cubic feet per minute.

In addition to this estimate, there is a considerable waste of water along these canals, which is not taken into the account. All these amounts are small when compared with the great body of water flowing into this channel, and we can scarcely suppose that this abstraction will produce any appreciable difference in the rate of recession; but there are other causes which will certainly produce an important diminution.

* This amount will be greatly increased by the enlargement of this canal.

Trigonometrical Survey and Map of Niagara Falls.

The accompanying map has been constructed from a very careful survey by Mr. Blackwell,* giving the present position and outline of both falls, and the river banks upon either side. Upon application to His Excellency Sir Charles Bagot, late Governor-General of Canada, I was authorized to establish monuments upon the Canada shore, and was also kindly offered every other aid to promote the objects of the survey. These monuments, together with those in New-York, will enable future observers to ascertain the amount of recession during any given period. In places where the rock is exposed, copper bolts have been fixed, and in other places hewn stone monuments. The starting point for all these observations is a copper bolt fixed in the rock on the north side, near the edge of the American fall; the trigonometrical point No. 1, is thirty-nine feet four inches north, 80° east from this. These points are connected with T. P. No. 2, so that in the event of those nearest the cliff being undermined, the latter can be resorted to. The accompanying table of observations will serve to reconstruct the map so long as any of the points remain.

The following are some of the elevations noted at the time of this survey:

Height of American falls, October 4th, 1842,	167.70	feet.†
Height of Canada or Horseshoe fall,	158.50	"
First terrace, height above top of fall at the point before mentioned,	14.75	"
(The surface of this terrace is uneven, with scattered fragments of limestone, appearing like the bed of a river.)		
Second terrace,	24.09	"
Third terrace,	32.42	"
Fourth terrace, (the one containing shells),	39.79	"
This terrace slopes upward to the railroad, a height of	46.20	"
General level of Goat island, corresponding to that of the fourth terrace,	39.86	"
Top of highest terrace at whirlpool,	70.00	"
Base of this terrace, or level of the bank at the same place,	46.98	"
Shells were found in a fine clayey loam at the whirlpool, at an elevation of	33.03	"
More abundant at	35.00	"
And continuing upward to	46.00	"

* This survey was made in the fall of 1842, though the observations had been principally made by Mr. Blackwell in 1841; but as no permanent monuments had been established, it was thought better to review the whole. Through the kindness of Mr. Fay, the resident engineer at Lockport, Mr. Gibson and Mr. T. Evershed were directed to accompany me, and, together with Mr. Blackwell, to make the requisite observations and run the levels, all of which are shown upon the map.

† This elevation is from the level of the water below the falls to the copper bolt near T. P. No. 1. The elevation varies from four to twenty feet with the elevation of the water in the river below the falls.

It will be seen that the elevation of the point where these shells occur at the whirlpool corresponds with Goat Island and the fourth terrace on the east bank of the river. This can leave no doubt that these points are portions of a once continuous deposit, and it is not improbable that it may be traced still farther to the north. It will be recollected that the tooth of a mastodon, and shells of *Cyclas* and *Valvata*, were dug from the fourth terrace, eleven feet below the surface, or about four feet lower than those seen at the whirlpool, though these may have extended as low. In the terrace at the falls, these shells have not been found at an elevation so great by about six feet as at the whirlpool.

TABLE OF OBSERVATIONS.

Trigonometrical Points.	Course.	Points of intersection.	Trigonometrical Points.	Course.	Points of intersection.	Trigonometrical Points.	Course.	Points of intersection.
From No. 1	N 66° 35′ E 60 ft	to No. 1	From No. 5	S 49° 30′ W	to No. 31	From No. 7	S 61° 53′ E	to No. 2
.. . .	N 86° 20′ W	. . 2	.. . .	S 37 50 W	. . 32	.. . .	S 56 30 E	. . 3
.. . .	S 70 0 W	. . 3	.. . .	S 49 0 W	. . 33	.. . .	S 52 45 E	. . 4
.. . .	S 33 5 W	. . 16	.. . .	S 65 0 W	. . 34	.. . .	S 49 30 E	. . 5
.. . .	S 19 0 W	. . 19	.. . .	S 72 0 W	. . 35	.. . .	.. ..	. . 6
.. . .	S 11 55 W	. . 20	.. . .	S 88 50 W	. . 36	.. . .	S 48 15 E	. . 7
.. . .	S 8 0 W	. . 21	.. . .	S 80 45 W	. . 37	.. . .	S 46 45 E	. . 8
.. . .	S 11 0 E	. . 22	.. . .	S 70 40 W	. . 38	.. . .	S 44 0 E	. . 9
.. . .	S 15 50 E	. . 23	.. . .	S 63 30 W	. . 39	.. . .	S 43 15 E	. . 10
.. . .	S 16 50 E	. . 24	.. . .	S 51 15 W	. . 40	.. . .	S 39 15 E	. . 11
.. . .	N 25 0 W	. . 48	.. . .	S 37 30 W	. . 41	.. . .	S 38 30 E	. . 12
.. . .	N 46 10 W	. . 49	.. . .	S 37 40 W	. . 42	.. . .	S 37 5 E	. . 13
.. . .	N 67 30 W	. . 50	.. . .	S 27 50 W	. . 43	.. . .	.. .	. . 14
.. . .	N 73 30 W	. . 51	.. . .	S 17 40 W	. . 44	.. . .	S 33 5 E	. . 15
.. . .	S 85 0 W	. . 52	.. . .	S 8 50 W	. . 45	.. . .	S 19 20 E	. . 47
.. . .	N 31 45 W	. . 56	.. . .	S 70 15 W	. . 46	.. No. 8	N 74 27 E	. . 4
.. No. 2	S 74 45 W	. . 16	.. . .	N 73 30 W	. . 53	.. . .	N 78 57 E	. . 5
.. . .	S 41 45 W	. . 19	.. . .	N 54 30 W	. . 54	.. . .	N 80 0 E	. . 6
.. . .	S 38 0 W	. . 20	.. . .	N 59 10 W	. . 55	.. . .	N 81 27 E	. . 7
.. . .	S 40 45 W	. . 21	.. No. 6	N 68 15 W	. . 28	.. . .	N 82 40 E	. . 8
.. . .	S 14 05 W	. . 22	.. . .	N 76 0 W	. . 29	.. . .	N 83 27 E	. . 9
.. . .	S 8 40 W	. . 23	.. . .	N 83 30 W	. . 30	.. . .	N 84 40 E	. . 10
.. . .	S 5 20 W	. . 24	.. . .	S 86 0 W	. . 31	.. . .	N 87 0 E	. . 11
.. No. 3	N 31 30 W	. . 48	.. . .	S 65 0 W	. . 32	.. . .	N 88 7 E	. . 12
.. . .	N 55 30 W	. . 49	.. . .	S 71 15 W	. . 33	.. . .	N 88 50 E	. . 13
.. . .	N 78 30 W	. . 50	.. . .	S 85 0 W	. . 34	.. . .	S 89 45 E	. . 14
.. . .	N 82 0 W	. . 51	.. . .	N 88 30 W	. . 35	.. . .	S 77 45 E	. . 15
.. . .	S 77 45 W	. . 52	.. . .	N 75 20 W	. . 36	.. . .	S 69 15 E	. . 47
.. No. 4	N 42¼ E 100 ft	. . 17	.. . .	N 84 0 W	. . 37	.. . .	S 34 55 E	. . 25
.. . .	N 48 30 E 46 ft	. . 18	.. . .	S 83 40 W	. . 38	.. . .	S 30 15 E	. . 26
.. . .	S 70 45 W	. . 53	.. . .	S 77 30 W	. . 39	.. . .	S 25 30 E	. . 27
.. . .	S 85 45 W	. . 54	.. . .	S 63 10 W	. . 40	.. No. 9	S 88 25 E	. . 25
.. . .	S 88 50 W	. . 55	.. . .	S 47 0 W	. . 41	.. . .	S 85 25 E	. . 26
.. . .	N 6 30 W	. . 56	.. . .	S 45 50 W	. . 42	.. . .	S 82 5 E	. . 27
.. No. 5	S 68 45 W	. . 28	.. . .	S 36 15 W	. . 43	.. . .	S 68 10 E	. . 29
.. . .	S 61 15 W	. . 29	.. . .	S 29 15 W	. . 44	.. . .	S 62 40 E	. . 30
.. . .	S 55 30 W	. . 30	.. . .	S 16 45 W	. . 45	.. . .	S 54 50 E	. . 31
			.. . .	N 56 30 W	. . 46	.. . .	S 40 10 E	. . 32

STONE MONUMENTS set at Trigonometrical Points No. 1. 2. 5. 6. & 8, and one set N. 68° 10′ W. 2.00 Chs. from T. P. No. 6.—COPPER BOLTS set at Trigonometrical Points No. 7. & 9, one set S. 67° 30′ W. 72¼ feet from T. P. No. 9, and one set S. 80° 30′ W. 39¼ feet from T. P. No. 1.

190.

Conesus Lake. From a sketch by Mrs. Hall.

CHAPTER XXI.

LAKES.

Lakes of the district, their geological situation, etc.—Elevation and depression of water in the great lakes—Mean length, breadth, elevation and area of the several great lakes—Elevation of the smaller lakes—Elevation of different points in the district from Lake Ontario southward.

The physical features of the district have already been alluded to at the commencement of the volume; the principal valley of drainage is that of Lake Ontario, while the Susquehannah and the Allegany are the outlets of a part of the waters of the southern portion of the district. The north and south valleys, occupied by the Cayuga, Seneca, Crooked and Canandaigua lakes, with the lesser ones of Honeoye, Canadice, Hemlock and Conesus, are distinguishing features of the district. These bodies of water, though small when compared with the great lakes, are nevertheless of sufficient magnitude to claim our attention. They are all situated in valleys of erosion; the rocky strata, with a slight dip to the south, appearing on both sides. One of the remarkable features of this chain of smaller lakes is, that the four first named, with several on the east of them, unite in one general outlet, the Oswego river, and empty their waters into Lake Ontario. All these lakes, with the exception of the Cayuga, are situated on the south of the great Helderberg series of limestones, which extend westward from the Hudson river. The northern extremity of Cayuga lake valley is excavated in this limestone, and in the Onondaga salt group below. The greater part of these excavations have been made in the rocks of the Hamilton group, the Portage group, and the northern portion of the Chemung group. The small western lakes of this series do not extend so low as the Hamilton group, as will be seen on reference to the Geological map of the district.

These bodies of fresh water exert a very sensible influence upon the temperature of the surrounding country, and the effects of frosts upon vegetation bordering them is not observed so soon by many days as on the higher grounds.

Cayuga lake, the most easterly of the chain, is nearly forty miles long, with an average breadth of more than two miles. Its greatest ascertained depth is 390 feet. For several miles before reaching its northern extremity, this lake is quite shallow, the bottom being distinctly visible; finally it is covered by aquatic plants, which reach the surface, and these are succeeded by marsh grasses. The marshes have been before alluded to, and from their immense extent are of great interest. The mode of reclaiming these by dykes, and by removing the surplus water by aid of windmills, has been suggested in my annual reports, and it still appears to me practicable. Even during the warm summer months, there is almost constantly a sufficient breeze upon these lakes to move a windmill; and after the first expense of draining the surplus water from the higher grounds, it could be kept out by this method with little trouble or expense.

Seneca lake, the second in order, is of about the same length and breadth as Cayuga. Its depth, however, is considerably greater, being five hundred and thirty feet. It does not become shallow toward the northern end, as Cayuga lake. The outlet of this lake is evidently of more recent excavation than that of the lake valley: it turns to the eastward, and joins Cayuga lake near its northern extremity. It cuts its channel through the Corniferous limestone, and the limestones and marls of the gypseous formation below.

The channels of both these lakes are very similar, and their valleys extend northward, joining the great valley of the Susquehannah. Their banks are mostly perpendicular cliffs of shale and sandstone, for a height of ten to sixty feet; and from this the country rises in a gentle slope to a height of several hundred feet. This is covered with forest in its native state, and when cultivated, forms some of the most beautiful tracts. The surface is indented with ravines, which become deeper on approaching the lake shore, and open as deep gorges in its perpendicular cliffs on the margin.

Crooked lake, is the third in the series. The aboriginal name of this lake is *Keuka*. Its northern half consists of two branches, separated by a bluff of land, which rises, at its southern extremity, more than three hundred feet above the lake. It appears to lie in a deepened portion of a north and south valley, which northward joins the valley of Flint creek, and southward the Conhocton at Bath. Its depth has been variously estimated; but from soundings made at several points, the average is probably less than two hundred feet. The outlet is lateral, and of very modern origin; emerging at Penn-Yan, and excavating a channel in the lower part of the Portage group, the whole of the Genesee slate, and about two hundred feet of the Hamilton group, it flows into Seneca lake at Dresden. The descent along this outlet is two hundred and seventy-one feet.

Canandaigua lake, the fourth in the series, occupies a position in the rocks of the Hamilton and Portage groups, extending northward almost to the Corniferous limestone. Its length is about fourteen miles, and it has a breadth of from one to two miles. Towards its northern end it is becoming shallow, and aquatic plants and grasses rise above the surface of the water. There is also an extensive marsh at its southern extremity. This is the most westerly lake that flows into the Oswego river. Its outlet is northward for several miles; passing over the Corniferous limestone, and then turning eastward, it excavates a channel through marl and gypsum beds of the Onondaga salt group.

The three lakes, Honeoye, Canadice and Hemlock, lie in deep gorges in the rocks of the Portage group. The first opens northward into a beautiful valley, along which the waters of its outlet flow. The outlets of the other two unite, and after a circuitous route join that of the Honeoye, which flows into the Genesee river. The length of the two largest of these lakes is about six miles, and of Canadice about three miles.

The Conesus lake, of which a sketch is presented at the head of the chapter, is one of the most beautiful sheets of water in the district. It is situated in rocks above the Hamilton group, and presents gently sloping banks to the water's edge, covered with a fine forest of oak, hickory, etc., except where the hand of industry has replaced them with cultivated fields and meadows. Its length is about nine miles, with a width of one mile. Its depth does not exceed sixty feet, and for the greater part is much less. Its outlet passes over rocks of the Hamilton group, the Marcellus shale, the Corniferous and Onondaga limestone.

West of the Genesee valley, we find several small lakes in the higher rocks, and some of them at great elevations above the ocean. The principal are Silver, Java, Bear, Cassadaga and Chautauque lakes. These are not situated in the well defined north and south valleys, like those previously enumerated. Chautauque lake is the only one of any considerable magnitude. It is eighteen miles long, and contains sixteen thousand acres.

All the last named lakes, with the exception of Silver lake, flow into the Allegany, mingling their waters with the ocean in the Gulf of Mexico.

Of the chain of great lakes, we have to notice two as coming within the district: Lake Ontario being the northern boundary, and Lake Erie, with the Niagara river, the western boundary. They form two of those great depressions in the immense basin of the St. Lawrence which are occupied by these seas of fresh water. The length of this basin or valley, from the Gulf of St. Lawrence to near the sources of the Mississippi where it commences, is almost two thousand miles; and the whole area has been estimated at more than five hundred thousand square miles, of which from eighty thousand to ninety thousand are covered with water.*

* The area of this valley, and the surface of the water, are differently estimated by different individuals.

The amount of fresh water contained in all these lakes has been estimated at ten thousand five hundred cubic miles, being more than half the fresh water on the surface of the whole globe.

The basin of Lake Ontario is excavated in the Medina sandstone, the Grey sandstone, the Husdon river group of shales and sandstones, and towards its eastern extremity in the Trenton limestone. It appears probable, however, as stated by Mr. Vanuxem, that the Trenton limestone forms the bed of this lake, its estimated general depth reaching to about the surface of that rock. On its southern side the Clinton and Niagara groups of rocks rise in a high escarpment, and the excavation from this point northward is doubtless due to the same cause which eroded that portion now occupied by the lake.

The basin of Lake Erie is in like manner in the bottom of a deep valley of erosion; and on its eastern and southeastern side, at the distance of four to eight miles, an escarpment of the higher rocks rises to an elevation of from five hundred to eight hundred feet above the level of the lake. It is quite evident that the strata, whose outcropping edges now appear on the southeast of Lake Erie, once extended much farther to the north and west; and since there is no evidence on the northern side of the lake of any sinking down of the strata, it would be an unnecessary supposition to bring in any such agency to account for the existence of this valley.

The Corniferous limestone forms the northern margin of the lake for many miles, and dipping southward, probably forms its bed, as the small depth of the lake appears to indicate. Had the eroding agency removed this limestone, the soft rocks of the Onondaga salt group coming beneath would allow of a deep excavation with much less power than the limestone above; and if this had occured, Lake Erie would probably have been the deepest lake of the whole, while now it is the most shallow.

Elevation and depression of the water of the Great Lakes.

The fluctuating level of the water of these lakes has long excited attention, and many speculations have been hazarded to account for the phenomenon. The somewhat general belief, that the periodical rise and fall in the water of these lakes occupy seven years, appears not to be founded upon authentic observation. Sandbars and beaches, or the inlets to certain bays, are regarded as the landmarks; and these being liable to fluctuation from accumulation or removal, it follows that no hypothesis founded on such observations can be of any value. Of this character were many of the early observations, where the harbors were entered with a certain depth of water, which at some subsequent period was found to have diminished. It is nevertheless true, that there are important fluctuations in the lake levels, which are unconnected with the influence of winds.

The only rational explanation of these changes yet offered, is that depending on the waste and supply of water. From the immense surface exposed to the sun's rays, it is plain that the amount of water evaporated is immense; and if by any means this process becomes retarded, the water is elevated. Again, the greater quantity of snow falling during certain seasons has been considered a sufficient reason for explaining this increased elevation of th lakes. If after such a season, a summer follows when there is a small proportional degree of sunshine, the amount of evaporation being thus diminished, the lakes remain at a higher point. These causes, though perhaps satisfactory, and without doubt true, at least to a certain extent, do not always appear sufficient to account for the fluctuations which have been noticed. Twenty-five and thirty years ago the beach of Lake Erie was a travelled highway beyond Buffalo, but at this time it would be quite impossible to travel along the same.

Though the removal of beaches of sand and pebbles may in some degree have modified this line of coast, yet it is evident that the water now reaches several feet high upon rocky bluffs, which at that time were beyond the reach of the waves. From the united testimony of persons residing along the margins of all the lakes, and from other demonstrative proof, it appears, that for many years previous to 1838, all the lakes had been rising; that about this period they attained their maximum, and have since been subsiding.

Mr. Hiram Burton, who has resided at the mouth of Slippery-rock creek for twenty-three years, informed me, in 1840, that the water of Lake Erie was then four feet higher than when he came to that place; that in 1838 it was still higher, but he had made no accurate measurements. This was estimated from the original position of a mill, which from the rise of water had become useless. Several other persons who reside along this lake testify to the same facts; and others, who travelled there many years since, agree in stating that the road from Buffalo to Dunkirk was along the beach.

I have no means for determining the time or degree of the minimum depression of these lakes. Mr. Higgins, topographer to the geological survey of Michigan, has given the rise of the lakes as five feet three inches from 1819 to 1838; he regards it as probable that the minimum period continues for a considerable length of time, while the maximum continues only for a single year. In the absence of authentic observations, we can only rely on the testimony before mentioned. This goes to prove that the lakes were at a low stage for twenty years previous to 1819.

A single individual has informed me, that about the year 1788 or 1790, the lakes were nearly as high as in 1838; and we have everywhere sufficient evidence that the water of the lakes has, at some former period, been at a higher elevation than in 1838, and that subsequently it has been lower for a long period, previous to its last ascent. This evidence consists in raised beaches along the lake shore, which have been left by the receding water, and upon which trees have grown, and subsequently been undermined by the rise in the water. An example of this kind, and perhaps the most satisfactory, is near Van Buren Harbor, on Lake Erie. The water has encroached upon a line of beach, which borders a low ground, and exposes a section of the same, which is composed of pebbles and lake sand, presenting in all its characters and appearance the proof of its origin. After its formation the water subsided, and it became covered with trees, which the water at the present time is undermining. Numerous similar examples might be mentioned as occurring both on Lake Erie and Lake Ontario; and after making all allowances for the fluctuating nature of the modern beaches, we have no other mode of explanation left than the one suggested. The existence of rocky cliffs along the lake shores is likewise evidence of the same fluctuating elevation in the waters.

The annual fluctuations in the level of the lakes are doubtless due to the nature of the seasons, depending on the quantity of rain and snow and the amount of evaporation. But it is not so satisfactorily demonstrated that for a series of twenty years the quantity of rain and snow has increased, or that evaporation was lessened uniformly throughout this period.*

The effect of winds in producing temporary elevations and depressions of these lakes is very remarkable. A strong westerly wind will raise the water in the eastern end of Lake Erie several feet in a few hours; a much larger quantity is driven down the Niagara river, and although so rapid a stream below the falls, the water frequently rises fifteen or twenty feet during a westerly wind. At the same time the water in the lake is diminished at the western extremity, and a corresponding depression takes place. The prevalence of a strong easterly or northerly wind, in the same way, drives the water to the western and southern parts of the lake, and a much smaller quantity flows down the Niagara river during such a period. The same effect takes place in a greater or less degree in all the lakes; the rising at one extremity and sinking at the other, till the wind subsides, when it resumes its equilibrium, and in so doing presents a beautiful exhibition of the long swells which are observed in the ocean after the subsidence of a high wind.

The relative situation and elevation of these large and small bodies of water, with the rivers and lakes of this and other parts of the State, have largely contributed to place New-York in her exalted commercial relations with the surrounding country. The valleys of the Hudson and the Mohawk have opened a passage through two ranges of mountains, by which the waters of Lake Erie are mingled with those of the Atlantic, affording by the artificial means an easy navigation from the one to the other. Again, the waters of the upper Hudson are turned into the Champlain canal, on its summit level, and mingle with the Atlantic in the Gulf of St. Lawrence instead of the Bay of New-York. The waters of the Tioga river are turned from their natural course, through the Chemung canal; and instead of flowing by the Susquehannah into the Chesapeake bay, now pass by Seneca lake into Ontario, and thence into the Gulf of St. Lawrence. Far to the westward again, by the Illinois canal, the waters of Lake Michigan are destined to mingle with the Mississippi. Man has here done much to accomplish all these changes; but before man began, nature had done more, and to her are we indebted for those facilities which no other portion of this or any other country enjoys.

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* I had collected some facts to prove that the former condition of the great lakes was, in some degree at least, influenced by the elevations and depressions which have taken place along the eastern portion of our continent, extending sometimes as far as these lakes. Other subjects, however, have so occupied my time, that nothing more than a crude hypothesis could be offered, and therefore the subject is left for a future opportunity.

In connexion with this subject, I have learned from the early navigators of the Hudson river, that forty years since, the influence of the tides was not felt at Albany; but since that period they have been gradually advancing, so that at present the difference between high and low water is about two feet. This is alleged to have improved the navigation at some distance below Albany, so that what were formerly difficult places to pass, now afford sufficient depth of water. This circumstance bears strongly upon the modern accumulation of silt below Albany, which now obstructs the navigation at certain seasons. If from any circumstance the tide has been gradually advancing up the river, the point of deposit of these light materials, being at the meeting of the stream and tidal wave, would likewise take place at a higher point in the river. This is a subject of great interest, and as connected with the evidence of a former greater elevation of water in the Hudson river, is worthy of attention.

TABLES OF ELEVATION, etc.

The following tables present the elevations, areas, etc. of the great lakes, and the elevations of the principal lakes in the district.

TABLE *of elevation, mean depth, length, breadth and area of the several collections of water in the Great St. Lawrence Basin.**

	Elevation above tide level.	Mean depth.	Mean length.	Mean breadth.	AREA.
	Feet.	Feet.	Miles.	Miles.	Square miles.
Lake Superior,	641	900	300	80	24,000
Lake Huron,	596	900	200	95	19,000
Lake Michigan,	600	900	300	50	15,000
Lake Erie,	565	120	230	35	8,030
Lake Ontario,	231	492	180	30	5,400
River St. Lawrence and smaller lakes,		20			1,500
Total water surface,					72,930

* From Prof. J. HENRY's Topographical Sketch of the State of New-York. Transactions of the Albany Institute, Vol. I.

TABLE *of the mean length, breadth, depth, elevation and area of the Great Lakes and the River St. Lawrence.**

	Mean length.	Mean breadth.	Mean depth.	Elevation above the level of the sea.	AREA.
	Miles.	Miles.	Feet.	Feet.	Square miles.
Lake Superior,	400	80	900	596	32,000
Green Bay,	100	20	500	578	2,000
Lake Michigan,	320	70	1,000	578	22,400
Lake Huron,	240	80	1,000	578	20,400
Lake St. Clair,	20	18	20	570	360
Lake Erie,	240	40	84	565	9,600
Lake Ontario,	180	35	500	232	6,300
River St. Lawrence,			20		940
					94,000

It will be perceived that there are some differences in the two preceding tables; and not having the means of deciding the absolute truth, both are given. These are to be regarded as an approximation to the truth, rather than as absolutely correct.

The following are the elevations of the principal lakes within the district.

	Above Lake Ontario.	Above tide water.
	Feet.	Feet.
Cayuga lake,	156	387
Seneca lake,	216	447
Crooked lake,	487	718
Canandaigua lake,	437	668
Chautauque lake,	1,060	1,291

The elevation of the other lakes is not known with sufficient accuracy to give them in this table.

The three following tables of elevations, from the paper of Prof. Henry before quoted, present three lines of section in a north and south direction across the district.

* Report of Dr. HOUGHTON, State Geologist of Michigan.

TABLE *of ascents and descents from Great Sodus Bay, on Lake Ontario, along Seneca lake and the route of the Chemung canal, to Newtown on the Chemung or West Branch of the Susquehannah river.*

ROUTE.	Miles.		Feet.		
Lake Ontario, at Great Sodus Bay,					231
Lyons, on the Erie canal,		15	Rises	170	401
Outlet of Seneca lake, near Geneva,	12	27	Rises	46	447
Along the lake to its head,	34	61	Level,		447
Summit between the lake and Chemung river,	8	69	Rises	443	890
The Chemung at Newtown,	10	79	Falls	53	837

TABLE *of ascents and descents from Lake Ontario, along the valley of the Genesee river, to the mouth of Black creek in Allegany county, and thence to Olean on the Allegany river, along Oil and Black creeks.*

ROUTE.	Miles.		Feet.		
Mouth of Genesee river,					231
Erie canal at Rochester,		8	Rises	275	506
Squakie hill,	29	37	Rises	68	574
Gardeau flats,	6	43	Rises	76	650
Head of the great falls, Portage,	8	51	Rises	453	1,103
Mouth of Black creek,	16	67	Rises	162	1,265
*Summit level between Black and Oil creeks,	10	77	Rises	221	1,486
Olean on the Allegany,	13	90	Falls	78	1,408

TABLE *of ascents and descents from the mouth of Oak-orchard creek on Lake Ontario, in nearly a direct line to Olean on the Allegany, by the route of Batavia, the Tonawanda creek, Lime lake, and the valley of Ischua creek.*

ROUTE.	Miles.		Feet.		
Lake Ontario, at the mouth of Oak-orchard creek,					231
Albion, on the Erie canal,			Rises	275	506
Tonawanda creek, at Batavia,	17	25	Rises	77	883
Attica, along Tonawanda creek,	11	36	Rises	571	954
Dividing ridge between Tonawanda and Cattaraugus creeks,	18	54	Rises	426	1,480
Lime lake,	14	68	Rises	143	1,623
Olean point, on the Allegany, along the valley of Ischua and Oil creeks,	27	93	Falls	214	1,409

* This summit is a marsh, the discharged waters of which find the level of the ocean in the Gulf of St Lawrence and the Gulf of Mexico.

CHAPTER XXII.

Local Geology and Economical Products of the Counties comprising the Fourth Geological District.

[The details of this chapter have been chiefly extracted from the Annual Reports of the District.]

WAYNE COUNTY.*

The rocks of this county consist of the Medina sandstone, Clinton group, Niagara group, and the Onondaga salt group, ranging in nearly an east and west direction throughout the county. In the eastern part of the county the Medina sandstone forms but a narrow belt along the lake, but gradually expands towards the west. The other groups follow in succession. The best lines of exposure are from the Wolcott furnace southward along the creek; at Whiting's mill, about three miles further east; at Sodus bay, and in Ontario. The Clinton group presents some interesting features in this county which have not been observed farther eastward; and the geologist will find the Wolcott ore-bed, the creek at Wolcott's furnace, Whiting's mill, the former Shaker settlement, and the town of Ontario, interesting localities of these rocks, their minerals and fossils.

South of the Ridge road the country is occupied by numerous long, narrow and parallel ridges, rising from twenty-five to thirty-five feet above the general level, and having uniformly a north and south direction. The ridges are composed of sand and gravel.

They extend regularly as far north as the Ridge road, where they all terminate. This was observed particularly in the towns of Sodus, Williamson, and Ontario. We saw no instance in which these ridges cross the Ridge road.† On the old Sodus road we travel northward, for about a mile, between two of these parallel ridges, which are here quite as high as any in the county, when, upon descending a little towards the flat country, they terminate, and here a continuation of the lake ridge connects the points of these ridges or hills. This place is about half a mile south of Griffith's tavern, in the town of Sodus. From this point to the lake, the country is a gradually descending plain.

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* The details of this county are principally from the Report of the late Dr. G. W. Boyd. (Ann. Rep. of the District for 1838)

† This circumstance is referred to particularly, because the fact is important in considering the origin of the *lake ridge*.

The ridges about Clyde, and generally in the town of Galen, north of the canal, are numerous, long, narrow, low, and have a north and south direction.

Ridges in Lyons are also long, narrow, and low; both sides and top are cultivated.

The only exceptions to the northerly direction of the ridges were noticed in the town of Walworth, near Walworth corners, where there are two or three east and west ridges, upon one of which the village is situated. These form the highest land in this part of the county, between lake Ontario and the Erie canal. Also, in the town of Macedon, between the centre and the Erie canal, the country is broken, and the hills irregular.

The lake shore in Wayne county is generally bold, and composed of a bank greatly varying in height. About the mouth of Salmon creek it is ten feet high; at Pultneyville, in the town of Williamson, about eight feet; at Sodus Point, from eighty to one hundred feet. The bank is composed of sand and gravel, with occasional layers of clay. Generally a beach of some width runs along the shore, varying from fine to coarse gravel, according to the state and direction of the winds; it is sometimes entirely swept away by the excited waves of the lake.

In Wayne county, the Erie canal is carried along the valley of the Clyde, from both sides of which the country takes a very gradual rise. Canandaigua, Crooked, Seneca, and Cayuga lakes discharge their waters northwardly into the stream which traverses this valley. The stream is known first as Mud creek, until joined by the Canandaigua outlet, when it becomes Clyde river, and so continues eastward as far as Montezuma, where it receives through the Seneca outlet the waters of Crooked, Seneca, and Cayuga lakes, and then continuing east through Cayuga into Onondaga, joins the outlet of Oneida lake, with which it forms the Oswego river. The latter finally empties all the waters of the Clyde and Oneida valleys, including fifteen lakes, into Lake Ontario.

It was suggested to me by Col. Elias Cook, of Sodus Point, that at a former period, and perhaps previous to the formation of the Cayuga marshes, the Seneca river discharged a part or the whole of its waters northwardly through the towns of Butler and Wolcott in Wayne county, along the Wolcott creek* into Port bay on Lake Ontario. An examination of the country renders this opinion very probable. The marsh extends past Crusoe lake, which is immediately north of the island of the same name, into the town of Butler, to within a short distance of Wolcott creek. Also, by the surveys of Col. Cook, it appears that the rock in Wolcott creek at Marble's quarry (lot 165 in Butler), is only one foot above the level of the Montezuma marshes. This is a distance of about six miles, and the excavations would be through sand and gravel. The extensive water-worn surface of rock in the creek at Marble's quarry, indicates the passage of a much larger body of water than is now transmitted through this channel. At the village of Wolcott, we also notice a large gorge or gulf, produced by the current of a great body of water along the course of the present stream. The creek at present falls over the eastern part of this gulf; and upon no occasion of freshet in the present stream, does the water extend to the other side of the gulf.

* Its proper name is Mill creek.

Marshes and Swamps.

The Cayuga marshes occupy a part of the town of Savannah, surrounding both sides of Crusoe island, and extend beyond Crusoe lake into the south part of Butler. These marshes contain a deposit of calcareous marl, apparently equal in extent to that of the marshes. The Erie canal is cut through them for several miles, and penetrates the marl to the depth of five or six feet. This marl contains abundance of freshwater shells.

One mile west of Newark, a bed of shell marl appears in the banks of the Erie canal. It is whitish, and contains shells similar to the preceding. The depth of this bed is unknown, but it is probably small. It extends about one mile along the course of the canal.

In the south part of the town of Williamson, at Cooper's swamp, is a thin bed of whitish marl, containing shells similar to the preceding.

The calcareous marl above mentioned consists principally of carbonate of lime, with a little vegetable matter, and is in an earthy or friable state, perfectly adapted to employment as a manure. We are not aware, however, that it is at present applied to any useful purpose; but we conceive that it is equal in value to our western plaster, and may be a better application to some lands. We would suggest to the intelligent farmers in the vicinity of the Cayuga marshes, who may penetrate this marl in the course of ditching, to make a comparative trial of this article with the neighboring plaster.

A cranberry swamp was noticed at the head of Port bay, about three miles in length and one and a half in breadth; it shakes, is movable, and at times an acre or more has become detached and floated into the water.

Boulders.

Primitive boulders are noticed in abundance in Wayne county, but they do not occur of a large size; they seldom exceed half a ton in weight. Some of them could be distinguished as of similar character to rocks in the northern counties of the State; and among all the erratic masses which I have noticed, none were considered to be of southern origin. A great variety of primitive boulders occur in and about the village of Clyde; also in the town of Butler.

Soil.

South of the ridge the soil consists of a sandy loam, lightest, as the farmers say, on the west side of hills, and strongest and best on the eastern sides. This may be owing partly to exposure, and to the circumstance that the western sides of hills are frequently bared of snow by the westerly winds of winter. Beach, maple and bass-wood generally prevail on the east sides of hills, and hemlock on the west. North of the ridge, the surface is decidedly more sandy; yet in Wolcott and other towns in the south part of the county, the soil is generally productive, and the crops are good: it is a grain-growing country.

Mineral and other waters.

The springs in this county arise chiefly from limestones, or from shales and marls, which contain a proportion of lime; of course they are more or less impregnated with calcareous matter. Along the lake, however, the sandstone range furnishes springs of a pure and soft water.

Sulphur Springs.

Several sulphur springs arise in Brown's mill pond, about one and a half miles south of Newark. The water running from this pond deposits sulphur, and sulphuretted water issues from the bank at the road opposite the dam, and forms a whitish deposit. When the water in this pond becomes low, the small fishes which it contains are sometimes found dead, floating on the surface. No other cause than the properties of the sulphurous springs has been assigned for this fact.

On Salmon creek, near the forge in Sodus, a weak sulphurous spring rises from the red sandstone, and forms a reddish deposit. One or two sulphur springs also occur in and near Palmyra. At Jenkins's hill, in the village of Clyde, there is a weak mineral spring, probably of a sulphurous nature. With the exception of that on Salmon creek, all these springs occur in gypseous rocks. About half a mile northeast of Marion Centre, a sulphur spring rises from the bituminous limestone. This place is resorted to by residents of the vicinity, and occasional visiters.

Salt Springs.

The old Galen salt works are situated on lot No. 54 in the town of Savannah, immediately on the western edge of the Cayuga marshes. The spring is large, and is indeed quite a pond of perhaps twenty feet in diameter. Salt was manufactured about twenty-five years since, when the country was new and but thinly settled.

One or two salt springs formerly appeared in the creek, a short distance below Wolcott furnace; they are now neglected and filled with fresh water. These springs were worked in 1815, and furnished a reddish salt. They rise from the red sandstone. Another salt spring rises from the red sandstone upon a small creek emptying into Sodus bay, near the point.

Two miles east of Lockville, near the Erie canal, boring was made for salt. There was originally a spring at this spot, and salt was manufactured to a small extent.

Deep boring for Salt Water at Clyde.

In 1832, a company bored to the depth of 400 feet in the immediate vicinity of Clyde. The spot selected had no indications of a saline or other mineral character, and there was no spring; the boring was commenced in the gypseous rocks. Salt water was obtained in small quantity, but quite strong. A square wooden tube now projects several feet at the spot where the boring was made, but at present the water does not rise to the surface. Gypsum was found at the depth of twenty-five feet, which continued at intervals for 100 feet; below this was found sandstone, and occasional hard layers of rock — towards the last, so hard that the drill gained only an inch per diem. They passed through a fissure at 100 feet. Salt or brackish water appeared at 170 feet. The lowest rocks were sandstone and slates. Inflammable air was discharged during the boring, and also subsequently. At the time of our visit, on shaking the wooden tube, a gurgling noise could be heard below; and then upon passing down a burning paper, an explosion took place in the tube. No decided odor could be distinguished. Doubtless this inflammable air was carburetted hydrogen, as it has been frequently noticed in the Western States in similar borings for salt. Messrs. Reese and Stowe were of the company who made the search, and from them we received the preceding account of the work; the former gentleman presented us with the only sample he then possessed of the rocks penetrated during this boring, and which was extracted from the depth of 348 feet.

Clay.

Clay, suitable for the manufacture of brick, occurs abundantly along the line of the canal, and in limited beds at several points near and north of the ridge.

Gypseous Marl.

Plaster marl (the local name) occurs at many points on the Erie canal, and extends south into the adjoining county of Ontario. It generally appears as a soft slaty rock, or as an indurated marl, of an ash grey, and sometimes a greenish color. It is the gangue of the gypsum or plaster, in this, as well as in the neighboring counties. This marl generally contains an appreciable proportion of lime, although in some instances it is entirely argillaceous. Although of the nature of solid rock when first extracted, upon exposure to the air it slackens and crumbles down in a short time. We are not aware that it is used as a manure, but without doubt to sandy soils its addition would be very profitable, perhaps as much so as the plaster which it affords; inasmuch as soils purely sandy require clay as well as lime to give them a proper character of composition.

Near Clyde, the gypseous marl is seen of a dark grey color, slaty structure, and contains marine fossils, among which are Orthoceræ, Trilobites, and a variety of shells.

At Lockville, one mile east of Newark, it occurs, greenish, reddish, and variegated, in the banks of the canal, and in various excavations, especially at a race-way from Price's mill. At the latter place I examined and collected the marl. The greenish variety is amorphous, and contains gypsum in irregular or curious crystals. It effervesces with acids. Another variety is slaty, grey or ash color, soft, penetrated by numerous very thin seams of gypsum, and does not effervesce with acids. It appears to be entirely argillaceous, slackens upon exposure to air and moisture, and crumbles to a grey earthy powder.

Bog and Argillaceous Iron.

About one mile east of Lockville, bog iron occurs, covering about an acre; it is in large solid masses near the surface, and is frequently turned up by the plough.

A stratum or bed of argillaceous oxide of iron extends through Wayne county, parallel to and at the distance of about two miles from the lake. Furnaces for the reduction of this ore have been constructed in the towns of Wolcott, Sodus and Ontario. It has been ground for paint, and hence receives the name of *paint ore*. It belongs to the *lenticular* variety of mineralogists. It is always accompanied by greenish argillaceous shales and thin layers of shell limestone, and the ore itself seems to be composed chiefly of marine shells and other fossils, similar to those in the shales and limestones above and below.

The argillaceous ore makes a hard, brittle iron. When melted without any flux, it is too sharp, i. e. the cinder is equally as fluid as the iron, from which it does not separate, but will sometimes run to the end of the mould. The melted mass is too thin, and therefore it is necessary to mix loam with the ore. At the Wolcott furnace, Mr. Hendrick uses one part of sandy loam to two parts of ore, upon which the cinder separates, and perfect castings are produced. Mixed with the rock ore, or magnetic oxide from Canada, in equal parts, and also in the proportion of two parts of argillaceous to one of magnetic ore, a softer and better iron is produced.

The argillaceous oxide requires a high heat for melting, and consumes one-third more charcoal than the harder ores. There is always produced considerable carburet of iron in thin bright scales or leaves, exactly resembling plumbago; we have also seen this substance formed from the magnetic ores of iron at a high heat.

When casting plough irons, they run them upon a *hardener* (which is a piece of cold iron), so that for two inches on the edge, which is liable to wear, the castings are hardened like steel. The effect is, to change the usual granular texture of the casting into one that is lamellar, like bismuth. This difference is perceptible, and the line of demarcation is also very evident when the casting is broken.

Ontario furnace is situated upon Bear creek, about two miles north of the ridge. The argillaceous iron ore is extracted in two places in the immediate vicinity of the furnace; it is a continuation of the same stratum that is explored in the towns of Sodus and Wolcott. The layer of iron ore is situated about fifty feet above the surface of Lake Ontario. Solid ore occurs about three feet thick, and to a greater extent mixed with rock; it is clean, of a bright red color, exhibits its fossils very distinctly, and its characters are generally similar to those of the Wolcott ore. It is said to yield from 33 to 35 per cent of metallic iron. The iron which it forms is brittle, and is employed for large castings, as potash kettles, ploughshares, etc. Bog ore improves it. The ore is quarried and delivered at the furnace for $1.50 per ton. There were formerly manufactured at this furnace 300 tons of iron per annum. This ore was first dug during the last war, carried to Auburn, and ground for paint, of which it is said to form a good article with the addition of a little red lead.

Quicklime.

The Niagara limestone runs in an east and west direction across Wayne county, through the towns of Butler, Rose, the lower part of Sodus, Marion and Walworth, upon which are situated a line of Kilns, which furnish an ample supply of lime of an excellent quality. The limestone is frequently of a dark color, and contains bitumen, which is, however, expelled in the process of burning, and a white lime is produced.

Hydraulic Lime.

One mile south of Newark there occurs a grey sandy limestone of a slaty structure, which resembles the hydraulic limestone of Onondaga county. Also, in the south part of Williamson there appears a slaty, siliceous limestone, similar to, and in the same range with the hydraulic limestone of Monroe county. The Williamson rocks are immediately under the Niagara limestone mentioned under the head of Building stones, while those near Newark are above it, and also superior to the gypsum. A similar rock occurs at Merrick's mill on Van Awken's creek, in the town of Rose.

Firestones.

Limestone, containing an abundance of shells and other fossil remains, is generally employed in this county for hearth stones, and in other situations exposed to frequent changes of temperature. Such stone occurs at Merrick's mill, in the town of Rose; in the town of Sodus, south of the ridge, and in other parts of the county, in the range of shale under the Niagara limestone.

The range of sandstone in this county is narrow, not exceeding two miles in width, and lies immediately along the lake shore. It does not appear to be used for architectural purposes; indeed, it is too soft, slaty and argillaceous, except in the town of Wolcott, where the upper layers are hard, siliceous, and occasionally pass into conglomerate or puddingstone. These upper layers have been quarried and used in the construction of furnaces, as at Wolcott. At the forge on Salmon creek, the sandstone contains abundance of the Fucoides Harlani.

The sandstones of Beard's creek and Little Red creek, in the town of Wolcott, endure the action of heat sufficiently well to answer for side stones of furnaces, and they are employed for that purpose at Wolcott. When exposed to a red heat, and beyond that, they do not expand; on the contrary, they appear to contract, so that when used for the hearth, the temp stone (which is like the key stone of an arch) has sometimes fallen out.

At the Wolcott furnace, at present, they use and approve of the Oswego stone, viz. the red sandstone of Oswego falls, which is a part of the same formation as this in Wayne. The Oswego stone expands upon being heated, and is therefore well adapted for hearth stones.

At the glass-house in Clyde, they have employed the Haverstraw sandstone; but they now use, in preference, the stone from Perryopolis, Penn., and from Vienna, Ontario county.

Building Stones.

The range of limestone that we have referred to under the head of Quicklime, passes through this county about midway between Lake Ontario and the Erie Canal, in an east and west direction, having a width of from two to three miles. Many favorable situations occur for the extraction of building stone of an excellent and durable nature. This rock varies in color from light to dark blue, is of a granular texture, sandy, and emits a bituminous odor on percussion. It occurs in layers, of from one to three feet in thickness, having a horizontal position, and an elevated and dry situation.

Uttoe's or Miner's quarry, lot 132 in Rose, is on the head waters of Sheldon's creek. The rock occurs in extensive layers, two or three feet thick, of a dark blue color, granular texture, and highly bituminous. This quarry has furnished an approved stone, which was employed in the locks of the Erie canal, at Clyde.

Henderson's quarry, lot 111 in Butler, affords large blocks of a building stone, similar in all respects to that last mentioned.

Roe's quarry, in Butler, furnishes a dark compact limestone, which is bituminous. It is employed in building, and also for the manufacture of lime, of which it affords an article of excellent quality. It is a magnesian limestone, and contains only a few fossils, among which we recognize *Cytherina*.

A compact shell limestone, which occurs near the Shakers' mill in Sodus, is quarried as a marble, and used for ornamental purposes.

Gypsum.

The range of gypseous rocks extends on both sides of the Erie canal, along the southern part of Wayne county, but generally lies too low for profitable exploration. At Clyde, gypsum is found in wells at the depth of twenty-five feet. In wells at Lyons it has been found at forty feet, and also in Palmyra, at about the same depth.

About two miles west of Newark are two hills, from which gypsum is quarried. At this locality it is mostly lamellar, transparent, and receives the local name of isinglass plaster.

MONROE COUNTY.

The rocks of this county are the same as those in Wayne county. The Niagara group, however, becomes better developed, and its fossils more numerous. The Medina sandstone expands to a greater width, bordering the lake shore. The Clinton group perceptibly diminishes in thickness, and its most prominent fossil, the *Pentamerus oblongus*, disappears before leaving this county. The Onondaga salt group seems even better developed than in Wayne county, and its numerous beds of gypsum are more extensively exposed. The course of the Genesee river affords the best section of these rocks, and is quite sufficient to give one an idea of the position and nature of the strata without visiting any other place.

Surface of the Country, Streams, &c.

The general elevation of the northern part of this county is about three hundred or three hundred and fifty feet above Lake Ontario. All that portion of the county south of the canal maintains about this elevation, if we except the drift hills, which rise to the height of from fifty to one hundred feet. On the north of the canal the surface declines gradually, and almost imperceptibly, to the lake shore; on the east side of the Genesee being more uneven than on the west. In the northern part of the county, particularly north of the Ridge road, the surface is remarkably even. We here find scarcely an undulation or depression disturbing the uniformity, except the channels of the present streams.

East of the Genesee, particularly in the vicinity of the Irondequoit creek and bay, the country is very much broken into deep ravines and high ridges. The ridges are composed chiefly of fine sand, or sandy loam, with strata of pebbles or boulders near the bottom. Most of the boulders in these hills are from the rocks in the vicinity, those of the primitive rocks being comparatively few in number. In this and some other respects, the drift along the Irondequoit differs from that of any other part of the county. There have been vast accumulations of diluvial matter about the head of Irondequoit bay, and along its shores. It appears as if at one time this had been a great water-course, and that some inundation of sand, gravel, etc. had filled it up, and changed the direction of the stream. The sand of these hills is stratified, and the strata often curved, or inclined at different angles. The banks of the bay are high, with deep ravines scooped out by the action of the smaller streams.

The bed of the Irondequoit at Penfield, is much lower than the bed of the Genesee at Rochester and farther south. From examining the surface of the country, this seems the most natural course of the Genesee, and it may at one time have flowed in this channel. The Irondequoit is now a small stream, pursuing its course in a deep valley of denudation, showing that some more powerful agent was formerly active in this quarter.

Farther south and distant from the streams, through the towns of Penfield, Perrinton, Mendon, etc., the drift hills are of moderate elevation, giving a gentle undulating appearance to the country. In the south part of Perrinton the surface is very irregular, the hills rising from fifty to one hundred feet above the general level. These are composed of gravel and hardpan, and the general character of the soil is gravelly. Some of the hills are sandy, supporting a growth of shrub oaks and whortleberry; the soil, however, is said to be good when reclaimed. West of the Genesee, few hills rise to a greater height than thirty or forty feet. All those in this part of the county rest upon the gypseous formation, and many of them are formed by the destruction of the upper portions of these strata.

Most of the streams afford eligible mill seats, and it is to the water power furnished by the Genesee that Rochester owes much of her prosperity. The great accumulation of water power at that place, depends on the geological structure of the country. Had all the strata been of equal hardness, the grand and beautiful succession of falls and rapids would not have been produced, but in place of them a uniform, rapid current to the lake.

The Mountain ridge, or "limestone ridge," so-called, becomes well defined a few miles west of Rochester. Here its elevation is only fifteen or twenty feet, but it gradually rises towards the west, and at the western line of the county is forty or fifty feet above the level of the country on the north. This ridge or terrace does not pursue a direct line, but is tortuous and irregular in its course.

In many places we find swamps or marshes with large accumulations of partially decomposed vegetable matter, though none of it has yet become peat. The substance is usually termed "muck," and is used in some places as manure. There are several of these swamps along the lake shore, where immense quantities of "muck" are deposited. Others on the south side of the ridge road, exhibit finely comminuted vegetable matter, with trunks of trees, deposited, often to the depth of several feet. The trees growing in these swamps are commonly black-ash, tamarack, and cedar. In the southern part of the county are several swamps of this character, where the vegetable matter covers a deposit of shell marl—both substances of great value as manures.

Lake Shore.

The lake shore of this county is for the most part low, the land gradually declining to the level of the water. The action of the waves, together with the ice, have raised beaches, which in many places protect the land from inundation during high winds. In the eastern part of the county, the banks are abrupt, consisting of gravel, sand and clay. These banks are gradually worn away by the waves, and the materials carried to points where the banks are low. By this wearing action the lake encroaches upon the land in some places, while the land is gaining upon the lake in others. In the course of a year, several feet of these banks are abraded by the waves. The wind from the northeast carries the abraded materials towards the mouth of the Genesee, and thus aids in filling up the channel, and extending the shoals and sand-bars in the vicinity. The shores being low on the west of the Genesee, a west or northwest wind brings few materials from that quarter. When the lake is higher than usual, even the low beaches are worn down, and the materials transported to other parts of the shore.

The bank of the lake, from the Genesee river to the eastern boundary of the county, is from ten to thirty feet high. From the Genesee to the western line of the county, the shore is generally low, or raised into a beach a few feet above the lake. During the rising of the lake, which occurs at intervals, the beaches and sand-bars are removed, to be deposited in other places, and to fill up the mouths of streams. It therefore becomes a matter of importance to protect the shores from such effects, and from the loss of land thus sustained. To do this, trees and shrubs should be permitted to grow on the banks, and shrubs with strong roots might be planted to effect the same object.

*Boulders—Erratic Blocks.**

Boulders of different rocks are abundantly distributed over some parts of the county. They are most abundant north of the mountain ridge, and over the gypseous rocks in the south part of the county. In many places the surface is literally covered with them for a considerable extent, and again for a mile or two few are seen. These boulders are of the primitive rocks, as granite and gneiss, and of sandstone from the lower formation. Granite and sandstone are the prevailing boulders, but rounded and angular fragments of rocks of every formation, in the district, are found on the surface, some of them immediately above the original rock, and others at no great distance from it. The predominance of felspar is observed in all the granite boulders; many of them being of that variety called Labrador felspar. This felspar is very indestructible, and masses of that rock form some of the largest boulders in the county. Some of the spherical masses are eight or ten feet in diameter. These are in many places so abundant as to be broken up and used for building materials.

Soil.

The prevailing soil of Monroe county is a gravelly loam; but we often find clayey loam, sand, etc. extending over considerable areas. Approaching the Genesee river on either side, the soil is more sandy; this character prevails, also, along the Irondequoit. In some places the different soils blend into each other, and in others are quite distinct, or their limits are defined by the small streams. Sometimes changes of this kind are remarkable, where on crossing a stream the character of the soil is entirely different. The sandy soils are not deficient in carbonate of lime, and the sand from several feet below the surface is apparently as

* We cannot, with propriety, restrict the term boulder to a rock distant from its original formation, for in the southern part of the State, rounded masses of the red sandstone are boulders; while masses of the same form are found on the lines one a few rods south, and in the soil above the original rocks which by that definition are not boulders.

fertile as the original soil. Some of these sands require the addition of aluminous matter, to render them of proper consistence for retaining moisture.

Where there are no disturbances in the surface from streams or other causes, the character of the soil depends much upon that of the rock beneath; but owing to such causes, we cannot safely depend on this criterion. The upper strata of the sandstone produce a sandy soil, but its character is modified by the decomposition of the shales above, which generally supply sufficient argillaceous matter. The marl of the sandstone formation below the upper strata, produces a loamy soil, in some cases approaching to clayey loam. Sometimes this soil is mixed with gravel or sand, and no one kind prevails over an extensive district. It is no uncommon occurrence to find, in the same field, sandy, clayey and gravelly soil. The soil on the north side of the lake ridge, for the most part, is more uniform in character than on the south. That on the north side requires more care and labor in the cultivation, but is thought to produce quite as good crops as the soil on the south side. Wheat, in some instances, has been sown on these soils ten years in succession. The soil above the sandstone has often a brownish color, arising from the character of the rock beneath.

The shales above the sandstone produce a clayey soil, which, however, contains a sufficient quantity of carbonate of lime to render it extremely fertile. The soil produced by the decomposition of the shale, north of the mountain ridge, is perhaps the most productive of any in the county. It is peculiarly adapted to the growth of wheat; but if tilled for a long time, and particularly if worked while wet, it becomes "stiff," and hard, like clay.

Clays might be used, to manifest advantage, on some of the sandy soils, particularly in the eastern part of the county, where the same farm often contains both sand and clay.

The soil upon the limestone is from a few inches to twenty feet in depth, of a loamy character, and very fertile throughout. The slow disintegration of the limestone affords a sufficient proportion of carbonate of lime; and if vegetable matter be also furnished, the soil will not soon be exhausted. In the southern part of the county the soil is gravelly or sandy on the hills, and clayey in the valleys and low grounds. It contains a large proportion of carbonate of lime, arising from the decomposition of fragments of slaty limestone which are distributed throughout. In some places we find extensive deposits of coarse gravel, with boulders.

Clays.

The clays of Monroe county are of that kind fit for bricks and the coarsest kinds of pottery. The varieties are grey, blue and brown clays: grey and blue varieties prevail along the lake shore; those in the interior of the county are brownish or variegated. Every part of the county furnishes beds of clay of greater or less extent, but the demand for bricks has been limited to a few points. As many as five or six beds of clay have been wrought in the vicinity of Rochester, from which about 2,000,000 of bricks are furnished annually. Bricks have been made near the village of North-Penfield, and there is an extensive deposit of clay on the lake shore in the north part of the town of Brighton. Bricks are made near Fairport, and at Mendon and Pittsford. Beds of clay occur near Clarkson and Brockport; from some of which, bricks have been made. We might enumerate every town in the county, but the materials are similar, and are found in all.

The decomposing gypseous marls appear at the surface in Pittsford, and other places, where they have been mistaken for clay. This marl contains too much carbonate of lime to be useful for bricks, but would be valuable if used as a manure on sandy lands. It makes bricks of a very inferior quality, which crumble on exposure to rains, and are peculiarly unfit for exposure to water.

Sands.

The only pure siliceous sands we find in this county are on the lake shore. With these, garnet and iron sands occur in small quantities. Coarse sand or fine gravel, fit for making mortar, is found in many places, particularly along the Irondequoit, and in many of the drift hills. The fine sand of these hills contains too much argillaceous matter to be useful where a siliceous sand is required. At the outlet of the Irondequoit bay, great quantities of a pure siliceous sand is drifted into ridges along the shore. Sand may be obtained from this place, in sufficient quantities for the manufacture of glass, or for sawing marble, should it ever be required for such purposes. This kind of sand is found at intervals, and in great quantities along the lake shore from the Irondequoit to Sandy creek. Magnetic iron sand and garnet sand are also found in considerable quantities, and collected for writing sand. The iron is not in sufficient abundance to be of importance as an iron ore. These two sands result from the destruction of granitic rocks containing both iron and garnet.

Water and Springs.

All the water of the county, and indeed of the whole district, contains lime in some form, being what is termed hard water. The county generally is well watered, though in some parts water is not so readily obtained. Along the northern slope of the "Mountain ridge," and over the whole of the sandstone formation, water is abundant, either rising to the surface in springs, or collecting in the low grounds and forming small streams. In digging wells, where the sandstone approaches the surface, it is often necessary to penetrate the rock a few feet before a constant supply of water is found. After ascending to the top of the limestone, water is not so abundant. Few springs rise to the surface, and the water accumulating in the low grounds and forming small streams, is dried up in summer, or lost in the fissures of the rock; consequently, at such seasons the supply of water on the surface is very limited. Water is obtained by digging, at different depths; sometimes at the surface of the limestone, but commonly by penetrating it a few feet, and often to the depth of thirty or forty feet. In these cases it is usual to find a cavity or fissure in the rock, which affords an abundant supply. The water from the wells never overflows the surface, though from the dip of the rocks it might probably be made to do so. The water all flows into wells from the north, as we would expect from the dip of the strata; and in some cases a well dug to the south of one already supplying water, will drain the latter entirely. In such cases, it is only necessary to excavate the northern well deeper to obtain a supply.

The southern part of the county is plentifully supplied with water, both from springs and streams; though towards the northern limit of the gypseous marls it is often necessary to penetrate these rocks to the depth of fifty to sixty feet, and in some instances to two hundred and even three hundred feet, before a supply is obtained. The earthy or compact portions of these rocks afford but little water, till penetrated to considerable depths; and when it is obtained, it appears to flow from a cavity or reservoir in the rock.

Springs of hydro-sulphuretted water are of frequent occurrence in almost every part of the county, but more particularly along that portion occupied by the shales, both above and below the limestone. Some of these springs are celebrated, and are much resorted to by invalids and fashionable visiters. Among these may be enumerated the Monroe springs, about five miles from Rochester, pleasantly situated in a grove not far from the road leading from Rochester to Pittsford.

There is a copious spring of this kind, rising to the surface, on the land of Timothy Colby, in Ogden. There is also another similar spring, very highly impregnated with sulphuretted hydrogen, in the northern part of this town.

The Riga mineral spring is said to be very beneficial in cutaneous diseases. This spring rises from near the junction of the limestone with the gypseous rocks above. Inflammable gas (carburetted hydrogen) rises from this spring in sufficient quantities to supply a constant flame from a half inch tube. Iron is an ingredient of the water, as appears from the tests applied, and the presence of some salt is indicated by its taste. The rock from which the spring issues is a dark green gypseous marl.

Many springs contain large quantities of carbonate of lime in solution, which, as the water comes to the air, is deposited in the form of tufa, or a fine pulverulent marl. Where the quantity is small, it forms the porous vesicular deposit called tufa; but where the water is abundant, or where the spring rises in a level tract or swamp, the deposit is marl. The most copious spring of this kind is in Caledonia, Livingston county, though the deposit is chiefly made in Monroe county. There is a similar spring at the source of Mill creek. After the carbonate of lime is deposited, the water of these springs is nearly pure acid water.

Salt Springs.

There are several salt springs in the county, from which salt has formerly been made, but they have been abandoned since the facilities of transportation have increased; and salt is now obtained much cheaper from Salina than it can be made from these springs. None of them appear to have been penetrated to a great depth, and in their present state are so much diluted with fresh water that the saline taste is barely perceptible. Owing to this circumstance, and to the impossibility of obtaining accurate local information, no estimate can be formed of their value. All these springs appear to have their origin in the indurated marl of the Medina sandstone. Whether the decomposition of this marl affords chloride of sodium, I am not prepared to decide; but we know that this mineral does result from the decomposition of the shales above the sandstone. The shale along the Genesee below Rochester produces chloride of sodium and sulphate of magnesia.

The situation of the salt springs in Monroe county, is unfavorable to large accumulations of water, and this may be the reason why they have not been more productive. Those which I have observed are along the margin of small streams, and the salt water as it comes to the surface is carried off by the fresh water, or becomes too much diluted.

Tufa, Marl, and materials for manures.

The substance usually denominated marl is a calcareous deposit from springs, but partially decomposed calcareous shales are properly marls.

Rain water has the property of dissolving the calcareous rocks over which it flows, and the water of many springs holds large quantities in solution. This property is owing to the presence of carbonic acid gas in the water; when the gas is dissipated in the atmosphere, the calcareous matter before held in solution is thrown down. The porous or more compact portions of this deposit, usually containing incrusted plants, leaves and other substances, is called travertine or tufa. Besides this, a portion of the deposit in some situations is of a fine pulverulent texture, often containing great numbers of fluviatile shells.

Wherever the calcareous rocks are exposed, the action of rain and the percolation of water from the soil produce depositions of tufa. Along all the streams and rivers where calcareous rocks form the banks, we find deposits of tufa collecting, and remaining attached to the rocky cliff, till, from their increasing weight, they fall into the stream.

Along the Genesee river, below Rochester, are considerable accumulations of this substance. Vast quantities of calcareous matter are also carried down this river and smaller streams, to be deposited in Lake Ontario, probably in much more extensive beds than those found on land.

Tufa is mostly used for burning into lime, of which it affords a fine quality. The more compact parts of it have been employed for building, and form a cheap and durable material. When first removed from the ground, and while moist, it is easily cut or sawed, and is thus shaped into blocks of any required dimensions. After exposure the moisture evaporates, and it becomes very hard.

Deposits of shell marl are found in various places in Monroe county. The most important locality is in the southern part of the county, along the course of Allen's creek in Wheatland. The eastern part of this deposit extends southward into Livingston county. Tufa forms the upper portion in many places to the depth of three or four feet, and below it is the shell marl three or four feet thick. Some portions of the formation are nearly pure carbonate of lime, containing abundance of the shells mentioned; in other places it is impure from admixture of earthy matter. It extends in length about three miles, and in breadth from half a mile to one mile. The general thickness is about five feet, though often much greater. At its smallest dimensions, we shall find it 125,452,800 cubic feet, or 2,309,056 loads.

Another extensive deposit of this material is found along the course of Mill creek, extending from its source to Cady pond, and filling the marshes around the pond for the extent of many acres.* Its thickness is unknown, but in some places it exceeds three or four feet. Tufa forms in many places, in exposed situations, along this deposit. The soil above these deposits is usually a light, partially decomposed vegetable matter, allowing the water to pass through it, by which means it soon becomes parched, and the crops perish. By spreading on this soil a small quantity of clay or loam and the marl beneath, it could be made of the finest quality. The partially decomposed vegetable matter is also one of the best manures with marl or lime.

In the town of Riga, on the land of Mr. Knowles, a deposit of this marl, of unknown depth, covers thirty or forty acres. It has been penetrated ten or fifteen feet, without finding its termination. The upper portions are very pure carbonate of lime, yielding lime of a very superior quality. It is cut out, while moist, in masses of the form and size of bricks, and laid in the kiln and burned. After penetrating this deposit about two feet, it becomes mixed with sand and other impurities, rendering it unfit for lime, but not for manure. By accident, several loads of this marl were deposited and remained for several years on a barren piece of ground; afterwards this spot was ploughed, and has yielded large crops every year since, though before it produced almost nothing. Strange as it may seem, this change in the character of the soil was not attributed to the marl; consequently it has not been used on other parts of the farm. Numerous other localities have been noticed, but these are the most important. Those enumerated are upon the gypseous rocks, and similar deposits may be expected in the low grounds throughout the whole of this formation, the extent of which may be learned by referring to the Geological map.

The decomposing gypseous rocks afford a marl, which is sometimes too clayey to be beneficial as a manure, but in other cases it is valuable, especially when mixed with shell marl. This marl approaches the surface in many places in the town of Pittsford, where it is of a character well adapted for use on sandy lands. The same marl is seen east of Pittsford, along the line of the canal, and at Fairport. Gypsum in small quantities has been found in the marl at these localities. On the west side of the river we find the gypseous marl in Riga, Chili and Wheatland, in some places approaching the surface, or appearing in the beds of small streams. The only place where this marl has been applied is in the town of Wheatland. Mr. Merry has used this and the shell marl, separately and mixed, and finds the results fully to realize his most sanguine expectations. Used on the light vegetable soil of the swamps in that neighborhood, this marl has produced astonishing results. A meadow of this kind, which produced little or nothing, was dressed with this marl, and sown with timothy

* The source of this stream is a spring rising among the gypseous rocks. The spring in Caledonia, Livingston county, is the source of the stream from which most of the marl of the first named locality is deposited.

seed; and in less than ten weeks from the time of sowing, three tons of hay to the acre were cut from the meadow. The composition of this marl is admirably adapted to fertilize such soils, producing a mixture of calcareous, aluminous and vegetable matter. Without dwelling on particular localities, we may observe, that this marl may be found on almost every farm in the southern range of towns in this county.

Gypsum.—Plaster.

The gypseous rocks extend across the southern part of this county, occupying all that portion south of Black creek, and between it and Allen's creek. In one or two localities gypsum has been found south of Allen's creek, but the formation is soon succeeded by the corniferous limestone. Plaster has been obtained in small quantities at Cartersville, in the town of Pittsford, but the quantity was not sufficient for profitable working. At this place, the marl is decomposed to the depth of fifteen feet, and presents the appearance of a greenish grey clay. Marl of this character appears in several places along the canal, near this place and at Fairport, but the quantity of plaster contained in it is too small for working.

The workable beds of gypsum are almost wholly confined to the southern part of the formation. Along the valley of Allen's creek, and Mill creek, two miles farther north, most of the plaster of Monroe county is obtained. Both these places are in the town of Wheatland. In the towns of Riga and Chili, gypsum is found in thin seams, and small nodules disseminated throughout the rock. In these place, marls, which readily crumble on exposure to the air, can be substituted for gypsum. Until within a few years, the value of plaster, as a manure or stimulant for vegetation, has not been generally appreciated, but it is now much used; the demand is constantly increasing, and will doubtless continue to do so. It is mostly employed on grass lands, particularly on clover, as preparatory to a crop of wheat. It is also used on wheat crops in the fall and spring, and Indian corn is much benefitted by the use of plaster. One bushel to the acre is generally considered a sufficient quantity for grass crops.

The manner in which plaster affects vegetation, is asserted by Liebig to be by a decomposition, in which the sulphuric acid becomes combined with ammonia, which then acts upon the vegetation. This process, however, is not admitted by all to take place, and the operation of plaster seems yet obscure. In the use of this, as well as many other manures, the fact is overlooked, that plants are supported, in a great degree, by carbonic acid, and that much of this food is taken up by that part of the plant above ground. In this view of the case, any substance, above or beneath the surface, which presents carbonic acid to the plant, affords it food. Thus many substances which do not enter into the composition of plants, afford much food for them, either by absorbing this gas from other bodies and giving it to the plant, or affording it from their own decomposition.

At present, about 5000 tons of plaster per annum are obtained from the town of Wheatland; of this quantity, 4000 tons are used in Monroe county. This, however, is not the whole amount used in the county, as much plaster is brought from counties further east. Of the 5000 tons, 1500 tons are obtained from Mr. Garbutt's farm, in the north part of Wheatland;

1000 tons from Messrs. Sage and Herman's, the adjoining farm; and 1000 tons from the Messrs. McVean's farm, on lot 49. The remaining 1500 tons are supplied from an extensive deposit at Garbutt's mills, on Allen's creek. Ground plaster is sold for three dollars per ton.

Metals.

Iron is the only ore of any importance in this county. Blende and galena (or the sulphurets of lead and zinc) are found in the Niagara limestone, but never in large quantities. The argillaceous iron ore, already noticed, extends from the Genesee river to the eastern limits of the county, but has not yet been explored in any part of this distance.

Quicklime and Hydraulic Cement.

Quicklime is manufactured in considerable quantities from the Niagara limestone. There are several kilns near Rochester, and others farther west and south. East of Rochester, lime is made from boulders and fragments of limestone on the surface and imbedded in the soil. This limestone contains magnesian earth, and some other impurities, rendering the lime less valuable than it otherwise would be. In some localities certain strata only are used for making lime, and in other places the whole of the rock is too impure for that purpose. This is owing to the predominance of siliceous and aluminous matter.

Hydraulic Cement.

As this material is extensively used along the line of the Erie canal, it may be proper to offer some remarks on the quality and situation of the substance used for this purpose. Nearly all the hydraulic cement now used is brought from Onondaga.

I have already remarked, that there is no formation to which the term hydraulic limestone is exclusively applicable. The upper part of the calcareous shale, as it graduates into the Niagara limestone, becomes, by admixture of siliceous and argillaceous matter, a substance considered fit for hydraulic cement. The upper portions of the gypseous rocks, by similar admixture, become an argillaceous limestone, used for the same purpose.

From the circumstance that these rocks are an intermediate formation, or produced at the passage of a shale into a limestone, no two strata are alike. For example, an upper stratum may be nearly a pure limestone, while a lower one is almost wholly argillaceous; thus no reliance can be placed upon its quality. The same stratum at different places may also change the proportion of its component parts. The greatest objection in regard to the stone used for this cement is, that it contains too much argillaceous matter, and for this reason will never withstand the action of freezing water. Much of the cement now made is of very inferior quality, and losses are constantly sustained from its use. This subject is one which requires strict and constant investigation, and the State of New-York would save large sums in the construction of her public works by procuring a cement of good quality.

The rock used in this county for cement, is usually blue or greenish blue, when first exposed to the atmosphere, but becomes rusty grey and partially decomposed by atmospheric agents. In the locality last mentioned, the original color of the stone is grey, or of the color of pipe-clay.

Fire Stone.

A stratum of light grey limestone, of a porous texture, extends through the towns of Ogden and Sweden. This stone resists the action of ordinary fires for many years with little apparent loss or change. Its character depends on the presence of magnesian earth, and the porous structure of the stone, which prevents it from cracking when heated. It is much used in this neighborhood for the backs and jambs of fire-places, and also for door and window caps and sills. At the place where the stone is quarried, the stratum is not seen in place, but masses of the broken outcropping edge are used.

Some of the strata of the gypseous rocks are sufficiently siliceous to be a good fire stone, and have been used for hearths of iron furnaces.

Materials for Construction.

Common building stone is obtained in many places along the course of the Niagara limestone formation. A very durable stone is quarried from the bed of the Genesee river at Rochester, and has been used for the foundation of the new aqueduct. Some of the stone is injured by the presence of thin seams of shale, admitting water, which, on freezing, will expand and split the stone. The portions free from seams of this kind, furnish one of the best and most durable materials in the county. A very good stone for ordinary purposes of construction is obtained at the rapids near Rochester; but owing to its geodal structure, it cannot be used where a smooth and even surface is required. Dark, bituminous limestone is quarried in several places in Penfield.

In West-Mendon the upper strata of the Onondaga salt group are extensively quarried for step-stones, door and window caps and sills, lintels, blocks for corners, pedestals, etc. The rock is a silico-argillaceous limestone, sufficiently hard and compact for ordinary purposes. When first quarried it is soft and easily worked, but becomes harder on drying. This stone is much used in Rochester and the adjoining towns, and the demand is constantly increasing. The common thickness of the layers is from four to eight inches, and they can be procured of any required dimensions. Except the more siliceous portions, these stones should not be used where they will be subjected to the action of freezing water, farther than to rains, which seem scarcely to affect them.

The Medina sandstone and the indurated marl of the same formation have been used for building stone; but experience has proved what a knowledge of their composition would have foretold, viz. that in Monroe county they are almost entirely unfit for any useful purpose whatever. Many apparently compact blocks of this rock will, in the course of a few weeks, if exposed, crumble into a loose mass. Where used in buildings, it has in some cases, been little affected by the weather; but in most, it has been rapidly destroyed. The great objection to the stone, is the presence of a large proportion of argillaceous matter, absorbing water, which destroys it by the same process that the hydraulic cement is removed from the walls of locks.

The limestone of Monroe county affords no marble or materials for decoration. The more siliceous portions of the Niagara limestone furnish a fine material for macadamizing roads, and it is much used near Rochester for that purpose. Paving stones are obtained from the drift. Flagging stone is not abundant, but is found among the siliceous strata of the Onondaga salt group.

The sandstone has been quarried near the outlet of Irondequoit creek, and used in the construction of piers at the mouth of the Genesee river. By the action of the waves and freezing water, it is very rapidly destroyed, and it becomes necessary to rebuild the piers almost annually. The stone from this quarry has recently been rejected for the construction of piers, and limestone substituted. An expense of several thousand dollars had been incurred in opening the quarry, before the stone was rejected. Had the proprietors submitted it to the examination of some competent person, or to the common tests, all this expense would have been saved.

ORLEANS COUNTY.*

The rocks of this county consist of the same as those on the east, with the exception of the Onondaga salt group, which has not been detected within its limits. The Niagara group rises in a terrace above the surrounding country, becoming more elevated in a westerly direction. The Clinton group appears in much diminished thickness, but still highly fossiliferous. The Medina sandstone abounds in fossils at Medina, that being the principal locality where shells occur in this rock. The section from this place southward will give one a correct idea of the strata. The vicinity of Albion and Farwell's mill, are also good localities for fossils in the Niagara group. The Medina sandstone occupies more than half the width of this county.

Surface of the Country.

The most prominent character of Orleans, when compared with the adjoining counties, is a remarkable evenness of surface. Indeed, the whole county, with the exception of its two

* The details of investigation in this county, are principally extracted from the report of the late Dr. G. W. Boyd. (Annual

ridges, may be considered as nearly a level; and in traversing it at any part in an east or west direction, there is neither ascent nor descent of any consequence, nor any irregularity of the surface, other than where the streams have worn down their present channels. This is especially the character of all that part of the country north of the Erie canal, from which to Lake Ontario there is a gradual and almost imperceptible descent; the country presenting an uniform level face, with the exception of the ridge, on the summit of which passes the Ridge road. The Erie canal is in this county at an elevation of 275 feet above the level of Lake Ontario, and its distance from the lake is between eight and ten miles.

The level country continues south of the canal for about two miles, when we meet a sudden rise, upon ascending which, we arrive upon the limestone range. This rise bears the name of Maple ridge at Shelby, two miles south of Medina; and following the course of the canal, it is seen at Millsville; then going east it passes about two miles south of Albion, preserving the same distance for two and a half miles, when it gradually inclines northward, and crosses the Transit line at a road one and a quarter miles from the canal. Hence it continues east, and soon reaches Jefferson lake, of which it forms the southern shore. From this small lake it turns rapidly to the south, and reaches Clarendon centre; beyond which it continues still south for about two miles, and then turning to the east again, passes into the county of Monroe. This ridge, or terrace, has a pretty uniform elevation of about fifty feet.

From Maple ridge southwardly, the country has a very gentle rise for about two miles, when we arrive at another distinct, but more moderate step, which is about thirty feet in height. South of Shelby, this rise bears the name of Windfall ridge, and in other parts of the county is known as Limestone ridge. Its course is east and west, parallel with Maple ridge, from which it preserves a distance of about two miles, and can be followed from the western part of the town of Shelby, passing by Barre centre eastward to the Transit line. After ascending this terrace, we are on the summit of the limestone range, and on the highest ground in the county. The country now continues quite level for about two miles to the south, and then descends gradually to the Tonawanda marshes, which in this county are only ninety feet above the level of the Erie canal.

Lake Shore, Streams, etc.

The shore of Lake Ontario forms nearly an uniform straight line from east to west, and presents a bank of moderate height, in general protected by a beach.

During the summers of 1836 and 1837, the lake encroached on the land. On the east side of the Oak-orchard creek, three or four rods were removed, together with a fine beach of two or three rods in width; so that at present the waves dash against and undermine the bank, which is constantly falling into the lake. In the course of the summer of 1837, the bank, for a limited extent, and to the width of 20 feet, was swept away by the waters of the lake.

At Tony's harbor, we noticed several small mounds, considered to be of Indian origin; and similar ones are said to be numerous in the town of Shelby, a short distance south of the canal.

Oak-orchard creek is the principal water course in Orleans county. On the east side of the creek, at the mouth, we saw two or three mounds about three feet high, and ten feet in diameter, containing human bones.

It will be noticed, upon reference to the map of this county, that all the creeks have a general bearing to the east. This may be owing to the direction of the rock fissures, which are generally northeast.

The Tonawanda marshes extend along the southern edge of Orleans county, and occupy a part of Clarendon, Barre and Shelby.

Immediately south of the ridge, in the north part of Murray, is a tamarac swamp, about three miles in length, which communicates at one end with Marsh creek, and at the other with Sandy creek. Its reclamation has been commenced by drainage.

Soils.

The prevailing character of the soil north of the ridge is sandy. Limited tracts of a clayey nature occur, which were observed more especially near the lake.

Proceeding from Ridgeway to the lake, we find a sandy soil extending from the ridge to within two miles of the lake; then clay predominates, and the soil consists of a clay loam, which is a strong and warm soil, producing good crops. But little plaster is employed as manure.

From Sandycreekville, the country inclines very gradually to the lake; about three miles north of the village, we cross a tract of clay land about one mile in width. Two miles west of the village, it approaches quite to the ridge.

In Carlton, the soil is a sandy loam.

The northern part of Orleans embraces many fine farms, which although the soil is sandy, are very productive. Farms immediately along the ridge are also more productive than we should expect from the character of the soil; but the sand of the ridge we suppose to be not exclusively siliceous, but to contain considerable lime.

In the immediate vicinity of Albion, clay prevails in the soil; and about two miles east there is a very sandy tract, of limited extent.

The soil upon the limestone range in the towns of Shelby, Barre and Clarendon, appears to be an excellent mixture of clay, sand and lime, and is very productive. But little plaster is used in this part of the county, and there is evidently but slight necessity for it, inasmuch as the soil is the result, chiefly, of the underlying limestones, and limestone shales. The road from South-Barre to Clarendon runs upon the limestone range.

Springs and Mineral Waters.

North of the Erie canal, the springs and wells furnish good soft water. On the limestone range, and in the county south of the canal, the water is hard, containing lime.

At South-Barre, limestone is found at the depth of seventeen feet, and water is generally obtained at the surface of the rock, or upon penetrating it for a short distance.

The salt springs of Orleans county are in every instance upon the [illegible] of sandstone.

In the town of Ridgeway, one and a half miles north of Medina, near Oak-orchard creek, is a saline spring, now neglected and nearly filled up, where salt was manufactured in the early settlement of the county, more than twenty years ago.

A small salt spring is also known in the town of Gaines, at Fairhaven.

In the town of Kendall, lot 137, now occupied by Mr. Hamblin, there is a brine spring, at which salt was formerly made.

Near Scofield's mills, Johnson's creek, in the town of Yates, salt was formerly manufactured from a spring now neglected and filled up.

A salt spring was discovered in the east bank of the Oak-orchard creek, at the village of Oak-orchard, where salt was manufactured by Mr. Bennett. He bored to the depth of one hundred and forty feet, and obtained a stronger brine, but the quantity was not increased. The rock is red sandstone, of a soft, slaty nature. The works have been discontinued, and gone to decay, and no taste of salt can at present be perceived in the water.

At Holley are three salt springs, formerly used for the manufacture of salt. They are all situated in close proximity, in the bed of Sandy creek, immediately at the south side of the culvert. One spring or well is now seen on the west side, and on a level with the bed of the creek; having been neglected for some years, and having been exposed to overflow from the creek, its proportion of saline matter could not be determined, but it has a decided brackish taste. Another small spring is immediately opposite, on the east side of the creek; and here, about four years since, borings were made to the depth of about thirty feet, but no subsequent operations were performed. A third spring was discovered immediately under the culvert, and a wooden log was laid to conduct away the water. At present all these springs are neglected. About the year 1821, considerable salt was made at these springs, and was sold at five dollars per barrel; but when the Erie canal was constructed as far as Holley, salt was brought from Salina, and furnished at a rate so low, that the works at this place and others along the canal were at once discontinued.

There are two sulphurous springs at Holley village, the water of which has been used as a bath in cutaneous affections.

Clay.

Blue, yellow, and variegated clays, occur at many points in Orleans county, and are employed in the manufacture of bricks; as at Albion, where there are several kilns immediately in the village. A fine blue clay was seen at Linden, a thriving village one mile south of Yates centre. Blue and yellow clays appear at several points along the lake shore, forming limited beds in the banks, but at present they are not explored.

Boulders.

A variety of primitive boulders were noticed along the Erie canal, between Hulberton and Holley; also a little north of Medina, between the canal and ridge; and on the lake shore, in Yates. In the northeast part of Barre, on the limestone range, one large boulder of granite was observed, with greyish quartz and opalescent felspar. Also, at the same place, one very large transported mass of sandstone.

These erratic blocks are found scattered over the surface, but I think in less profusion than farther east. Near Jefferson lake are several large masses of granite, with dark blue felspar, resembling the rock which occurs in place in Essex county, where it forms entire mountains. At Oak-orchard, on the east bank of the creek, one small boulder was noted, consisting of dark limestone, with fossils distinguished as belonging to the limestones which repose upon the sandstone seen in the southern part of the county; but from its situation, it was considered to have been brought down the stream by the high waters of the creek.

Marl.

There is a limited deposit of calcareous marl about one mile south of Holley, on the west side of Sandy creek. It is white, in a state of powder, and contains an abundance of shells, principally the *Helix albolabris* (white-lipped snail). It occurs on the side of a hill, resting on the red sandstone, and was exposed in digging a raceway.

Calcareous marl also occurs in a swamp on the farm of David Hooker, two and a half miles north of Medina.

Calcareous tufa forms in large quantities at the falls of Oak-orchard creek at Shelby, from the decomposition of the calcareous shales.

Bog Iron Ore.

Several deposits of bog iron ore were noticed in the county, which, however, are not explored, so that their extent is unknown. It occurs in solid masses one mile west of Albion.

One mile east of Ridgeway corners, on the south base of the ridge, bog iron is found in grains, both loose and forming small masses in the soil, which is here a sandy loam. It has the local name of *shot ore*. Bog iron also occurs one mile, and one and a half miles west of Ridgeway corners.

In Ridgeway, between the ridge and west branch of Oak-orchard creek, there is a swamp covering four hundred or five hundred acres, containing an abundance of bog ore, from which iron has been manufactured.

Quicklime.

The limestone range in the southern part of this county furnishes an abundant supply of materials for lime of an excellent quality. Kilns are erected south of Shelby, at Millsville, about one mile south of Williams's quarry in the town of Barre, and at other places in the limestone region. At Barre, and on the range to Clarendon, the rock is of a light blue color, and occurs in large irregular and ragged masses, either forming ledges, or scattered profusely over the surface. It resembles very closely in character the limestone at the Bull's Head, one mile from Rochester, and contains generally the same fossils.

Two miles west of Farwell's mills, occurs a dark blue, bituminous, magnesian limestone containing fossils.

Hydraulic Lime.

We were informed that the upper layers of the rock at the falls of Oak-orchard creek, at Shelby, are advantageously used for the manufacture of water cement. They consist of a sandy limestone, but do not resemble in texture and other characters the best hydraulic limestone. The cement used in the aqueduct at Medina was from this place, and has stood the test of time as well as any other on the canal.

At Farwell's mills, Clarendon, there is a deposit of sandy limestone, slightly bituminous, agreeing in texture, color and other characters, with the most approved hydraulic limestones of the western counties, and, according to Judge Farwell, has been burned, and converted into water cement of an excellent quality. This stone is also used for building.

Building and Flagging Stones.

The Medina sandstone prevails in the northern half of the county, and is exposed almost continuously along the Erie canal, from Holley to Medina. North of the canal it is seen in the banks or beds of the creeks, and in other situations near the surface, which it immediately underlies. It has been mentioned in the preceding pages, as frequently soft, argillaceous, and not durable; yet there are courses of this rock which are more dense, or siliceous, and furnish an excellent material for building.

A little north and west of Medina is a quarry, which has furnished a handsome pink-colored sandstone in large slabs and blocks, with smooth surfaces and of good texture.

The freestone was quarried on Otter creek, about two miles south of Eagle harbor, for some of the works on the Erie canal. At this quarry the layers are thick, hard, not slaty, nor argillaceous as elsewhere, and yet it crumbles upon exposure.

In the southeast part of the village of Albion, a quarry was in operation, which furnished rock of a reddish or variegated description, intended for buildings. The same quarry also furnished courses of a grey sandstone of a firmer texture, with less argillaceous matter, and altogether more durable.

The upper layers of the sandstone near Albion consist of a greyish sandy rock, which is preferred for the corner stones of buildings. The upper layers at Medina and Holley are very siliceous, and too hard to be wrought with advantage. For foundations and rough work, they are well adapted, and are of a texture to withstand the effects of moisture, frost, and all other exposure.

The sandstone or freestone was also employed in the construction of the culvert over Sandy creek at Holley; but the arch below showing a tendency to disintegration, a new one, composed of limestone, was consequently built within, in order to sustain the first. We have already mentioned that it was quarried near the mouth of Oak-orchard creek, and used in the works pertaining to the harbor.

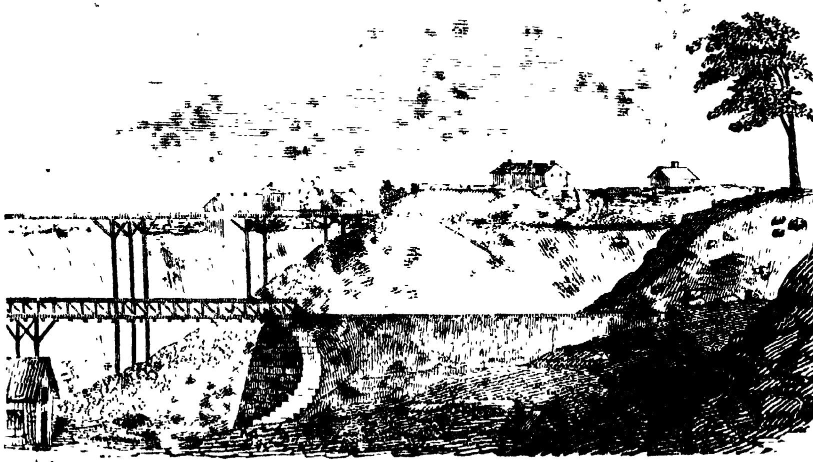
The rock under consideration is mostly inclined to disintegration upon exposure to the weather, although quite firm when first quarried. In this respect it resembles the sandstone of the Genesee river, below Rochester, of which it is a continuation.

Thin layers of limestone are extracted from the bed of Oak-orchard creek, between Medina and Shelby, and used at the former place for flagging. They appear to be of a siliceous character, occur in large slabs, and the surfaces are frequently covered with fossil vegetables of the family of fucoids; they strongly resemble the petrified stems of terrene plants.

Williams's quarry, in the northeast part of the town of Barre, furnishes a siliceous or sandy limestone, at present used for fences and underpinning, and which resembles the rock employed in Monroe county for the preparation of water cement.

A grey, porous, siliceous limestone is quarried at Farwell's mills, Clarendon centre, and used in buildings. Some of the layers contain a considerable proportion of lime, although they mostly consist of a porous, flinty rock, much resembling the French buhrstone. The quarry is quite extensive, and occupies the summit of the ridge which overlooks the village. Its porous structure is due to the removal of small fossils and fragments of crinoidal stems.

191.



NIAGARA COUNTY.

We find the same rocks in this county as in the preceding ones. The Medina sandstone forms a broad band on the northern side of the county, reaching nearly to the line of the Erie canal, and the Onondaga salt group forms a narrow band on its southern edge. The Niagara and Clinton groups form a high terrace, extending entirely across the county, and are only interrupted at the Niagara river, pursuing their way beyond into Canada. This remarkable terrace furnishes a good opportunity of examining the rocks of these groups, and no locality offers so good facilities for this purpose as Lockport and the gorge of the Niagara.

Surface of the country — Streams, &c.

The Mountain ridge* is the most remarkable feature in the surface of this county. This ridge gradually rises to the westward, and at the Niagara river is about three hundred and fifty feet above the level of Lake Ontario, and two hundred and fifty feet above the country on the north. At Lewiston, the whole descent to the north is made at one offset; but farther east it descends by two, making two grand steps, or terraces. This double offset is produced by the unequal hardness of the rocks; a stratum of sandstone causing the lower one, while most of the rocks below and above it to the limestone are soft. In the eastern part of the county, this stratum of sandstone has so far declined that it dips beneath the general level of the country on the north. The mountain ridge passes through the towns of Lewiston, Cambria,

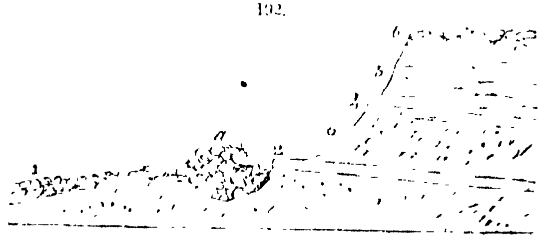
* The terms "[illegible] ridge" and "terrace" have been used indiscriminately; the [illegible] commonly applied, though latter is more app[illegible]e.

Lockport, and Royalton. From the foot of this terrace the country declines gradually towards the lake, and the top of the terrace is the highest land in the county. From thence there is a gradual slope south, to the Tonawanda creek. The streams flowing to the lake have cut their channels deeply into the red marl and sandstone, and their great breadth and depth indicate a much larger quantity of water at some previous time.

The drift hills do not rise more than a few feet above the general surface. The soil every where is composed, in part, of water-worn materials; but the hills, if there ever were any, have been levelled by some subsequent cause.

In descending the terrace on the north, we find ridges of loose materials extending from the top and sloping gradually off to the surface below. Where the northern extremities of the hills have been excavated, we find large rounded masses of limestone and shale, from the rocks south, with masses of granite. These are all mingled together in confusion; and the masses of limestone are worn and scratched, as if having been borne along with blocks of harder rock. From these appearances, and the form of the hills, it is very evident that a current of water flowed from the south. But again, on the summit of this terrace we find masses of sandstone from the north, often wedged into fissures of the limestone, as if driven there by violent force. The following section of the cliff, and a superficial deposit of this kind, at Lewiston, illustrates the subject. At the point *a*, which is just beyond the edge of the projecting mass of grey sandstone, there is an immense accumulation of partially worn fragments of sandstone and limestone; large numbers of the latter being from the top of the terrace above. This deposit has been penetrated seventy feet, without reaching the rock beneath.

192.



1, 2, 3. Lower, middle and upper parts of the Medina sandstone. 4. Clinton Group. 5. Shale of the Niagara Group. 6. Limestone of the Niagara Group.

Several extensive marshes along the lake shore are gradually being filled with materials brought into them by streams, and deposited, while the outlets are dammed up by beaches. Swamps on the south side of the Ridge road contain deposits of partially decomposed vegetable matter, to the depth of three or four feet. When the swamps are filled with water, this substance expands, and the surface is elevated considerably above the level which it occupies when dry. When drained, and the vegetation burned, the vegetable soil below takes fire, and is with difficulty extinguished. A swamp of this character commences five miles east of Lewiston, extends three miles, and is about half a mile wide. The vegetable soil is from one to three feet thick, and underlaid by clay, though in some parts a deposit of calcareous marl is interposed.

The vegetable soil of these swamps will eventually become peat; indeed its composition is now the same, but it is not yet sufficiently decomposed to allow the particles to cohere. The swamps south of the Ridge road can readily be drained, and will become fertile meadows The south part of Niagara county is not thickly inhabited: the ground is low and marshy; the growth of timber, tamarack, elm, ash, etc. The land only requires draining to become as good, or better, than any in the county. The junction of the limestone and gypseous rocks is near the southern line of the county, and at this point we always find some of the best land. The dam across the Tonawanda, near its mouth, is a serious impediment to draining this region; and unless the streams flowing into this, are cleared from obstructions, and the accumulated water carried off, the south part of this county and the north of Erie must long remain unimproved.

In following the lake ridge from the east to Eighteen-mile creek, it suddenly disappears, and is again seen four miles farther west. When the lake was at this elevation, probably a broad bay at the outlet of this creek prevented the continuation of the ridge. About seven miles west of Eighteen-mile creek, the ridge divides; and a portion, precisely similar to the continuous ridge, after extending two miles in a northwest direction, suddenly terminates This fork was evidently a bar projecting into the ancient lake.

Lake Shore.

The lake shore, forming the northern boundary of this county, rises abruptly to the height of from ten to thirty feet. The bank is generally composed of gravel, sand, and clay, with a beach of pebbles at its base. The lake at its present elevation washes the foot of the bank, and in many places is undermining and wearing it away rapidly. On some farms ten feet in width have been worn away in the course of a year, though the average loss of land may not be more than four or five feet annually. Being upon the lake shore in this county during a violent storm of two days (25th and 26th of October, 1837), I found that, during that time, the soil to the width of three or four feet had been worn away. This effect was not confined to a single spot, but extended for miles. The waves, during storms, are dashed against the shore with such force that they are thrown entirely over the bank. It has thus become a matter of much importance to the farmer, to protect his land against the ravages of the lake.

The Medina sandstone appears in the bank in many places, and at such points the land is in a measure protected from the action of the waves. All the projecting points along the lake shore are of sandstone, or marl of the same formation; and where it does not appear in the bank, it is found at a little depth below the level of the lake. The most northerly point of this rock on the lake shore is at least four hundred feet below the upper stratum of the formation.

The pebbles along the lake shore are red sandstone, and greenish blue siliceous limestone, both containing fossils, the latter rock more abundantly. The fossils in these pebbles are *Corallines*, *Orthocera*, bivalve and univalve shells. Both the character of the stone, and the fossils, differ from any in the Fourth District. The mineralogical character of the pebbles along the lake shore farther east, is very similar, but they contain no fossils. The pebbles in the lake ridge, in Niagara county, exhibit the same fossils, and are precisely similar to those on the lake shore, all being from the Hudson river group.

Abraded materials from the banks are transported by the water, and form bars and shoals at the mouths of smaller streams. The only river is the Niagara, and the immense body of water brought down its channel entirely prevents any obstruction from depositions at its mouth, though there is doubtless a vast deposit in the bed of the lake where the current becomes neutralized.

Boulders.

Boulders of granite, and other rocks, are scattered over the northern part of the county, in some places the surface being literally covered with them, while in the southern part they are almost entirely absent. In this respect Niagara county differs from Monroe, where in the southern part boulders are very abundant and of large size. They are more abundant in the eastern part of this county than towards the Niagara river. These boulders appear to follow certain courses, and to extend in great profusion over certain districts; this distribution appears to have been governed by some law, and we may yet arrive at data which will enable us to describe the drift, and its varying characters, with as much precision as we now do a stratum, or a series of strata in an older formation.

Soil.

The soil between the mountain and the lake ridges contains a large proportion of clay, although extremely fertile. The lake ridge and the soil, for a limited distance, on either side, is sandy or gravelly. North of the Ridge road, the soil for a short distance is clayey, except along the streams, where it is sandy. From the ridge to the lake shore, the prevailing soil is sandy loam, of a yellowish color, inclining to brown where the sandstone approaches the surface, as it does in many places. It contains carbonate of lime, which often cements the gravel below the surface. All kinds of crops flourish on this soil; and wheat, in Niagara, is considered better than in the counties adjoining.

The indurated marl, or marly sandstone, does not admit the passage of water; and when it approaches the surface, unless on a declivity, the water is too long retained. The soil in these cases becomes wet and cold, and in rainy seasons the crops are sometimes injured.

In some places in the northern part of this county there are alternations of a clayey with a sandy soil, often several miles in extent; and generally, in this part of the county, the soil seems divided into nearly equal proportions, in one of which sand predominates, and in the other clay. The sandy portions are a little elevated above the loam or clay soil, as if transported by a gentle current over the bottom of the ancient lake, which might move sand; while clay, if once deposited, would be less easily disturbed.

The soil upon the mountain ridge is sand, or sandy loam, for a mile or two south, when the proportion of clay increases. Along the Tonnewanda, clay soil predominates, owing to the gypseous marls, which are argillaceous, in the lower part of the formation. These marls extend into Niagara county, their outcrop being a little distance north of the Tonawanda creek.

Clays.

Beds of clay are found in every town in Niagara county, though many are of impure quality from admixture of sand and carbonate of lime. The demand for bricks has, however, been confined to one or two points, and consequently these beds have not been explored. The prevalence of limestone, and limestone shale, more or less affects all the deposits of clay, except those along the lake shore.

Many of the bricks manufactured in the county are of inferior quality, arising from the use of sandy loam mixed with the clay, instead of a pure siliceous sand. This loam contains abundance of fine particles of limestone, and when burned, becomes lime: the action of water on such bricks is rapidly destructive.

On the lake shore, a bed of clay continues almost from the eastern to the western extremity of the county. In some places this thins out, and its place is occupied by gravel or loam, and sometimes the clay is intermixed with one or both these substances; the upper part being grey and less pure than the lower, which is usually of a bluish color throughout, or variegated with spots of brown and green. Where the lower part of the stratum is seen, it rests on a partially indurated deposit of gravel and clay, of a reddish color, and this rests upon the red marl or sandstone. The clay is from two to six feet thick, and often contains pebbles and boulders, similar to those on the lake shore. Frequently we observe alternations of the clay and a part of the gravel stratum below and above, and the clay is often much bent and contorted, although it rests on a nearly horizontal base. These alternations and contortions are in many places very remarkable, and would induce the belief that almost any position, observed in stratified rocks, may be given during their deposition. The presence of pebbles and boulders in the clay, proves that the water from which it was deposited had sufficient velocity to transport large and heavy materials.

The grey loamy clay above the blue clay sometimes attains the thickness of four or five feet, and in some places the whole deposit is of this color. The grey, where it occurs, appears entirely distinct from the blue, as if it might have been deposited at a subsequent period. In this clay we find the calcareous concretions called clay stones, or "clay dogs," which assume all imaginary forms, sometimes the most fantastic. They are often spherical, and sometimes two or more of them attached together. They appear at regular intervals in the strata, and commonly a line of them marks the junction of the grey with the blue clay below, being at that point where the surface water meets an impervious layer. These substances are an earthy carbonate of lime, which is apparently deposited from the water precolating from the surface.

Fibres (apparently vegetable) extend from the surface to the depth of three or four (sometimes twelve) feet; and around these fibres, as a nucleus, the deposit is made. The grey loamy clay is pervious to water, while the blue clay is not; and the fibres never extend into the blue clay, but always terminate at its surface. We find the clay stones surrounding the same fibre at different depths, and can often trace the connection of several; sometimes these are merely rings of calcareous matter, the internal part still being clay. Those formed directly around the fibre are usually perforated; but others are often attached on every side of this one, which are entirely solid. It appears as if the water had been conducted downwards by this fibre, and the solid material deposited, forming a ring. But when the accumulations are large, or where the stratum below is impervious, the calcareous matter is forced out on every side, and produces the fantastic forms which we so often find.

This deposit of clay is found on the Niagara river, and extending nearly a mile from its mouth. At this place, the grey or yellowish clay above attains a much greater thickness than at any other place.

Sands.

No extensive deposits of siliceous sand occur in this county. In many places along the lake shore, it appears in small quantities.

Water and Springs.

The county is well watered throughout, both by springs and streams. Along the foot of the mountain ridge, numerous springs of fresh water gush out from fissures in the limestone, or at the junction of the shale and limestone below. Water is readily obtained in almost any situation, by penetrating a few feet below the surface. North of the mountain ridge, it is sometimes necessary to penetrate a few feet into the marl or sandstone, before a sufficient supply is obtained.

Springs of hydro-sulphuretted water,—"sulphur springs," are of frequent occurrence in many parts of the county, but few of them have any celebrity. Some contain sulphate of magnesia in solution, in sufficient quantities to affect the taste very sensibly.

Near Lewiston a copious spring rises from beneath the stratum of grey sandstone, about one hundred feet from the top of the formation. The water of this spring is slightly charged with sulphuretted hydrogen, and contains a notable proportion of sulphate of magnesia. Its situation, however, is almost inaccessible, and for that reason will not soon become a place of resort. Other similar springs, but less copious, occur in the vicinity. "Sulphur springs" are found in many places in the shale and limestone along the northern slope of the mountain ridge. They occur wherever iron pyrites is disseminated through the rock. At Lockport, in the limestone above the shale, a spring of this kind, when opened, discharged gas sufficient to support a constant flame from a small tube. On the Tonawanda creek, about two miles from the village, on the land of Mr. Vandenburgh, is a spring of this kind, which has some celebrity. About three miles below Niagara falls, near the margin of the river bank, there is a sulphur spring, which is prepared with accommodations for visitors.

I observed but one chalybeate spring in the county. This is on the farm of Capt. Leonard, two miles north of Lewiston. There are several other springs at the same place, and the water of some is said to yield salt on evaporation. Two miles east of Lewiston, a copious sulphur spring rises from the shale on the mountain ridge.

Salt Springs.

In Niagara county, as in Monroe, we find salt springs along the course and in the beds of almost all the streams in the northern part of the county. These springs are not copious, but we frequently find three or four in the distance of half a mile. Several of these springs occur along the course of Eighteen-mile creek, between Lockport and Lake Ontario. Salt springs, affording small quantities of water, occur along Golden-hill creek and Johnson's creek. Salt was formerly made from a spring within three miles of Lockport; which, at the time I examined it, was filled with fresh water.

It is the general belief that the water of these springs increases in strength on descending into the rock, but this may be doubted. At St. Catharine's, U. C., a boring of five hundred feet was made in the same rock, and it was found that the water at three hundred feet was 27° (hydrometer), and at four hundred and twenty-five feet, 29°; but this degree of strength was not constant at the same depth at different times.

Tufa — Marl — Materials for Agriculture.

Tufa is found in small quantities in many places, particularly along the north slope of the mountain ridge; but it nowhere occurs in such abundance as in Monroe county.

Shell marl is found in swamps between the mountain and the lake ridges. An extensive deposit of this substance occurs in a swamp five miles east of Lockport: it has been used at this place as a substitute for lime, but not as a manure. Several other swamps of a similar character occur on the south side of the Ridge road. In the south part of the county, along the Tonawanda creek, are found beds of marl, but the condition of the country will not admit of accurate examinations. These beds being in low grounds, cannot be available till the land is drained.

The lower part of the gypseous rocks extend into Niagara county, and where they approach the surface, can be used to great advantage on sandy soils.

The partially decomposed calcareous shales on the northern slope of the mountain ridge, are a good material for manure on sandy lands; but the large proportion of argillaceous matter precludes their use where there is already sufficient clay in the soil.

Metals.

Bog iron is the only metallic ore of any importance, and this is not found in sufficient abundance for manufacturing. It occurs in beds a few inches thick in many places in the northern part of the county, perhaps none more than six or eight inches thick. I collected specimens from Lewiston, and Wilson. In both places the deposit covers a considerable extent of surface, but is of little depth. The rocks from which this ore is derived are shale and sandstone, and the proportion of iron in these is so small that large deposits are not made.

The argillaceous iron ore of Wayne and Monroe counties is not anywhere found in Niagara county, though the formation is continued.

Blende (sulphuret of zinc) is found in cavities of the Niagara limestone at Lockport and at Niagara falls, and sometimes disseminated in the rock. The quantity is only sufficient for cabinet specimens.

Quicklime and Hydraulic Cement.

The Niagara limestone is the only rock in Niagara county from which quicklime is made The lower portions only of this limestone, near its outcropping edge, are used for making pure lime; any part of it, however, is pure enough for agricultural purposes.

It has already been stated that the outcropping edge of this limestone follows the course of the mountain ridge, so that at a glance one may perceive in what part of the county lime is manufactured.

Hydraulic cement has been manufactured from the impure limestone, forming the beds of passage from the shale to the limestone of the Niagara group. In many places farther east, the same bed in the mountain ridge furnishes the hydraulic cement used on the canal. That furnished for the aqueduct at Medina was from this rock, which occurs at Shelby, two miles south of Medina. The same strata extend across the county from near Middleport to Lewiston. At many places along this distance a good cement may be obtained, but the best stone for this purpose is near the top of the terrace at Lewiston. The stone at this place is a siliceous limestone, with some argillaceous matter, and containing a small proportion of the oxide of manganese. Owing to the presence of this ore, the stone presents a greenish hue when first exposed, but finally becomes a rusty grey.

Materials for Construction.

Both the limestone and sandstone formations furnish good and durable materials for the construction of buildings. There is a stratum of the sandstone formation about twenty-five feet thick, which affords a very fine building stone; and from the peculiar smoothness of some of the layers, it is often very beautiful. The stone is a very pure siliceous sandstone, separating into laminæ or layers of from one eighth of an inch to eight inches thick, with very even surfaces. The position of this stratum, or bed, has already been noticed as occurring in the midst of the red marly sandstone.

The limestone, particularly in the lower strata, furnishes a superior stone for building. It is only at intervals, however, that the same strata furnish a similar material; for at one point we may obtain regular blocks of almost any required dimensions, and often at a short distance the the same stratum is divided into thin laminæ. The best material of this kind in the county, and indeed far the best I have seen in the district, is obtained at the Coldspring quarries near Lockport. These quarries are at three points within a mile of each other, and within three miles of Lockport. Two of the quarries belong to Mr. W. D Shuler, and the other to Messrs. Skinner and Day. Mr Buell has since opened another quarry near the village of Lockport. The stone is of a light grey color, generally compact, or sub-crystalline, though often exhibiting a porous surface. They are among the most durable materials for construction, as may be proved by examining the locks of the canal at Lockport, where the same kind of stone has been exposed to all changes of temperature, and to freezing water, and still remains firm. Wherever this stone has been used in buildings, it remains unchanged by the action of atmospheric agents. It is extensively used at Buffalo, Lockport, Rochester, and many of the villages along the canal. The quarries are favorably situated, being on the brow of the mountain ridge.

Variegated Marble of Lockport.

At the village of Lockport, we find the same strata as at the Coldspring quarries; but here they are more compact in texture, and contain abundance of fragments of crinoidal columns. These columns, and a few other fossils in the rock, are of a reddish brown color, giving to the surface a beautifully variegated appearance. The rock is sufficiently compact to be polished; it has been used for some ornamental purposes, and is known as "Lockport marble."

The variegated strata are from five to eight feet thick, and extend over an area of many acres. This marble will doubtless become valuable at some future time, when the demand is greater than at present.

Flagging Stones.

Flagging stones of the finest quality are obtained from the Medina sandstone. The principal quarry belonging to Mr. Whitmore, is one and a quarter miles northwest of Lockport. The stone quarried for flagging occupies about five feet in thickness, of the upper part of the strata; the stone separates into thin laminæ or layers commonly of the thickness of two to four inches, but often not more than the eighth of an inch.

The slabs are frequently obtained twenty feet square, and no more than four inches thick. One in the collection of the State, is six feet long, four feet wide, and little more than an inch thick. From its even surface this stone is admirably adapted so the purposes for which it is used, and the purely siliceous texture renders it extremely durable. It is now much used in Buffalo, Lockport and Rochester.

SENECA COUNTY.

All that part of the county north of the Seneca lake outlet, with the exception of a small portion south of a line drawn from Waterloo in a northwest direction to Ontario county, is occupied by the Onondaga salt group. Nearly all this northern part of the county is deeply covered with alluvium; and the rocks appear at very few points. One of these is in the bank of Bear creek, where gypsum was quarried many years since; and another about three miles north of Seneca-falls, where gypsum and gypseous marl were penetrated in digging a well.

The great depth at which gypsum is found in the north part of the county will, for the present, and for a long time to come, preclude its profitable exploration. The waters of Seneca lake, which have worn a recent outlet along the southern limit of this series, expose the gypsum and associated rocks near Seneca-falls village, and for nearly three miles below. Along this distance the gypsum is extensively quarried. It occurs in irregular, often conical masses, enclosed in a greyish friable marl, with which it is often much intermixed, and in consequence deteriorated in quality.

There is here no evidence that the masses of gypsum have forced up the strata, as noticed in some places in Monroe and Ontario counties. On the other hand, the lines of stratification in the marl are continued through the mass of gypsum without interruption. The strata are undulated, the depressions being between the beds of gypsum, and this appearance may have been caused either from the porous nature of the marl by which some of it has been dissolved and carried off, or from contraction, on drying of the mass between the gypsum beds. The latter, being a chemical compound, and the force of aggregation greater on becoming indurated, has contracted less than the surrounding marl; it consequently presents a slight convexity in the surface. In these beds all appearances prove that the gypsum was separated from the marl by chemical attraction, while each was in a fluid or semifluid state. Small particles and seams of gypsum still remain scattered through the surrounding mass and it very appropriately receives the name of gypseous marl.

The rocks belonging to this formation are already described; they all bear much uniformity in character at different points, and are easily recognized, even when the gypsum is not present, by their argillaceous nature, and nearly uniform drab or ash color on exposure to weather. Some portions are harder and darker, or frequently green on first exposure. Owing to the usually soft nature of the strata, they have been removed from extensive tracts, and the space filled with alluvium from more northern rocks; this is particularly the case in Wayne, and the greater part of Monroe counties, as well as in Seneca and Ontario; and from this fact, a principal member of the series, the red shale, has been overlooked. Knowing the character of this rock, from examining other localities, we find evidence of its existence along the northern part of this formation from the color of the soil; but after much careful examination, I have not found a point between the Cayuga lake and Genesee river, where that rock is exposed. Near King's corners, in the town of Butler, Wayne county, the soil for some distance along the road is of a deep red color, owing to the proximity of the red shale: farther west the line of this rock is covered by deep alluvium, which in many places is colored by the red shale.

The quarries below Seneca-falls are extensively wrought, and large quantities of the plaster sent westward on the Erie canal, and southward up the Seneca lake, and thence by the Chemung canal; it is thus distributed over the counties of Chemung and Steuben. The quantity of plaster annually taken from these beds is about five or six thousand tons. A small proportion only of the vast quantity has been removed, and, at the present rate of consumption, it will be long before these beds are exhausted.

That portion of the county south of the outlet and north of the turnpike leading to Cayuga bridge, is probably underlaid by plaster, and the working of the beds on that side of the outlet will gradually lead to its development.

Above the gypsum, at this place, is a compact marl, containing small masses of granular gypsum or selenite, which often appear to have crystallized in the fissures and seams. The action of crystallization in this case appears to have taken place after the rock had become partially indurated; and the indurated part of the marl in many places is filled with irregular cavities, lined with crystalline carbonate of lime. This appearance may have occurred from the rock having been broken up after partial induration, and thus forming with the gypsum, then in solution, a kind of conglomerate, as is seen in some rocks below this.

The soft gypseous marl, surrounding the beds of gypsum, could be very advantageously employed on the sandy soils north of Seneca-falls, and west, towards Waterloo. The argillaceous matter of the marl would form with the sand a soil of proper consistence; while the calcareous matter, and the small admixture of plaster, thus introduced, would be efficient in promoting vegetation.

On Black brook, three miles north of Seneca-falls, this mineral was obtained many years since, but it has not been farther explored. At another point in the same neighborhood, a bed was found in digging a well, thirty feet below the surface. This depth, however, will effectually preclude any explorations for the mineral while it bears no higher prices than at present. On the south side of the outlet, the beds probably continue an unlimited distance; but the increasing depth of the superincumbent materials, from the dip in that direction, will effectually preclude its exploration at this place.

Along the south side of the Seneca outlet, the Corniferous limestone occupies a belt of country about two or three miles wide, gradually approaching the stream about a mile west of Waterloo village.

Along the area where this rock is exposed, there is evidence of several downheaves; probably caused by the solution and removal of the soft rocks below. These downheaves are connected with, or produced by the same cause as those more important ones on the east side of Cayuga lake, described by Mr. Vanuxem. No manifestation of disturbance appears on the surface; the limestone is scarcely raised above the level of the surrounding country, and the strata observed in the quarries all dip south at an angle of from four to six degrees

Noting the amount of dip in this rock, and finding it to occur frequently for a distance of several miles, we might, at first view, be disposed to estimate it as of great thickness; but in each of these quarries we find precisely the same rocks repeated, and the whole apparent thickness consists of a few strata which have been several times broken up.

In one of these faults, arises a copious spring of pure cold water, from the bed of which, and over an area of twenty feet, nitrogen gas is abundantly emitted. No deposit of any kind is left by the water, which through its whole course to the lake is remarkably clear and limpid. The water from this spring, and another similar but much smaller one near, supplies the Canoga flouring mills, a saw-mill and some other machinery. From no other spring in this part of the State is nitrogen gas known to issue, all others known in the State being near the junction of transition with primitive or metamorphic rocks.

The principal quarries of the Corniferous limestone are those of M'Allister, Rorison, and one belonging to the county, adjoining the latter; half a mile south of the last is another extensive quarry, and also one half a mile southwest of the Canoga spring. The stone is quarried for buildings and enclosures, as well as for burning into lime. The layers do not generally exceed a foot in thickness, and are separated by thin seams of shale. From six to eight courses of the stone are to be seen in each quarry, which are generally separated by thin seams of shale, and sometimes by a layer of hornstone; two or three of the latter sometimes occur in the same quarry, separating the courses of limestone. The hornstone is more commonly in courses of nodules in the limestone; sometimes one, and at other times several courses, occurring in the same stratum of the different quarries. When dressed with the chisel, it forms an elegant and durable material for stepstones, door and window caps and sills.

The Marcellus shale and the Hamilton group occupy a broad belt in this county. The different members of the latter are well developed on the shores of both the Cayuga and Seneca lakes. These shales are chiefly interesting in the vast number of fossils which they contain, and in the production of a calcareous soil.

Succeeding the Hamilton group we find the Tully limestone, the Genesee slate, and the shales and flagstones of the Portage group.

Almost all the ravines where the Hamilton group is exposed, appear to have formerly been large water courses, the present streams cutting a narrow channel in the *bottom*, which is composed, sometimes to great depth, of water-worn fragments of shale and the rocks above, and covered with soil supporting the largest forest trees. Along the banks of the ravines, the destruction of the shale has produced a thin but rich soil, which, though the rains are constantly washing it down into the valleys below, produces a small growth of trees, and a luxuriant one of flowers, of which a greater variety and in greater beauty can scarcely be seen. The family of *Trillium*, the *Corydalis*, *Dentaria*, *Caulophyllum*, *Tiarella*, and the delicate *Mitella*, with hundreds of others, spring up in the greatest perfection and profusion. As beautiful objects of natural scenery, these ravines cannot be surpassed.

Localities of the shale of this group are so numerous that it is unnecessary to enumerate them all. The shore of Seneca lake, from three miles above the outlet to Goff's point, presents an almost continuous exposure of greater or less height. The western shore of Cayuga lake, and for nearly the same distance, exhibits these shales, but not in high cliffs as on the other side of the county.

The Tully limestone is one of the most important rocks of the county, furnishing a supply of lime along its line of outcrop, from ten to twelve miles south of the Corniferous limestone. There are a few localities where this rock is very compact; the layers are from one to two feet thick, and it can be quarried of any required dimensions. Its northern edge extends in a curve entirely across the county. From where it is first seen, it may be followed in a north-easterly direction to a point two miles north of Ovid village, where it is quarried for burning into lime, and for various other purposes, on the land of Mr. Thompson Johnson. This point is the greatest northern extension of the curve. From here it gradually bends to the southeast, and appears on the Cayuga lake shore, in a line nearly east from its point of appearance on the shore of Seneca lake. This curved outcropping of the mass is merely the effect of erosion; the greatest force of the northern current being in the channels of the two lakes, its power was diminished towards the centre of the county, which consequently left the limestone extending farther north at this point.

The Genesee slate, resembling very nearly in appearance the black shale of the coal formation, has been mistaken for the same; and explorations for coal have frequently been undertaken at great expense, resulting in final disappointment and loss. Most of the excavations for coal in this part of the State are made in this shale, or the next succeeding group, which often contains fragments of vegetables. The emission of inflammable gas, particularly when arising from this rock, is supposed to proceed from beds of bituminous coal. Although the fallacy of such a supposition has been frequently shown, the opinion is still entertained.

In the rocks of the Portage group, in this county, we find large numbers of fragments of what appear to be terrestrial vegetables; some of these are several feet long, producing a seam of coal of the same dimensions. These appearances have been sufficient to induce a belief in the existence of workable beds of coal, but I need not say that such a supposition is entirely unfounded.

About four miles south of Lodi village, an excavation for coal has been made in the rocks of this group. The principal inducement in this case appears to have been iron pyrites and the sulphurous odor of the water, which is covered with a film so common in water flowing through pyritous or other rocks. Petroleum also occurred in globules on the lower surfaces of the slaty layers, which circumstance was considered by an "old miner," who directed the excavation, as a sure indication of coal. When I saw the place, the original excavation was filled with dirty water, and the shales thrown out were nearly dissolved into soil.

Some good flag-stones are obtained from this group in the town of Lodi, and there are numerous localities where these may be obtained in this part of the county.

This group is exposed in many of the ravines south of Lodi village, on the Seneca lake shore; also in the same latitude on the Cayuga shore, in the south part of Covert, and in the ravines extending towards the middle of the county.

The principal building materials are the Corniferous limestone in the north, and the thin-bedded sandstone in the south part of the county.

Calcareous tufa and marl occur in small quantities in several places; but from the narrowness of the county, descending on either side to the lake shores, there are few situations admitting of large accumulations. The most extensive which I have seen, is on the farm of Mr. Dunlap, near the village of Ovid.

This county possesses few mineral resources except gypsum, being eminently agricultural with a highly fertile soil. The northwestern portion is somewhat sandy, becoming loamy on the south side of the outlet, while some portions east of this are quite clayey. The prevailing soil of the higher parts of the county is a clayey gravel.

Northern boulders are rare in this county, though the rocks of the northern part of the district are largely intermixed in the soil.

ONTARIO COUNTY.

In this county we find the same rocks, and in the same general order, as in Seneca. The "*Saliferous Group of Onondaga*" occupies that part of the county which lies north of a line drawn from a point one mile north of Oak's corners, in the town of Phelps, along the course of the Canandaigua outlet to Manchester, and thence west to Victor. The vast accumulation of drift, however, leaves the rocks exposed but at few points, which are mostly along streams. In a few cases, what appear externally to be drift hills are isolated masses of gypseous marl, etc. deeply covered; and in some instances small masses of gypsum have been found in these, much above the ordinary level of the valleys and surrounding country. Admitting that the gypseous rocks originally held a higher elevation, and equal to that of the drift hills, before the intermediate portions were transported southward, the fact proves the vast quantity of matter removed by this agency.

This group of rocks is much better exhibited in Ontario than in Seneca county, having a greater extent, and in one or two places developing a different character. The gypsum here occupies three distinct ranges; the northern or lowest appearing upon, or just north of the county line, and the other two within the county. In the first the gypsum is associated with a grey marl, which reposes on a green marl containing no gypsum. The grey marl exhibits iron stains and decomposing pyrites; and pyrites is also found with the plaster which occurs in small irregular masses, having a granular or crystalline texture, and frequently accompanied by selenite. Masses of selenite are very abundant in the marl, varying from the size of a walnut to several pounds weight, isolated as regards themselves, and having no connection whatever with the larger masses of gypsum. In appearance and mode of formation they are very analogous to those found in the Tertiary clays. The limpid selenite often embraces a small piece of solid marl, having its faces and edges grooved or striated as in the pseudomorphic crystals of common salt. The grey marl is also traversed by seams of gypsum, generally flesh-colored or reddish, in such quantities that the whole is ground and sold for plaster. Both the green and grey marl rapidly disintegrate, and form a tough clayey soil.

The second series is developed near Port Gibson, and also about a mile distant, at an elevation of twenty-five or thirty feet above the Erie canal. An argillaceous limestone appears on or near the surface in low knolls or hillocks; this rock, on removal, is found to be fractured, as if upraised from beneath, and at the depth of four or six feet, is found a flattened, spheroidal mass of gypsum, quite disconnected with the surrounding rock. This gypsum is fine-grained, compact, contains no selenite, and in general appearance is quite different from that last described. The surrounding fractured rock is in thin layers from four to six inches thick, which break into pieces from one to three feet square. The surfaces present numerous little seams or cracks, similar to those produced in clay on drying; and the sides of these are all smooth, and appear worn as if by the passage of water.

This character is very constant, so far as has been observed, and serves better than any other to distinguish the rock. The external color, after weathering, is that of common clay; on fresh fracture it is bluish, often nearly black. Water is with difficulty obtained along the extent of this formation; the fractured rock beneath admitting the percolation of water so rapidly as entirely to drain the soil, the little hillocks become in summer too dry to support vegetation. Very little gypsum has been obtained from this series in Ontario county, though it seems to be the same which furnishes a great part of that mineral in Monroe county. It will doubtless be explored, after the supply along the Canandaigua outlet in Phelps becomes exhausted.

The third series embraces the gypsum which is extensively quarried in the town of Phelps, between Vienna and the town line of Manchester, along the Canandaigua outlet. West of this point, one or two masses are seen in the bank of the outlet; and with this exception, and a single bed recently opened near Victor, the town of Phelps furnishes all the gypsum from the county. This, with its associated rocks, are very similar in character to those on the Seneca outlet. It occurs in the same irregularly shaped or somewhat conical masses, producing no disturbance in the surrounding strata, while the lines of stratification in the marl pass through the beds of gypsum, and in several instances where one or two thin courses of hard argillaceous limestone occur in the former, these also are continued through the latter, the intervention of the rock merely breaking the continuity of the plaster, without otherwise affecting it. In this series the force of aggregation or chemical attraction seems not to have been sufficiently powerful to separate the gypsum from all surrounding materials, consequently we find it much intermixed with the marl; and wherever the attraction of particles was stronger than in either of these, as in the limestone, the strata continued their course through the mass, scarcely interrupted at all. The greater tenacity of the latter may have prevented the mobility necessary to an entire separation of particles, and from this cause in part may arise the admixture of substances.

The course of the Canandaigua outlet, from Manchester village to near Vienna, is along the line of the Saliferous group and Water-lime, leaving the latter entirely on the south, and the former, with the exception of a few beds, on the north. East of Vienna, all the marl and gypsum has been removed, and is replaced by a deep deposit of sandy alluvium. In the west of Manchester, the same thickness is observed; and on the north side of the outlet, instead of the gypsum, we find alluvial hills rising eighty or one hundred feet above the valley, but not appearing south of the stream. From Manchester to the west line of the county, a low valley extends along the southern boundary of the gypseous rocks, with alluvial hills rising on its northern side. The original course of the Canandaigua outlet appears to have been north; and it is very evident from the character of the rocks along which it passes, after turning east, that this portion at least was excavated recently, or long after the deposition of the alluvium, which may have closed its northern egress.

The principal quarries of gypsum are those of Robinson, Norton & Co., Cook, Vandermark & Co., and Hildreth. From these about six thousand tons annually are ground at the mills on the outlet, and sold within the county. The supply is sufficient for a much greater amount, and unless the demand increases, the quarries will not be exhausted in many years. Whenever this happens, explorations will extend north of the present quarries; and in all the valleys along the north part of the county, the middle series of plaster beds will probably be found.

The water-limes are better developed in this county than in Seneca, appearing in their characteristic drab color. The mass may be traced almost uninterruptedly from near Oak's corners, in Phelps, to Manchester village; and beyond this it appears at many points, as on Mud creek, and near Victor village. East of Vienna, all the strata of this division are highly calcareous, and burned only for common quicklime. The principal quarries and kilns are within one and a half miles of the village. It is also quarried for buildings and enclosures, the layers being sufficiently thick. It becomes stained with iron on exposure, and in almost every locality it is highly bituminous.

At West-Vienna, this rock is burned for hydraulic cement, and is said to produce a very good quality. Two miles farther west, at the quarry of Mr. Maffit, large quantities have been used for this purpose. At this place, the stone varies little in external characters from that used for lime. It consists of three distinct varieties: two only are used for the cement, while the lower course is composed of thin layers of tough argillaceous, bluish limestone, breaking on exposure into small irregular fragments; and in mineral character, it is precisely the same as the strata which pass through the gypsum beds on the north side of the Canandaigua outlet. This portion, on burning, melts into a coarse porous slag, externally glazed and yellowish. The second stratum consists of thin layers, externally drab-colored, siliceous in texture, and harsh to the touch. This is succeeded by a few layers of irregular thickness, lighter in color than those below; and much more calcareous. Of the two last mentioned, each at intervals partly takes the place of the other, so that their thickness is variable, and the dividing line takes an undulatory direction. The whole depth of the two masses together varies from three to seven feet. If the lower of these is burned alone, the cement will not "set" under water; and if the upper is burned alone, it is found to be too calcareous, and less enduring than the more siliceous cements. To obviate this difficulty, both are burned together, but without regard to proportions. From the nature of the materials, it is evident that the proportions of siliceous, argillaceous and calcareous matter must be very variable; and too little attention has heretofore been given to this circumstance, and to the nature of the ingredients, in the manufacture of hydraulic cement.

West of the last named quarries, the water-lime appears in numerous localities south of the outlet, and near the road leading from Vienna to Manchester; but here it is used mostly for enclosures, and at Manchester village for building stone, some of the layers being two or three feet thick. It is too soft and argillaceous for hydraulic cement or good lime. Above the village of Fredon, this rock is exposed in all its varieties, for half a mile on Mud creek; and along the whole line from Manchester to that village it approaches the surface, and could easily be obtained in any required quantity. Thence it extends west to the quarries in Mendon, though the surface of the intervening space is mostly covered with deep alluvium.

The *Oriskany sandstone* appears in this county, upon Flint creek, at Vienna; it is not seen in Seneca county, though loose fragments containing the characteristic fossils are scattered upon the surface. At the locality just named it is a coarse porous sandstone, destitute of fossils, so far as observed, with the exception of a single specimen of *Ichthyodorulite*; the large *Atrypa* and *Delthyris*, which characterize this rock farther east, being entirely wanting. Its purely siliceous character and porous texture are well adapted to withstand the effects of rapid heating and cooling; it is much quarried for firestone, and used in the Ontario furnace, and in the glass furnace at Clyde. It contains numerous small geodes lined with chalcedony; also rounded masses of a dark rock are imbedded in its surface. These, on examination, prove to be very compact aggregations of fine sand, colored with carbonaceous matter, and may have resulted, as well as the chalcedony, from the long continued action of thermal waters.

At the place where this rock is quarried, it is four feet thick, divided into two or three layers, one of which is about two feet. It rests immediately on a slaty, argillaceous limestone, four feet thick, which succeeds the water-lime proper.

The Onondaga limestone, which, when free from seams, is perhaps the most durable of the limestones, and one of the most beautiful for buildings, is much quarried at Oak's corners, its eastern limit in Ontario county.

West of Vienna this limestone spreads out over a great surface, covered only with a thin coating of soil, and having its northern termination about a quarter of a mile south of the Canandaigua outlet. The principal quarries in this neighborhood are within two miles of Vienna, these have furnished materials for locks on the canal, for building and step-stones; and some partially crystalline portions, from the unequal expansion, form a good firestone for the ordinary heat of a fire-place. At these quarries four layers of limestone are exposed, two of which only are workable, the others being too thin, or separated by seams. The upper one has in many places been nearly destroyed by the action of running water.

The Corniferous limestone succeeds the Onondaga, and in some instances alternates with it. In Ontario county it follows the same course, and can be seen a little south of its outcropping edge. It is recognized by its darker blue color, fine texture and homogeneous structure; it is generally very brittle, breaking with a slight blow of the hammer, while in some localities it furnishes stone fit for building.

The Marcellus shale, and the shales of the Hamilton group, appear at numerous points in this county; and after leaving Geneva, they may be seen in nearly all the ravines and banks of streams which flow towards the north. The banks of Canandaigua lake also afford good opportunity of examining these rocks. In other parts of the county, the accumulation of drift is so great as to offer few exposures of these shales

The Tully limestone appears on the shore of Seneca lake, at Bellona, in the bed of Flint creek at Bethel, and about four miles northwest of this point. Before reaching Canandaigua lake, however, this rock has entirely thinned out, though its place in the shales is well defined for many miles along the shore.

South of the range indicated by this limestone, there is a width of from one to three miles of the Genesee slate, but this rock is only seen along the ravines. The gas springs of Bristol and other places rise from this shale, or the lower part of the group next succeeding it.

The Portage group occupies the towns of Naples, Canadice, and the south part of Bristol, and presents the same essential characters as described in Seneca county. The sandstone portions are used for flagging stones, and, when sufficiently thick, for building stones.

These rocks are seen to great advantage in the deep ravines about the head of Canandaigua lake, and in the banks of the Honeoye, Canadice and Hemlock lakes. These three lakes at present join their outlets, producing the Honeoye creek, which has been excavated since the deposition of the drift; and the rocks are exposed along its whole course. The original outlet of these valleys was probably farther east, and joining the present Irondequoit, passed into Lake Ontario by that channel. These valleys also extend south, and meet the Conhocton, showing that at some former period the course of the water was not restricted within its present limits, but extended south to the Tioga or Chemung. Thus a stream whose width embraces the valleys and beds of the lakes in this direction, may have passed southward from Lake Ontario to the Susquehannah; or, otherwise, a stream from the south may have flowed along the Conhocton and these valleys to Lake Ontario. It is quite evident, from the extent of the valleys and the alluvium piled up in their course, that few of our streams in an earlier geological era had their present origin, or were limited to their present extent. Every valley and every rock bears marks of the great body of water of which small under currents merely wore the course of the present valleys, while the mighty whole passed over the summits of our highest hills.

The principal mineral resource of this county is gypsum, the situation of which has already been described. There are several marl beds of importance; the most extensive one is in a marsh bordering Flint creek, south of the village of Bethel. Large quantities could readily be obtained at this place, and it would prove a valuable acquisition to the farmer, especially when combined with the muck with which it is deeply covered. There are several small deposits of marl near the northern edge of the county, upon the Onondaga salt group. There is a large muck swamp near Victor, which is probably underlaid by marl. This substance will, without doubt, also be found in the swamps at the head of Hemlock and Canadice lakes.

YATES COUNTY.

The rocks occupying the greater part of Yates county are similar to those of the southern part of Ontario, only the most elevated parts of Barrington and Starkey being occupied by the rocks of the Chemung group. The outlet of Crooked lake has excavated its channel through the rocks of the Portage group, Genesee slate, Tully limestone, and the upper part of the Hamilton group, presenting all these in their order along its course.

Northwestedly from Penn-Yan, and at Shepherd's quarry, the rocks of the Portage group are well developed. At this place the lower part consists of alternating arenaceous and argillaceous strata, containing much iron pyrites, large fragments of carbonized vegetables, and occasionally large Orthoceræ.

The lower part of the group furnishes large and fine flag-stones, which are used in the streets of Penn-Yan. These thin layers often contain small irregular concretions, surrounded by a coating of shale which soon disintegrates, and the concretions become loosened, in many instances injuring the stone. Some of these strata are shaly, and soon wear away on exposure.

This group appears about a mile south of Penn-Yan, in Sartwell's ravine, where its connection with the black shale below is very evident; the characteristic Lingula of the latter is found in abundance.

The same group extends west through the towns of Jerusalem and Italy, and appears in many of the streams and ravines near the west branch of Crooked lake. The thin layers of sandstone are used throughout the country for step-stones, foot-walks, and in many instances for enclosures, though rarely for building stones.

The outlet of Crooked lake affords a good opportunity of examining the higher part of the Hamilton group, and its connexion with the Tully limestone and the higher rocks.

The lower part of the Portage group is developed near Penn-Yan, and on the west bank of Crooked lake; it presents a more arenaceous character than on the Genesee river, and contains some fossils not seen elsewhere.

From the nature of the strata, there are few economical mineral products in this county. The outcropping of the Tully limestone along the Crooked lake outlet, is of great importance in furnishing lime. Farther south, near Big-stream point, where this rock is concretionary in structure, it affords a good hydraulic cement, which promises to be of importance to this part of the county.

Calcareous tufa occurs in several places along the banks of Crooked lake outlet, and marl may be found in the swamps at the northern extremities of the lake.

Under the head of Salt springs, has been noticed the occurrence of saline matter in the springs about the head of Seneca lake: a similar spring was found near Big-stream point.

Between Seneca lake and the east branch of Crooked lake, a high ridge or elevated plain slopes gradually to both, being divided transversely by the ravines and streams. Another elevated table land, varied by slight undulations, rises between Seneca lake and the valley of Flint creek, which extends to the head of the west branch of Crooked lake; this is interrupted by a depression to the northeast of Penn-Yan. Another similar portion, though more irregular, rises between the valleys of Flint creek and Canandaigua lake; and the part of the county between the two branches of Crooked lake terminates in a high bluff, called Bluff point.* From near the head of the west branch, extending quite across the peninsula, is a valley which appears once to have connected the two branches, the highest point of which is not now more than one hundred feet above the lake.

LIVINGSTON COUNTY.

The county of Livingston exhibits a continuation of the rocks of Ontario, beginning with the Water-lime or upper part of the Onondaga salt group, followed by the Onondaga and Corniferous limestone, the Marcellus shale, Hamilton group, Genesee slate and Portage group; the latter occupying the high grounds in the southern part of the county.

The deep depression of the Genesee valley, which extends through the centre of the county, from south to north, is among the most important features of the county.

The thick-bedded hydraulic limestone in the northern part of the county, passes through Caledonia and Avon. In the former place it is quarried in several localities. It underlies the village of Caledonia, extending thence southeasterly toward the Genesee river, reappearing on the other side, and extending northeasterly to Mendon. This rock is chiefly quarried for buildings and enclosures. In several instances where it has been burned for cement, it has been found unfit for the purpose, either from improper composition or from the mode of burning.

* This point is said to be the locality of native iron, an account of which appeared in the Transactions of the Geological Society of Pennsylvania, Vol I. page 358, and since it has been quoted elsewhere, I may here give the true explanation. The rocks of Bluff point are of the Portage group, which often contain iron pyrites. In quarrying stone at this place, a considerable quantity of this ore was found, and as it was supposed to be valuable, it was shown to Dr Sartwell of Penn-Yan, and afterwards to Prof. Cutbush of Geneva, both of whom informed the persons of its true nature. Not feeling satisfied with this, however, it was placed in a blacksmith's forge, and by much labor partially reduced, and in this state a portion of the mass was sent to Mr Clemsen of Philadelphia.

For a distance of two or three miles southeast of the village of Caledonia, thin flat masses of the drab limestone are scattered over the surface, in many places in sufficient quantities for enclosures; its outcropping edges often approach so near the surface as to be turned up by the plough. Three and a half miles southeast of Caledonia, it is quarried in large quantities for use on the Genesee valley canal. The quarry is owned by Mr. Wadsworth of Geneseo. There are about twenty feet in thickness of the rock exposed; the lower part is in thin layers of a bluish color, striped with lighter bands. The succeeding courses are from two to two and a half feet thick, of a drab color, striped with darker. It is easily quarried, splitting into masses of any dimensions, and becomes very hard and brittle on exposure. The upper seven feet of the mass is often in one course, though generally divided into two; this portion, and a course of two feet below, contain numerous irregular cavities, often filled with greenish clay, gypsum, sulphate of strontian, blende, etc. In some of these cavities there are remains of some coralline fossils, the greater part having been dissolved out, probably by the action of sulphuric acid, which formed, with the lime, gypsum, and with strontian its sulphate.

The same causes which here produced the small nodules of gypsum, were in operation over a large extent, to form the immense quantity which occupies a place in the rocks beneath the drab limestone. Owing to this circumstance only, we find no fossils in the gypseous rocks; for none could exist in a sea where sulphuric acid was a free ingredient.

The Onondaga limestone is but a thin mass in this county, scarcely appearing except in a few localities. The principal of these is at Caledonia, and extending for several miles northwest from the village. It abounds in its usual coralline fossils, but there are no places where it is sufficiently developed for quarrying.

The Corniferous limestone succeeds the last described rock; it scarcely extends into the town of Lima, but forms the substratum of the northern portion of Avon, and in the river valley extends as far south as the centre of the town. This rock is quarried in the Conesus lake outlet, and on a small stream a short distance further east; at these places, only a few feet of the upper part of the mass are seen. It is easily quarried in blocks of large dimensions, and is nearly free from hornstone. The stone is wrought for use on the Genesee valley canal. The fossils at this place consist chiefly of *Strophomena rugosa*, *Atrypa affinis*, *Delthyris*, and some fragments of trilobites. The greater portion of this rock, on the east side of the river, is covered by a deep alluvium, which renders it difficult to trace its bearing and outcrop with extreme accuracy.

On the west side of the river, this rock first makes its appearance in the southeast corner of Caledonia, near the town line. At this place a very extensive quarry has been opened, on the west bank of a small stream, on land of Mr. Christie. Large quantities of stone have been taken hence for the construction of locks, aqueducts, etc., for which purpose no better stone can be found. It is mostly free from seams, and is easily quarried and dressed. The whole thickness exposed does not exceed ten feet, the courses varying from one to two and a half feet. None of the layers are continuous of the same thickness: sometimes a thick one thins out entirely, and its place is taken by two thin ones; or a thin layer in one place becomes a thick one at a few rods distance. Sometimes the courses are separated by a thin irregular course of hornstone; at others, this hornstone is in the centre or near the surface of a layer of limestone.

From Christie's quarry the limestone pursues a northwesterly direction, passing just to the south of Caledonia village; it crosses the road a little west of that place, and pursues the same direction to the top of the terrace on the south side of Allen's creek. West and northwest of Caledonia, large numbers of fossils are found in this rock. In this part of the town, the lowest portion of the rock is thick-bedded and compact; above this it contains a large proportion of hornstone, and in some places is composed almost entirely of that substance. Being in irregular shaped masses, and surrounded by limestone, which decomposes on exposure, it is left scattered over the surface in rough and shapeless forms. These fragments are crossed in every direction by innumerable fissures, which are expanded by freezing water, and the whole falls into small fragments, which, in many places, literally cover the surface for many acres. Where the road crosses this part of the rock, it has the appearance of being made in a bed of flints.

From the jagged and irregular appearance of the hornstone rock, as it occurs in detached masses, it has received the familiar and expressive name of "*chawed rock*." This rock is the best material for road-making which Western New-York affords. Where it approaches the surface the soil is rather barren, producing only a growth of dwarf oaks; but where there is a tolerable proportion of finer materials, it produces a fertile soil. A large proportion of the native growth along this terrace consists of oaks.

Marcellus Shales.—The limestone is succeeded by the "Marcellus shales." These shales possess their usual essential characters; the middle portions quite compact and highly bituminous, becoming more slaty above and below. The compact part of the shale usually contains large septaria; these sometimes consist of large silico-calcareous masses, without seams of crystalline matter. This rock follows the same course as the limestone; commencing on the east near the north line of the county, it passes southwest to the Genesee river; thence its course is northwest through Caledonia, passing into Genesee county near the north line of this town.

On the Conesus outlet, near the lower saw-mill at Avon, this shale may be seen resting on the limestone. About thirty-five feet from the bottom of the shale there is a stratum of limestone one foot thick, sometimes concretionary, and containing *Orthoceras*, fragments of trilobites, etc. For several feet below this, the rock is black, slaty and very fragile. A few feet of the shale above this limestone is black and slaty; it abounds in fossils of *Orthoceras*, *Orthis*, *Strophomena*, *Avicula*, and a very small species of *Orbicula*. Above this the mass graduates into a greyish or bluish-grey slaty shale, and contains few fossils.

This shale is seen in the ravines and hill-sides on the west side of the Genesee, extending through the northeast corner of York, and thence through the southwest part of Caledonia. At one place in the south part of this town, a digging for coal has been made in the black shale. The indications which induced the undertaking at this place were the black and highly bituminous character of the shale, thin seams of coaly matter and petroleum. I did not learn to what depth the excavation extended, but presume it to have been less than forty feet, for at that depth the Onondaga limestone would have been reached. The excavations were made at two places, one on each side of a small shallow valley which was originally worn in this shale. North of the valley, on the farm of Mr. M'Lean, the same shale was penetrated in digging a well. Some portions of the rock are so highly charged with bitumen as to burn when thrown into a hot fire. In these shales, as well as in the upper Genesee slate, numerous excavations for coal have been made, and, in each, alike fruitless.

The *Hamilton group* is exposed in numerous localities in this county, and is everywhere highly fossiliferous. Their destruction has afforded the highly fertile argillaceous soil which is every where so productive of wheat in this part of the State, and perhaps nowhere more so than in this county.

On Jacock's run, the Ludlowville and Moscow shales can both be seen, separated by the thin mass of crinoidal limestone. Here as elsewhere in the district, the Moscow shale is known by its fossils, the *Calymene* and *Cryphæus*, while the Ludlowville shale contains *Atrypa concentrica*, and large numbers of *Cyathophylli* and other corals. These fossils are very characteristic of the two shales; still in some localities the *Cyathophylli* and smaller corallines occur in the Moscow shales, but are not characteristic of this mass.

At York, the Ludlowville shale is exposed on a small stream near the village; the fossils are chiefly *Cyathophyllites* and *Favosites*, both in great perfection and beauty. Among the former there is a specimen placed in the State Collection, consisting of twenty-six individuals of the species *turbinatum?* all closely grouped together. In the same ravine, several hundred feet lower, may be seen the hard calcareous shale, or shaly limestone, mentioned in the Report of 1839, as occurring at Tyler's on Seneca lake, and at Orleans in Ontario county. At several other localities, these shales may be seen; but being of little economical importance, they are described elsewhere.

At Moscow, the locality which gives name to the upper member of this group of fossiliferous shales, they are exposed in great perfection, containing abundance of the characteristic fossils. These are the *Calymene bufo*, *Cryphæus calliteles*, *Atrypa affinis*, and two or three species of *Delthyris*. The principal locality is in the beds and banks of Beard's creek, on the land of Jerediah Horsford, Esq. More than fifty species of fossils have been found at this place.

The Moscow shale is also exposed in a ravine, and the bed of a small stream, near the residence of the Hon. C. W. Patterson. These localities are in a deep valley of denudation, and much below the general elevation of the surrounding country, the surface of which is occupied by the Genesee slate.

Genesee Slate.—In the ravines both east and west of Moscow, we find the Genesee slate; also in a hill crossed in going from Moscow to the new bridge across the Genesee, and in the hill side ascending from the valley to Geneseo. The same shale is seen in Fall brook, where the water leaps a hundred feet from the top of this rock. It underlies the village of Geneseo, and is seen in many places on the road east from that place, and in the ravines between it and Conesus lake. In this neighborhood the black shale is succeeded by a thin stratum of impure limestone, which has been burned for lime at one place near Moscow.

At the bridge crossing the Genesee near Mount-Morris, the Genesee slate is exposed, possessing all its essential characters; being bituminous, containing thin seams of coal, great numbers of septaria, sometimes irregularly scattered, at other times in regular courses.

The arrangement and distribution of these septaria depended upon the supply of material; and the tendency to concretionary forms proceeded from the amount of material being too small for a continuous stratum, which, together with the homogeneous state of the particles, caused them to take this form. Sometimes we see a single insulated mass, and no others in the same parallel of stratification; at other times we find them distant from each other, but in the same plane of stratification. Again we may find a course of them in the same plane, and each of them separated only a few feet from the other. Still again when the supply was greater, we find a continuous stratum or bed, as in the case on Seneca lake, where the regular course of septaria in the upper part of the black shale becomes, from increase of material, a continuous stratum three or four feet in thickness. This change is seen in many cases near the thinning out of a mass, the supply of matter diminishing, till it is traced only by distant nodules or concretions.

The Cashaqua shale, for one hundred feet in thickness, is exhibited at the gorge at Mount-Morris, limited below by the Genesee slate, and above by the Gardeau flagstones. It also appears in many ravines in the south and southwest part of Leicester; in the vicinity of Mount-Morris; in the Cashaqua creek, whence it takes its name; in the ravines on the east of the valley, and at a higher elevation southeast from Geneseo and approaching nearly to the village.

The Gardeau and Portage rocks already described, are the southern rocks of the county. These are seen in the deep gorge of the Genesee, and in almost all the ravines and water courses of the southern towns. Among numerous localities as we approach Dansville, may be mentioned Stony brook in Sparta, where several hundred feet of these rocks are exposed. The shale in the upper part of this ravine has been ground and used as plaster.

There are several quarries between this place and Dansville, in which it is difficult to find any characteristic fossils. The rocks consist of thick layers of sandstone, with intervening masses of shale; and near Dansville, give more marked evidence of the group to which they belong. Quarries have been opened on both sides of the valley, where materials were obtained for locks, bridges, etc. on the Genesee-valley canal. This group also affords the finest flagging stones in the district; these are known by the presence of the fucoids already mentioned.

The great marl deposit of Wheatland extends into the northern margin of this county; there is also an extensive deposit of marl about one mile east of Caledonia.

The Gardeau slide, which occurred more than thirty years since, still presents an interesting appearance. The surface covered is several acres, and the clay is piled up in little mounds and hillocks, with depressions between them, much in the same manner as the drift hills of Ontario, and other parts of the district. Over a great portion of this surface no trees are growing, and in some places even grass scarcely grows upon the clayey slopes. On the opposite side of the river there is evidence of a former slide, even much more extensive than this one, but the uneven surface has become overgrown with a heavy forest. The Gardeau slide carried an immense body of earth into the Genesee river, which changed the direction of the channel to the other side of the valley. These slides are but miniatures of those which occur in the high primary mountains of the northern part of the State.

GENESEE COUNTY.

In this county we find the same rocks as in Livingston, with the addition of the Onondaga salt group on the north, which extends through the towns of Bergen, Byron, Elba and Alabama, and into the northern parts of Leroy and Stafford.

The most northern portions of this mass consist of greyish or greenish-grey marl, homogeneous in texture, and very compact when first exposed, but crumbling rapidly. Thin courses of reddish and chocolate-colored marl are seen in some places in the northern part of the county. Farther south, and along the centre of these towns, it is more grey or ash-colored, contains thin seams of fibrous gypsum and selenite, and occasionally small masses of granular gypsum. This part of the mass is exposed only in wells, which, from the difficulty in obtaining water, are often dug to the depth of seventy or eighty feet. The grey marl and gypsum is found to contain large seams or joints apparently water-worn; these without doubt act as drains, and carry off the water from above.

Some wells in this part of the group yield an acid water. One of these, belonging to Mr. Gifford, of Bergen, I examined; the water is said to contain acid enough to curdle milk; and though not sensible to the taste, is considered unfit for use. The famed acid spring in Byron rises from this rock. Some of the wells in the immediate vicinity, and in the same formation, yield good water.

A little north of Bergen centre the greenish marl comes to the surface, and is excavated for the passage of the railroad. Two miles west of that place, the same marl is seen in the roads and in the banks of the small streams, and approaches the surface over the greater part of this neighborhood.

The grey or ash-colored marls just described, are succeeded by bluish, slaty and drab colored impure limestones, which embrace large beds of gypsum. These occur mostly in the north part of Leroy and Stafford. Gypsum is also found in the western part of Elba, near the junction of the Pine-hill road with the Batavia and Lockport turnpike, which is the most northern point that I have found it, in the county. At this place some thirty or forty tons were quarried; but the masses being small, and about eight feet below the surface, requiring the removal of all the superincumbent earth and stone, the work proved unprofitable, and was abandoned.

In the vicinity of this quarry, and for some distance west, there are sufficient indications of gypsum in the peculiar irregularity of the surface, which is raised into little mounds, giving it the appearance of heaps of earth deposited on the level soil. The thin bluish or drab limestone is also found near the surface, and often ploughed up in the fields.

In the north part of Leroy, plaster is obtained in large quantities, on lots 118, 114 and 132. The quarries in the first are of white gypsum, free from seams and intermixture of clay; it is covered with a bluish kind of limestone with shaly seams, and which separates into laminæ one-fourth or one-half an inch thick. In the others, the gypsum is clay-colored, with seams of clay; this, when exposed, crumbles rapidly. The rock above is a drab limestone, resembling in general appearance the hydraulic limestone. In this I found some few fossil shells of a species of Avicula. Some parts of the rock are filled with small round pores, the size of a mustard seed; such are also seen in the soft limestone, a few feet below the hydraulic or drab limestone. The masses of gypsum are all more or less spherical; the surrounding rocks being raised in the centre, presents a fractured convex surface, dipping on every side.

The quarries last mentioned, belong to Messrs. Bannister, Collins and Clifford; the white gypsum to Mr. Hughes and Mr. Cash. The plaster is sold at the bed for fifty cents, and when ground, from three dollars to three dollars and fifty cents per ton. The different beds in this county furnish about three thousand tons annually.

The formation described, belongs apparantly to the second or middle series of gypsum beds; the upper, like that at Seneca-falls and Vienna, is not seen, neither have I been able to find the lower series; but although similar in general character, it would appear that the white gypsum above described, which is half a mile north from the others, must be at a different elevation, as well from its position as from its associated rocks. The general direction of the masses is N. W. and S. E., as appears both from the beds here, and from their reappearance in the western part of Elba.

The alluvial excavation along the valley of Black and Bigelow creeks, has either removed the gypsum, or covered it so deeply with drift that it is not reached in ordinary excavations; but unless so removed, the whole distance across the country is probably underlaid by it, though its depth may be too great for profitable exploration.

The gypsum is succeeded by various colored marls, mostly bluish, greenish and drab or ash-colored; some hard and very calcareous; others soft, crumbling, and forming a tenacious clay.

The drab limestone, or hydraulic limestone, is the next succeeding mass. The essential characters of this rock have already been described; its thickness is variable, and also the proportion of sand, clay and carbonate of lime. Its connexion with the Onondaga limestone above, is seen to advantage at the falls on Allen's creek, two miles north of Leroy; and also at Morgansville, where the Black creek descends from the limestone terrace to the level of the country north. The section at this place is given on page 140 of this report.

This rock forms the northern escarpment of the great limestone terrace, extending from the Genesee to Lake Erie, and is also seen in the counties east. It passes through the towns of Leroy, Stafford, Batavia, and the south part of Alabama, forming the lower falls on the Indian reservation. I am not aware that it has been used for cement in this county, though it is doubtless good for this purpose.

The Onondaga and Corniferous limestones occupy the summit of the terrace; extending from Livingston county westward; pass with variable width to the north of the village of Leroy; underlying Stafford, Morganville, the north part of Batavia and Pembroke. A few feet of the lower portion of these rocks is in regular courses, with little or no hornstone; the succeeding forty or fifty feet consists principally of hornstone, being a rough ragged mass, called the "*chawed rock*." This, in some places, contains large numbers of corals.

About two and a half miles north of the village of Leroy, and west of the creek, there is an extensive quarry in the Onondaga limestone. The rock at this place appears in courses, varying from six inches to two feet; it is almost wholly composed of fragments of *Crinoidea* and other fossils, crystalline in texture, quite tough. The thick courses are often divided by seams; these, when of clay, cause the blocks to separate; at other times they produce no injury. From the quarry, the rock is taken to a mill a mile south of the village, and sawn into slabs and blocks; it is afterwards polished and used for fire places, mantle pieces, etc. The polished stone has often a very beautiful appearance, and is highly prized by the collector, on account of displaying the internal structure of fossils cut through in the process. The crinoidal joints are frequently of a different color from the surrounding mass, a variety which increases the beauty of the stone.

Lime is burned at many points along this range, supplying the immediate neighborhood, and also the country north and south. In Stafford, Batavia and Pembroke, this rock appears in numerous localities. Two and a half miles from Batavia village, and half a mile from the north line of the town, the rock exposed is the hydraulic limestone, with some thin layers above, and the greater part consisting of the "*chawed rock*." This latter is most annoying to the farmer, and when it overspreads the surface in large masses, almost totally forbids cultivation. This is seen in several places of small extent, in the south part of Alabama. The growth of timber on such land consists chiefly of oak.

On the Indian reservation, this rock appears at the upper falls, and in the stream below; also between this and Pembroke. The thickness of the mass is very variable, as may be seen in the quarries, where thick masses at one place may be merely recognized in another by layers of a few inches. West of Batavia the terrace is not so well defined, though there is little difficulty in tracing the course of the limestone.

The shales above the limestone are seen to less advantage in the county of Genesee than in any other of the same range. At Leroy the Marcellus shale succeeds the limestone, and is well exposed in the bed of the stream at that village. It contains large masses of septaria, which are more calcareous than those of this shale in most places. The compact portions of the shale have been quarried for firestones; and the black stone store in this place is built of the same material.

Farther south, we find the lower members of the Hamilton group at Clifford's mill at Roanoak, and a little north, where it consists of those portions that are nearly destitute of fossils, and consequently of less interest. In the Four-mile creek near Roanoak, the same shale is seen.

The shales of this group are found in two or three places in the town of Covington: one of these is a mile north of Pavilion; and another, one mile and a half southwest, in the bank of the creek near Sprague's mill. The rock in place is scarcely visible at either of these localities; at the first it appears as a bank of clay, produced by the decomposition of the mass, leaving the fossils. This clay is used for bricks. At the latter, the decomposing edges of the strata are covered with gravel, the fossils being washed out by rains.

At one or two places near Bethany centre, the upper shales of this series are seen; and near the village of Darien, on the Eleven-mile creek, there is a natural section showing the Ludlowville shale, the Crinoidal limestone, the Moscow shale, and near the same place the Genesee slate. The Ludlowville shale contains its usual fossils, Favosites, Cyathophylli, &c., the *Atrypa concentrica* and *A. affinis, Delthyris* and *Strophomena*. The crinoidal limestone has fewer fossils than usual, but the Avicula is numerous. The Moscow shale appears much thinner than elsewhere, and exhibits fewer fossils.

The next range of towns south, as well as a great portion of Sheldon, Orangeville, Warsaw and Perry, are occupied by the Cashaqua shale and the Gardeau rocks. The southern towns, with the more elevated portions of the range next north, are underlaid by the Portage rocks, and in Arcade we find the commencement of the Chemung group.

In passing south through the towns of Darien, Bennington, Sheldon, &c., we find that the rocks (mostly shale) lie near the surface almost continuously, except in the valleys. Ploughing often turns up the black or the green Cashaqua shale, and the road sides expose the same at frequent intervals. These shales are left in little eminences above the general level of the country, and being covered with alluvium, are often mistaken for alluvial hills; whereas the soil is thin, and the removal of a few inches frequently exposes the rock. These knolls are seen along the road south, from Long's corners through Darien to Bennington. This condition of the surface, previous to the deposition of the alluvium or drift, appears to have resulted from the action of the waters of a lake or ocean, where numerous currents and counter currents might wear away the intervening masses, leaving the projection of the little mounds of shale as we now see them.

In several places slight "*diggings*" have been made, upon the indications of some thin seams of coal. Three miles south of Wyoming or Middlebury there have been excavations at two points, and at one of these a boring of thirty feet. At the time I examined the place, the owners, Messrs. Marvin and Joseph Everest, were about contracting for a deep boring, in the sanguine expectation of finding coal.

In the ravine west of Warsaw, some of the Gardeau rocks are exposed; and in the ravine southwest of the village are found rocks of the upper part of the Portage group, though mostly destitute of the characteristic fucoid. In this ravine there is a waterfall of one hundred and ten feet, which, together with the rocks above and below, gives a thickness of two hundred feet at this place; they are principally shale with thin layers of sandstone.

The upper part of this group may be seen at the falls on Allen's creek, near the north line of Gainesville, and about three miles south of Warsaw village. On elevated ground from Sheldon to Warsaw, this mass, with its vertical fucoid, appears in several places along the road.

The swamps in this county containing muck, are exceedingly numerous. This deposit, in the Fourth geological district, has in but few instances become sufficiently tenacious to be called peat; though it burns as readily, and is equally good for fuel; but in drying, it falls to powder. In many places, when the swamps shall have been drained, and time allowed for the muck to become more compact, and other vegetation to succeed the present, many of these deposits will furnish valuable fuel.

Near Batavia, several small swamps or ponds contain marl, and also the springs or ponds at the source of Spring creek. About three or four miles north of Leroy, between the gypsum beds and Bergen, there is a large marl swamp; the extent of the deposit I did not learn, but it is probably great, resulting as it does from the marls and slates of the gypseous formation. Two and a half miles south of Leroy, on the land of Archibald Stewart, and an adjoining farm, a marl bed covers about twenty acres, with an average depth of probably eight feet; a few rods from the margin being five, a little distance farther nine, and the centre fifteen feet. This marl is covered by muck, from one to two feet thick. Mr. Stewart has applied the marl as manure, and finds ample returns.

In examining Silver lake, I found the bottom in many places covered with a growth of *Chara*, which, when first thrown out, looks green, but on a little exposure it becomes white and brittle, readily crumbling to powder; they are almost wholly composed of carbonate of lime. The same species is found abundantly in the outlet of the Caledonia spring; and so rapid is its growth, that frequent removals are required to prevent it from impeding the water in the sluiceways to the mills. Towards the inlet, the bottom of this lake is covered with marl several feet deep, but I was not able to ascertain whether it occupied the whole area. From sounding, the bottom appeared soft. The marsh at the head of the lake was not examined, though it probably contains marl.

In all deposits of tufa and marl, a large quantity in the bottom of the bed is earthy, and considered unfit to burn for lime; these portions, either in their actual state or burned, can be advantageously used for agricultural purposes. Lime burned from this, and made into a compost with the black muck of swamps, would be an excellent manure for all the lands of the southern counties; and even the hardpan, which is considered almost worthless, may be reclaimed, and rendered fertile by the judicious application of muck and lime. The importance of this subject cannot be too strongly urged. While the farmer is perhaps cultivating a poor, hard soil, too compact for vegetable growth, his lands include a muck swamp, which is considered nearly worthless. Now, by ditching this swamp, and carrying its contents into his fields, both are essentially improved. The soil of these swamps, when reclaimed, is superior to the higher grounds.

ERIE COUNTY.

The lowest rocks of this county are those of the Onondaga salt group, which are succeeded by the hydraulic limestone, the Onondaga and Corniferous limestones. The central part of the county is occupied by the Marcellus shale and Hamilton group, while the rising ground to the south is formed of the rocks of the Portage group.

The Onondaga salt group occupies all that low ground on the north of the limestone terrace, which is generally designated Tonawanda swamp. The greater part of this portion of country is, however, very far from being a swamp, and at present the term may be applied only to that portion bordering the creek. Even here, too, its necessary condition is not a swamp, but requires only proper drainage to convert it into excellent agricultural land.

From the ancient condition of this part of the county, and the deep deposit of drift, the rocks appear but in a few places, and these only for a small extent. The principal place is in the bed of a stream on the farm of Mr. Martin, in the north part of Clarence.

The rock seen here is that portion containing small cavities of the size of flax seeds, often running together, forming linear ones; and in a few cases, the hopper-shaped cavities were observed, though the rock is usually quite solid and firm. Where the rock is penetrated beyond the influence of the weather, these cavities are filled with plaster. The portion of the mass here exposed is concretionary. No plaster, or even any evidence of it, appears at this place; the mass in question, however, is apparently that which has before been found, separating the upper from the next lower course of gypsum beds.

The shaly and marly portions of the group are met with in digging wells, generally from ten to twenty feet below the surface; in some places they are not found at all, and it becomes quite difficult to obtain water at the ordinary depth of wells.

From this fact we perceive, that a search for plaster, however successful as to the discovery, would be of little benefit, owing to the great depth below the surface, which would not allow of its being raised at the present prices. That the plaster exists, is very probable; for there is nothing in the character of the rocks, or of the plaster in the western part of Genesee county, which indicates that it disappears farther west. Plaster is also obtained on the Grand river in Upper Canada, forty miles west of the Niagara. A great portion at least of the intermediate space between the two rivers is in a similar condition to the country along the Tonawanda creek.

Thus far no excavations have been made in search of plaster; and in digging wells, I am not aware that it has been seen. Neither is it probable that such would be the case; for I am informed, that soon after coming to the rock, water is found; and the object of search thus obtained, nothing else is thought of. Should the value of plaster increase with the exhaustion of the beds farther east, we may then expect that search will be made for it in this region; and when the price is such as to repay its being raised from fifteen to thirty feet below the surface, we shall in all probability find a sufficient supply in this county for a long period.

The surface of the country north of the terrace is level, or gently undulating; the inequalities are caused by the accumulation of gravel, or sandy loam, the latter often covering gravel. The soil for the most part is loamy, of a yellowish or brownish color. A few inches of the surface is usually blackened by vegetable matter; sometimes the loam becomes stiff, from admixture of clay, and at other times it is mixed with fine gravel. In the lowest grounds the soil is clayey; often a stiff white or bluish-white clay, frequently stained with iron, at the depth of six or eight inches. On this kind of soil we find evergreens. The clay or soil, in such cases, seems to have been deprived of its coloring matter, which is iron, by the percolation of water through the carbonaceous matter above. This solution and removal of the iron by the carbonated water gives rise to the small beds of bog ore, so frequent in this valley. Where the rock is near the surface, or the soil contains much lime, this also is dissolved, and we have a deposit of tufa, charged with iron. Several of these beds have been met with, and one of them, north of Clarence-hollow, was formerly supposed to be valuable. There is not, however, sufficient iron to be of any importance, and the tufa is of no other use than for burning into lime.

From the generally even surface of this tract, we find numerous swamps, of small extent; in these are valuable deposits of muck, which will always be available as a fertilizer of the soil, more particularly the clayey portions, which require vegetable matter to render them lighter and easily worked, as well as more productive.

The hydraulic limestone follows the course of the terrace, lying at its base, or outcropping along the northern slope. It is characterized here, as elsewhere, by numerous and copious sulphur springs. These are generally to be found near the base of the terrace, or within a mile to the north. Near the eastern edge of the county, this limestone is developed in its entire thickness at the falls at Falkirk. The upper portions are extensively quarried and burned for cement. It possesses all the essential characters of that from Onondaga and Williamsville. The outcrop of the mass may be traced from hence westward, along the slope of the terrace. At Clarence-hollow it has been quarried and used in building. At Williamsville, it is extensively quarried by J. S. King & Co., and burned into water cement. There is made at this place annually from forty to fifty thousand bushels, or ten to twelve thousand barrels. About three feet of the upper part are unfit for burning, being too calcareous; below this there are four feet of good quality, and then a shaly mass of two or three feet thickness, below which the rock is fit for cement. The facilities for quarrying and grinding the cement are here very great, the Ellicott creek descending from the summit of the terrace at this place. Care is required in selecting the rock as it is quarried, thin seams of shaly matter intervening between the thicker masses, which only are fit for cement.

The next place west of Williamsville where this rock is exposed to any great degree, is in the Skajockety creek, about four miles from Buffalo. Here there are about twenty feet of the rock visible, extending for half a mile north of the road. The upper portions abound with cavities, many of them containing sulphate of strontian, but principally empty, and showing the remains of a small coral which has been partially removed. Below this the mass is quarried for rough building stone, in blocks from four to eight inches thick; thin layers are often quarried for flag-stones and door steps. The rock has all the external characters of the water limestone of Williamsville and Falkirk, and is probably as good for cement.

Between the place just mentioned and Black-Rock, the hydraulic limestone appears in several places; the most prominent, however, is on the land of Mr. Arms, a mile and a half east of Black-Rock, where large quantities can be easily obtained. The burning of the rock at this place has been heretofore attempted, but unsuccessfully.

At Black-Rock and the vicinity, the water-lime appears in several places. At the quarries near the ferry, the rock is visible to a depth of eight feet, underlying the blue limestone. Here, as at other places, the upper portion of the mass is too calcareous, and it is only the ash-colored and striped layers beneath that are fit for use as a cement. The situation at this place is very favorable; but where covered by the other rocks, it cannot be profitably brought into use. By pursuing examinations to the northeast of the village, the same mass may be found covered only by the soil, and consequently much more easily obtained.

In many places, and for the greater part of the breadth of this county, the *Onondaga limestone* forms a very thin mass, or the limestone above rests immediately on the hydraulic limestone. It is owing to the resisting nature of these two limestones, and to the soft nature of the rock on the north, that a terrace is formed, leaving the valley of the Tonawanda excavated from the rocks below. The undulating outline of the terrace is also caused by the greater or less thickness of the limestone. Sometimes we find it jutting out to the north a mile beyond the general line, and again falling below or south of the general direction nearly as far; the latter appearance usually occurs where the terrace is cut through by streams running to the north.

At Black-Rock, the Onondaga limestone is only from six to fourteen inches thick; it is of a greyish color, crystalline, and containing few fossils. This mass has been quarried, producing excellent stone for fine building or foundations. Some of it has been sawed and polished, being sufficiently compact to form a good marble; the colors, however, are dull.

The Corniferous limestone is extensively quarried at Black-Rock for the public piers, breakwaters, etc., and serves a very good purpose where rough stones are required. From its position, and its vicinity to the public works and canal, it becomes invaluable to the State.

The hornstone portion is largely quarried for use on the Macadam road, and is an excellent material for this purpose; the hornstone, from cracks and fissures, readily falling to pieces by the action of frost, produces a bed of angular fragments little affected by the changes of weather

In the town of Newstead, a mass of partially decomposed clay and sand lies between the water-lime and Onondaga limestone; it is about six inches or a foot thick, highly stained with iron, and exhibiting a partially conglomerated appearance. In this are several peculiar coralline fossils. It occupies the place of the Oriskany sandstone, and is its only representative.

The demand for lime in the city of Buffalo, renders the existence of this limestone range of the greatest importance to the inhabitants. There are burned annually, in this county, from 27,000 to 30,000 bushels of lime, and this amount is greatly increased in times of commercial prosperity.

The kilns at which this lime is made, are nearly all situated between Clarence hollow on the east, and three miles west of Williamsville. Along this distance there is a thick mass of limestone free from hornstone, consisting principally of grey crystalline rock, filled with crinoidal joints and other coralline remains.

The great accumulations of drift upon the southern slope of the terrace prevents, for the most part, the examination of the shales above the limestone. It is only in a few places along the Eleven-mile creek and the Cayuga creek that they can be seen; and these exposures are very partial, and would lead to little information concerning the rocks, did we not know their character at places farther east.

Following the latter stream below Alden, we trace its course in a deep alluvium, till near the line between Alden and Lancaster, where it crosses the limestone which is exposed by the creek for a considerable extent. The shales are slightly seen in several places on the Cayuga creek, but the banks almost continuously are of alluvium, from ten to twenty feet in depth. The junction of the Little Buffalo with the Cayuga creek exhibits the calcareous mass, which separates the upper Marcellus from the shale above. The lower Marcellus shale is seen at only one place on the Cayuga creek, and here only in the bed of the stream.

On the Seneca creek, and the Cazenovia creek, on the Indian reservation, these shales occur; and here we find them much better developed than elsewhere in the county, except on the lake shore. Near the Indian council-house on the Cazenovia creek, appears the limestone separating the upper and lower Marcellus shales. It abounds in a trochus-shaped fossil, and in fragments of Orthoceræ. This is the only place, so far as I know, where this mass is visible in Erie county. The lake shore, for eight miles above Buffalo, exhibits no rocks; the whole country is low and nearly level, constituting what was formerly designated "the swamp."

At Comstock's tavern, the shale appears for the first time on the lake shore. Beyond this, the shale becomes more fossiliferous, containing Delthyris, Atrypa, Strophomena, Calymene, etc. These increase in numbers as we ascend, and finally in many places the rock is completely loaded with them, particularly at Eighteen-mile creek.

The Encrinal limestone, below the Moscow shale, is here a very distinct stratum; and being undermined by the action of the waves, it falls down in large slabs, which furnish a very good building and foundation stone.

* The under side of this limestone is covered with a coating of iron pyrites, which has been wrought to some extent, on the supposition that it was silver.

The only representative of the Tully limestone is a layer of argillaceous, often concretionary limestone, about three inches thick, succeeding the Moscow shale.

The Genesee slate succeeds the Moscow shale, and is found near the limit of the county, on the Eleven-mile creek; it appears also on Cayuga creek, lot 30, town of Wales; again, at Hatch's mill on the Seneca creek, Indian reservation; and also on Cazenovia creek, near Aurora, and is barely visible in many other places in the small streams. It every where presents its usual character of black, slaty shale, and is every where marked by the presence of *Avicula fragilis*. Its first appearance on the lake shore is in a high bank, twelve miles from Buffalo, forming about six or eight feet of the upper part of the rock; beyond this it is not seen till after passing Eighteen-mile creek, where its whole thickness is visible, lying between the Moscow and Cashaqua shales. It disappears beneath the lake, nearly two miles southwest of Eighteen-mile creek.

In Erie county, the Cashaqua shale is seen in the Cayuga, Little Buffalo, Seneca and Cazenovia creeks; also in the banks of Eighteen-mile creek, extending for two miles or more from the lake. Southwest of the mouth of Eighteen-mile creek it appears in the high bank, exhibiting its whole thickness. It is of a greenish color, embracing numerous courses of irregular, flattened concretions, consisting of clay and sand, with some carbonate of lime. These masses are the only representatives of the continuous layers of calcareous and argillaceous sandstone, which occur further east. This shale forms a very tenacious, clayey soil, as is well seen after ascending the hill beyond Eighteen-mile creek, where the soil is almost entirely formed from this rock. It disappears near Lay's tavern, three miles southwest of Eighteen-mile creek.

Above the Cashaqua, we find black and dark colored shales; and to these succeed alternations of dark green and black shales, the green portions often predominating for miles, and the whole extending beyond the county line. These are all destitute of fossils, except occasional traces of fucoids. The higher part of this group may be seen in following up the Little Buffalo, Seneca, and Cazenovia creeks and their tributaries. The layers of sandstone are thin, and afford good flagging stones; they are also used for other purposes. This group occupies all the lower portions of the hills and moderately elevated grounds in the southern part of the county. It can be seen to advantage at Griffin's mills, three miles south of Aurora. Several of the thin layers of sandstone alternating with shale are seen in a small stream one mile east of Aurora.

Several quarries are opened near Boston centre, where the flagging-stones of this group are quarried. The slabs are from one to six inches thick, and separated by joints of eight feet by six broad; some are fifteen or twenty feet in length.

The rocks of the upper part of the Portage group occupy the highest grounds of the southern part of Erie county, frequently outcropping on the small streams and ravines. The sandstone of this group is thin, compared with the same farther east, and there are but few quarries opened.

About two miles south of Aurora, the higher rocks of this group are quarried by Mr. Treat and Mr. Jones; they are here characterized by a fucoid vertical to the strata. Half a mile east of Griffin's mill, the same mass is quarried by the road side.

On lot 22, six miles west of Springville, on Mr. Pack's farm, two quarries have been opened in this rock. There are also two other quarries about one mile north of Springville. The stones from all these are usually thin, though affording good material for ordinary building purposes.

This group commences at the ascent south of the Indian reservation. The thicker sandy portions occupy the brow of the hills or most elevated situations, while the whole slopes off to the north in proportion as the hard layers diminish. Thin flag-stones and building stones are obtained from the upper part of this group everywhere in the county south of the Indian reservation.

The soil between the top of the limestone terrace and the Indian reservation on the south, is for the most part a gravelly loam, though in many places it possesses different characters; towards the Niagara river, in the lower grounds around Buffalo, the soil is clayey. For some distance east of Buffalo, and particularly near the creek, it is a clayey loam, being adhesive when wet, but readily crumbling when dry.

Along the Cayuga creek, in many places, there are deep accumulations of gravel. Whenever the shale approaches the surface, it produces a clayey soil; but this is a small proportion of the whole, which is mainly of materials from farther north, as limestone, sandstone and argillaceous matter from the salt group north of the terrace. On the north side of the creek, in the towns of Alden and Lancaster, a deep gravel deposit extends for several miles. In its eastern termination it is more loamy, and the soil south of the creek possesses the same character, or becomes clayey. For the most part, the soil along the outcrop of the black shale, and for a little distance north, is clayey; but this is often concealed by the gravel deposit. The present stream runs in a narrow channel with a gravelly bottom; from four to ten feet above, a level bottom land spreads out on both sides for a quarter to one mile. This bottom is composed of fine loam, and evidently has resulted from quiet waters, both from its nature and its evenness. The sides of these flats are terminated by banks from fifteen to thirty feet high, sometimes rising gently, at other times abruptly. These banks, which appear to be the limit of the former stream, or estuary through which a stream flowed, are of mixed materials, coarse and fine gravel, sand and loam. The general character of the soil of these high banks is gravelly, and its extent on either side of the creek is variable. Sometimes, beyond this there is a second ascent or terrace, particularly where we come into the region of the rocks above the Genesee slate, and the sides of this are also covered with gravel to a certain height.

Round gravel, however, occurs but sparingly at an elevation much more than two hundred or three hundred feet above Lake Erie. The soil above this elevation is of a different character, being what is often and very expressively termed "*flat gravel.*" By this is meant, that fragments of rock contained in the soil are flat and angular, having never been subjected to wearing action sufficient to smooth them.

This kind of soil covers a large portion of the southern half of the county, more exclusively the higher grounds; rounded and worn materials occupy only the valleys of the larger streams, diminishing as we ascend from them. The "flat gravel" consists of the materials of the rocks in place near, and appears never to have been transported to any great distance. These rocks consist of soft shale, argillaceous and calcareous sandstones; consequently the soil is of the same nature, varying in proportion as the rocks beneath vary, sometimes more sandy and at others more clayey. It may be described as a clayey loam, becoming tenacious when wet, but not cohering when dry. The coarse materials consist mostly of argillaceous sandstones in thin angular fragments, and in some places still undecomposed shale. The transported materials in this part of the country are confined to those valleys which are connected with others farther south, and through which the north and south current found an outlet. In this soil there is a much larger proportion of lime, and we find it more productive of certain crops than the higher grounds. The valley of the eastern branch of Cazenovia creek, and the northern branch of Eighteen-mile creek, have a much greater surface covered with this kind of soil than the others, and we find that these communicate more directly with the Cattaraugus creek at the south.

Along the Cazenovia and Seneca creeks, above their junction, there is much gravelly soil, forming an almost level surface for considerable extent. This continues below the junction of these streams on the south side, and is seen in isolated patches, mounds, and low ridges, extending to the lake, four miles west of Buffalo.

The same soil is found along the Cattaraugus creek, and at about the same elevation above the lake; it also occurs, in less extent, in several other places, and is characterized by a growth of oak. It is evidently a deposit from coarse materials brought into the lake by streams, and by the action of its waters spread evenly over the bottom. The same features, to a small extent, are now to be seen on the shores of the present lake, where a large stream flows into it.

TOMPKINS COUNTY.

The northern part of this county, between the Seneca and Cayuga lakes, (being the western half of the county,) is occupied by the rocks of the Portage group, with the exception of the lake banks and the deep ravines of the same. In these situations we find the Genesee slate, the Tully limestone and the upper part of the Hamilton group, each one in its order disappearing beneath the lake level as we proceed southward. These rocks from the Tully limestone upward are well exhibited in the deep gorge of Halsey's creek, below Taghannuc falls. The Genesee slate, which is visible for more than one hundred feet above the Tully limestone, is succeeded by nearly three hundred feet of the rocks of the Portage group, consisting in the lower part of a mass of siliceous shale, and above alternating with argillaceous sandstone. The surfaces of this rock are often rippled, and covered with minute fragments of vegetables, which seem to follow the course of the marking, and accumulate or diminish with the ripple wave. The same appearance is presented by a beach of sand, where the ebbing tide leaves fine fragments of vegetable matter arranged in quantity and direction proportionate to the wave.

The Tully limestone and the shale below disappear on Cayuga lake, four miles from Ithaca, the black shale extending about two miles farther south; and on the western side of the county, in consequence of the greater elevation of Seneca lake, the black shale disappears near the southern boundary of Seneca county, with the exception of a small portion rising above the lake, which results from the undulation farther south. The succeeding group of shales and sandstones approaches the level of Seneca lake north of Hector falls, and Cayuga lake near its head.

The Chemung group, like the preceding, consists of alternations of shale, both slaty and compact, and argillaceous sandstone, but differs from it in the contained fossils, and in some particulars of its lithological character. It sometimes contains thin layers of impure limestone, the calcareous matter arising principally from the contained shells. This group is well characterized at Ithaca, at the inclined plane of the railroad; it extends also, far above the rocks here visible, attaining a much greater thickness, as can be seen in the valley of Chemung, south of Seneca lake. In the rocks of this series, individuals of two species of ferns have been found, precursors of the great abundance of that tribe in the Coal formation.

At Hector falls, and above, we find about four hundred feet of this group exposed; the lower part contains the ferns of Ithaca; and above, some of the other fossils. At this place, we find a few thick layers of sandstone, very compact and firm, which have been quarried. Few durable building stones are found in this county, if we except this sandstone, which, however, is little used. It furnishes the fine flagstones used in Ithaca and elsewhere. In general character it differs but little from that of the group below, except that the casts of mud furrows are more abundant and large, being often an inch in diameter and several feet in length. The surface of most of the layers is smooth, or even glazed with a thin coating of shale, which appears to have flowed over it, leaving marks of unequal deposition, and little ridges or prominences where the paste was less fluid. The deposition of these shales and sandstones progressed slowly, considerable time having elapsed between the deposition of the different layers; and in some instances a lower stratum became partially indurated before the succeeding deposit was made.

In some localities the sandstone is replaced by a kind of sandy shale, being a mixture of sand and clay; and the whole is rippled, the markings affecting each thin layer, and showing that it was deposited from water in motion which might transport from different directions the two materials of the rock. This group appears to have been deposited from an ocean alternately at rest, and disturbed. Thick masses of sandy shale occur, bearing ripple-marks through their whole depth; these are succeeded by others of variable thickness without ripple-marks, and having the faces smooth and plain. Numerous alternations of this kind have been noticed through many hundred feet. Fossils rarely accompany the rippled layers, but are invariably found with the smooth. The materials of the two differ very slightly in mineral composition, the rippled ones being more sandy. So far as I have observed in this and other localities, the greatest accumulation of fossils is always accompanied by the fewest ripple-marks.

In numerous localities of these rocks, the edges of strata, when exposed in ravines and other places, are found covered with crystals of sulphate of lime. This circumstance is by no means universal among the shales below, although observed in some localities; while in the present group there are few exceptions. Pyrites, in minute particles, is every where disseminated, decomposing on exposure, and hastening the destruction of the rocks; while the sulphuric acid combines with the minute proportion of lime which they contain, exhibiting the crystals along their edges. Wherever larger masses of pyrites occur, we find a proportionate increase in the quantity of sulphate of lime. Similar conditions in some of the limestones below have produced a mass of gypsum, filling the cavity previously occupied by the pyrites; and analogous circumstances, and varying in extent and effect, may have formed the vast gypsum beds of the same series, extending throughout the whole of Western New-York. The latter, however, could only have occurred before the entire induration of the surrounding rocks.

The thin-bedded sandstones of this county afford some of the finest flagging stones observed in this part of the district. These are quarried in large slabs, having a thickness of from three to five or six inches. The thicker layers furnish a good material for buildings and foundations.

There are several deposits of marl in the marshy ground at the head of Cayuga lake, which might be advantageously used for burning into lime. In the south part of the town of Hector, there is an extensive deposit which is already largely used for burning into lime. There is another deposit in the same valley at Reynoldsville.

About six miles south of Ithaca there is an extensive bed, and several small ones near Newfield.

CHEMUNG COUNTY.

The surface of this county is occupied by a series of broad high hills and deep narrow valleys; the Chemung valley is an exception, however, being broad and deep, with an extensive alluvial bottom.

In the deep ravines of the northern part of the county, the rocks of the Portage group are exposed; but nearly all the surface is occupied by the Chemung group, the characters of which are already described. The rocks are deeply indented by numerous ravines which expose the strata to great advantage, and offer facilities for exploring their fossil productions.

In the vicinity of Millport, and farther south, the sandstone layers attain a thickness of a foot or more, and are quarried for works on the canal and various other purposes; and at Pine valley, the sandy layers of the rock are quarried in two places. Mr. Sexton, the owner of the last, informs me that the firmest layers of sandstone often pass into shale, so as to be unfit for any useful purpose. This appears to be unlike the thinning out of the layer; but the proportion of argillaceous matter becomes so great that the mass crumbles on exposure.

At Maybee's quarry, a mile and a half east of Horseheads, the rocks are quarried for the sandstone which is used for flagging, step stones, etc. These layers are highly siliceous and compact; and sometimes contain a few fossils. They alternate with thick masses of shale; often several layers of the former separated by thin seams of the latter; and again, a thick mass of shale containing no sandstone. A similar quarry has been opened by Mr. Tuilegar, four or five miles east of Elmira; here the layers are very uniform, from half an inch to two inches thick, and dividing by the vertical joints into slabs from six inches to two or three feet wide, and from four to six feet long. The sandstone contains a few specimens of Atrypa, but the greater proportion of fossils are found in the shales. Wisner's quarry, near the village of Elmira, is in a lower position in the group, and the rocks are almost destitute of fossils.

The rocks of this group, containing an abundance of fossils, occur on a small creek coming into the Chemung valley from the northwest, and also on the Singsing creek, passing through Bigflats. On the south side of the Chemung river in Southport, the banks of the valley exhibit the rocks of this group with their peculiar fossils.

Between Elmira and Chemung they are seen at numerous points, but nowhere in the county so well as at the Chemung upper narrows, about eleven miles below Elmira. Here the excavation for the road along the margin of the river has exposed more than one hundred feet of rocks, containing abundance of the characteristic fossils, and in their greatest beauty and perfection. At a certain point in the mass exposed, we find a peculiar coralline fossil, confined to a thin stratum, and extending along the whole distance of the exposed rocks; it has also been found at other localities.

The mountain above the rocks exposed, at Chemung narrows, rises four hundred or five hundred feet, and is probably capped, as some of the hills in the neighborhood, by the conglomerate, which is the limit of the Chemung group upward. Farther south, near Tioga point, rocks of the same group occur, in the bank from one hundred to two hundred feet above the river, and some of the sandstone layers are three or four feet thick, and highly siliceous. I was informed, that on the top of the hill, the conglomerate is quarried for use on some of the public works below Tioga point.

At the Chemung upper narrows, and at several other localities, there occurs in this group a stratum of concretionary sandstone of a peculiar character. In a few instances only are the concretions perfectly formed, but generally have one side imperfect, with a solid nucleus partially surrounded with concentric laminæ, which easily separate from each other; the concavity being often so great as to contain several gallons.

In the valley of Cayuta creek, the group is well exposed in a ravine three miles north of Factoryville, where fine flagstones could easily be obtained. In the north part of Barton are great numbers of loose masses containing the fossils of this group, probably washed down from the tops of the hills in the vicinity.

The shaly rocks of this county are often highly charged with iron pyrites, which on decomposition stains the shale of an iron rust color. The same gives origin to numerous small beds of bog ore, which occur in many localities. One of these near Elmira, and another at Bigflats, furnishes a tolerably pure ore, but in most places it appears as a ferruginous tufa. On the southern margin of the county, in Southport, there is a small deposit of bog ore, which apparently owes its origin to the destruction of the conglomerate of the Carboniferous system.

Several beds of shell marl were noticed in this county, and it is probable that further search will develop more extensive deposits of the kind.

There are several beds of marl near Millport, and the water rising in some of the springs is so highly impregnated with calcareous matter, that on standing a few hours, a thin deposit is formed. There is also a deposit of this kind about two miles northeast of Johnson's settlement. In the town of Dix, at the Beaver dam, there is an extensive deposit of marl which is burned for lime; it is first cut out in large square masses, which adhere on drying, and it is then placed in the kiln. There is also a similar bed of some extent near the Horseheads. Shells of Helix, Limnea, Planorbis, Cyclas and others are abundant in the two last named beds.

The topography of this county is very simple. The Chemung river passes through its south western part, and opens a broad and beautiful valley, bounded by a range of hills, which are only broken by the lateral streams flowing to the river. The rocks on one side sometimes approach the river, while on the opposite is an extensive flat or bottom. Here, as elsewhere, the rocks on both sides of the valley bear evidence of erosion, and show that this river, as well as other streams, flows in a bed once occupied by rocks like those of the mountain mass.

The eastern boundary of the county is along the valley of Cayuta creek, which has its origin in the small Cayuta lake, in the north part of the county, and forms a continuous valley thence to the Chemung river. Wynkoop's and Baldwin's creek form valleys of less importance.

The Chemung valley, extending from the head of Seneca lake to the Chemung river, is the most prominent feature in the county. It offers the only route by which a canal could have been constructed, being through its whole extent alluvial, and presenting no remarkable elevations. The ascent from Seneca lake to the summit level of this canal is four hundred and forty feet in a distance of fifteen miles.

STEUBEN COUNTY.

The general character of the surface of this county is similar to all those of the southern range. A series of broad irregular hills with low valleys occupy the greater part of the county. It is also marked by several deep valleys, which present broad alluvial bottoms. The valley extending south from Crooked lake, the Conhocton, the Canisteo and Tioga, are the principal; these all unite in one, below Painted-Post, communicating with the Susquehannah.

The rocks of this county are of the Portage and Chemung groups, the line of demarcation between the two being much better defined than farther east. The lower group appears in all the deep ravines and along the water courses in the northern part of the county, while the high grounds are occupied with those of the next group. After leaving the head of Crooked lake, the rocks of the Portage group are not again seen in the county going southward, although upon the shore of Seneca lake they extend still farther south, from the greater depth of that valley.

Along the western shore of Crooked lake, the rocks consist chiefly of sandy and slaty or argillaceous shale, the former rippled or undulated, showing that each thin layer of the shale was subjected to the action producing the rippled surfaces, and this action continued uniform throughout the whole deposit. Alternating with the greenish shale just noticed, is a darker slaty shale containing fossils. At some localities occur a few thin layers of sandstone, but these are not abundant until we approach the head of the lake.

Four miles below Hammondsport, in a ravine on the bank of the lake, can be seen a concretionary stratum of impure limestone, composed of roundish or irregular masses cemented together by an argillo-calcareous cement. In other localities, the concretionary forms are not so distinct; and the whole bears the character of an irregular mass, separated in various directions by thin seams of shaly matter. So far as examined, this stratum bears a very uniform character; it disappears beneath the lake on the east side, one mile below Hammondsport. This limestone has been burned, but found too impure for quick lime, though it possesses some of the characters of hydraulic cement.

At Hammondsport, in the ravine above Mallory's mill, we find about three hundred feet of rocks exposed, belonging to the Portage group; they are well characterized by the *Fucoides graphica*. Few fossils other than fucoids appear through this thickness, though higher in the ravine are some fossils peculiar to the next group. The mass exposed consists, in the lower part, principally of shale and thin layers of sandstone, and at a higher point numerous layers of sandstone from four to ten inches thick. The edges of all the layers exposed, are covered with crystals of selenite, or crystallized gypsum. About one mile from the mouth of this ravine, an excavation for coal has been made in the black shale, which alternates with the sandstone and olive shale. The indications of coal at this point were a few fragments of vegetables, iron pyrites, and the odor of bitumen arising from the shale; all these were supposed to be unfailing evidences of coal beneath. The work is at present abandoned, until some new excitement, or reported exhibition of burning gas, shall induce others to engage in the enterprise. In the shale thrown from this digging I found *Cypricardia*, *Avicula*, and several other fossils. On the east side of the valley, opposite Hammondsport, a similar ravine exposes the same strata as those just described.

One mile northwest of Bath there is a stratum of very tough argillo-calcareous rock, three feet thick; the mass is filled with fragments of crinoidal columns, presenting surfaces like the finest birdseye maple. This furnishes some of the finest building and foundation stone, and should it be of such a quality as to receive a fine polish, it will be a valuable acquisition to the mineral wealth of the county. A large species of *Strophomena* and *Delthyris* occur in the lower part of the mass.

The rocks of the Chemung group continue along the valley of the Conhocton to Painted-Post, and as far up the Tioga as the south line of the State; the tops of the high hills excepted, which are capped by the conglomerate in a few places.

The valley of the Canisteo is bounded on both sides by almost unbroken ranges of rocks of the same group. The same rocks are seen along the valley of Five-mile creek, which appears to have been formerly a continuation of the Canandaigua lake valley, and the communication between that valley and the Conhocton.

The soil of Steuben, though not as favorable for the production of grain as the northern counties, is one of the best sections for grazing. From the valleys, the high country seems broken and uneven; but this is confined to the immediate edges of the hills, for after ascending to the table land, we find a beautiful undulating surface, which, when farther cultivated and cleared of forests, will prove one of the best grass-growing regions in the State. These remarks apply also to Chemung county; and in all the elevated portions of both, the water is pure and soft.

The facilities for communication in this county are very great; and when the New-York and Erie railroad shall be completed, the lateral valleys will afford thoroughfares from all parts of the county. Uneven as its surface is represented, the valleys of the Conhocton, Canisteo, Tioga, Five-mile creek, and numerous others, furnish means of establishing smooth and permanent roads from almost every part of the county.

The high banks on either side of the valley of the Tioga expose the outcropping edges of the strata, and numerous small quarries are opened for the extraction of the thin layers of sandstone everywhere interstratified with the shale. The hills are capped by thin layers of sandstone, with less shale than below, reddish or brownish in color, and highly micaceous. These upper portions, so far as observed, are less distinctly characterized by fossils.

The rocks, at the south line of the State and near the river level, consist of hard, thick strata of grey sandstone, a part containing abundance of *Strophomena* and *Delthyris*, and succeeded by a thick concretionary mass. The grey sandstone forms a fine material for building, and more durable than any other in this part of the country. Farther west, and a little south of the county line, a thick mass of concretionary sandstone, with regular strata of grey sandstone, is seen in the north bank of the Cowanisque creek.

In order to give any definite information regarding the connection of these rocks with those of known character above, I have found it necessary to extend my examination as far as Tioga, Pa., seven or eight miles south of the State line. At this place the upper member of the Chemung group of New-York passes beneath the Old Red sandstone, dipping south at an angle of from 6° to 8°. The Old Red sandstone, a little south of this place, is about four hundred feet thick, of a brick red color, with beds of softer or shaly rock of the same color, containing fucoids and bones of fishes. The upper portion, containing the scales of *Holoptychus*, often approaches in character to conglomerate.

The Old Red sandstone approaches the south line of the county, towards its western limits; and has been found forming a thin capping upon some of the higher hills in Troupsburgh. Here, as in other places on its northwestern margin, the rock consists of a thin layer of argillaceous sandstone, highly ferruginous in character, and bearing a general resemblance to the iron ore of the Clinton group. Its decomposition stains the soil a bright red color, and, from these indications, it has been supposed that valuable beds of ore would be found. It is necessary to observe, however, that it is extremely doubtful whether this stratum will ever prove of any importance as an iron ore. In the southern part of the town of Greenwood, the soil is deeply stained from the destruction of this rock, but I have not found the same in place.

In a section made from Dansville south, through the valley, to the Canisteo, and thence along Bennett's and Troup's creek to the south line of the State, nearly the same kind of rocks prevail as previously described, and in the same order of succession; also in the valley from Patchin's to Loon lake and Howard.

The valley of Loon lake is the continuation of the Hemlock lake and Springwater valleys. In the neighborhood of the lake, large accumulations of drift rise in rounded hills fifty or sixty feet above the general level, and skirt the valley on either side; while beyond, the hills formed by the rocks rise to a much greater elevation. The commencement of the fossiliferous strata of the Chemung group is at a little distance north of Loon lake. Few sections are exposed, and our observations are limited to the loose masses on the surface, and some shallow ravines where a few feet in thickness of rock are seen.*

The country known as Howard Flats, is formed of drift hills and ridges but little elevated above the general level, being a high and not well defined valley, presenting outlets in various directions. I could not ascertain the depth of the drift, but the deepest wells do not reach its termination; and the absence of an impervious stratum in the gravel renders it often difficult to obtain water in sufficient quantities.

* Loon lake is situated in a high valley, the hills on the east and west rise to a considerable height, but on the north and south there is almost a continuous level, forming an extensive swamp; the lake has no immediate outlet, but its waters supply Neil's creek, which rises in the swamp, half a mile south. From the north end of the lake an artificial outlet supplies water for mills, and is continued as far as Patchin's.

In passing from Howard to the Canisteo valley, at Hornellsville, we cross the highest hills in this part of the county. The rocks consist of portions of the last named group; shaly sandstone, shale and siliceous sandstone, all containing fossils, are found along the whole distance.

The northern drift, confined to lower levels, is not seen along the road from Howard to Canisteo; and the soil is a clayey gravel, formed from the substrata, and not highly waterworn. In descending into the valley of the Canisteo, we again come upon the northern drift, which is the soil of the valley, and covers the lower slope of the hills.

Five miles from the Canisteo, on Bennett's creek, there is a thick mass of sandstone, overlaid by calcareous sandstone, containing abundance of fossils of *Strophomena* and *Delthyris*. The stone is very firm and durable, and easily quarried in blocks of necessary size for building; and the part containing fossils is much used as a firestone.

Nine miles from the Canisteo, at Lagrange, in the town of Greenwood, the rocks are seen both along Bennett's and Rigg's creeks; and at the point of land near their junction are several courses of sandstone proper for grindstones. The whole thickness is from eight to ten feet, and the layers from two to eight inches. In ascending Rigg's creek, these strata disappear beneath the surface, and are succeeded by greenish shale, with thin layers of silico-calcareous rock with fossils. This shale contains iron pyrites, and decomposes rapidly. The grindstone stratum is visible on the west bank of Bennett's creek, and extends a mile north to Rock creek, and was also traced up the latter a mile above the junction. Its outcropping edges are found in the hills farther north; but the better situations for quarrying are along the banks of the small streams. The character of the mass is, however, variable; and its fitness for grindstones cannot, in all places, be relied on. At the mouth of Rock creek, it is much harder than at the quarry on Rigg's creek.

The exposed portions of the strata are greyish-brown, slightly stained with iron, rather porous and soft, and containing scales of mica. The rock above and below the grindstone portion is green shale; this, in some places, abounds with fossils, as at Rock creek, while above, the green shale, fifty feet thick, is not fossiliferous. It contains some thin layers of sandstone, and is succeeded by a stratum of sandstone about ten feet thick. This latter contains fossils, while the grindstone mass embraces few or none. The upper sandstone is also more hard and coarse than that below, and well fitted for building, underpinning and ordinary firestone. This is again succeeded by greenish shale. This place is between four hundred and five hundred feet above the Canisteo, and fifteen hundred feet above tide water. The source of Bennett's creek is about eight hundred feet above the Canisteo, and the surrounding hills are several hundred feet higher. Four or five miles south of the village of Lagrange, a sandstone is quarried on the land of Mr. Marshall, and used for hearth-stones, tomb-stones, etc. Grindstones are obtained in Canisteo, on the land of Mr. Carter; in Woodhull on the land of William Stroud, esquire, and elsewhere; in Jasper, on the land of Colonel Towsley. These quarries supply all the surrounding country. They are of great economical importance; and the occurrence of similar rock in so many different places renders it probable that the mass is continuous.

On the land of Mr. Davis, at Lagrange, a salt spring rises in the green shale; the water is turbid, and emits bubbles of carburetted hydrogen gas. Several years since, salt was made at this place, and previously by the Indians.. There are, however, no inducements for digging; for, so far as we know, no salt springs of importance are found in this rock, and it is probably only such a one as might occur in any marine formation.

There are numerous beds of lake marl and tufa in this county, some of which are important as furnishing lime. Two miles northeast of Arkport, there is a bed of this kind which furnishes a considerable quantity of lime. There is another similar one south of the village, from which lime was formerly burned. In the town of Troupsburgh there is a bed of this marl, but it has not yet attracted notice. There is an extensive deposit on the Canesaraga south of Dansville, from which lime is burned. The summit level between this creek and the Canisteo presents an extensive muck swamp, and some beds of marl, but their extent has not been ascertained.

ALLEGANY COUNTY.

The general elevation of this county is higher than Steuben and Chemung, while the rocks are the same; a difference produced both by a greater thickness of the mass, and a dip to the east or southeast.

The northern part of the county is occupied by the Portage rocks; the lower portion of these rocks, however, is rarely visible, except in deep ravines or water courses. The upper part of this group forms the cascades and deep escarpments along the line of their northern outcrop, in many places extending beyond the limits of the county into Livingston and Genesee. At the falls on the Canaseraga, in the town of Burns, the Portage rocks are much exposed; but it is at Portage, as has been before described, that they are fully developed, and may be seen in perpendicular cliffs from two hundred to three hundred and fifty feet high. The same rocks are traced along the Genesee valley for several miles, when they are succeeded by the olive shaly sandstone and black micaceous shale, which occupy a part of the towns of Eagle, Pike, Centreville, Burns and Portage. The thin layers of sandstone interstratified with the black shale, and also those usually succeeding it, are quarried on the Wiscoy, a mile west of Pike centre, near Pike hollow, and at many other places along the outcrop and in the ravines and valley sides.

The upper part of the Portage group consists of a mass of slightly argillaceous sandstone, compact and fine-grained, from one hundred and fifty to two hundred feet thick, in some places containing pyrites which stains the rock an iron-rust color. This sandstone is quarried in blocks from one to three feet thick, and of any required size; it breaks easily when first quarried, and will scarcely stand the vicissitudes of climate.

The tunnel at Portage is excavated in this rock, and the bank of the river above exposes it for one hundred and fifty feet, where it is cut for the passage of the canal; and again it appears at the north end of the bridge at Portageville. At these places large quantities of the rock have been quarried and dressed in blocks of various sizes for use on the locks, aqueducts, etc. of the Genesee Valley canal. At two or three other places within three miles south from Portage, the same rock is quarried in the shallow ravines along the valley of the Genesee river.

Succeeding the black micaceous shale, are the sandstones and shales constituting the Chemung group, which is every where visible in the ravines and banks of streams. Its northern limit extends through the south part of the towns of Centreville, Hume, Grove and Burns, and its characters are better developed in the next range of towns. In this county, more particularly along the Genesee river and west, the group differs in lithological characters, and consequently in some degree in fossils, from the same rocks in Steuben and Chemung; the latter containing more sandstone, and the shale having an admixture of siliceous matter, that renders the whole harsh to the touch. In the ravines along the Genesee river, a much larger portion is pure aluminous shale, of a deep green or bluish-green color; in this, at intervals, there are courses of nearly pure sandstone; sometimes a single layer of a few inches, at other times several, forming a mass of four to ten feet thick.

A very good exhibition of this group, and better than is elsewhere seen, in Allegany county, is on the Caneadea, from Rushford, near M'Call's mills, to the mouth of the creek. The rocks consist of numerous alternations of shale and sandstone, the latter, often in layers of two or three inches, and other thicker ones, which are quarried for lockstones, building stones, and grindstones. One stratum of this sandstone, containing several courses of variable thickness, affords a good material for grindstones, for which it is quarried on the land of Mr. Bannister. I did not learn the amount annually taken from this quarry, but judgin gfrom the numerous and distant points where the "Rushford grindstones" are sold, it is greater than any other in the district.

Rocks similar to the last, but none of the same strata, are seen in Black creek, Crawford's creek and White creek. In the banks of Black creek, at Rockville, some thick masses of sandstone alternate with green shale, which is slightly calcareous and contains abundance of fossils. Two of the sandstone strata are about six feet thick each, and divided into courses of from two to three feet. Similar sandstone is quarried half a mile southwest, on the line of the canal; it contains fossils of *Atrypa* and *Deltyris*; and a mile and a half south, and sixty feet higher than the last, a sandstone is exposed on a bank of a small stream. The layers are thin, but extremely siliceous and durable.

The rocks at Rockville are all highly bituminous, the sandstone so much so that it scents the clothes of the workmen; and the water of the springs, though clear, has the taste of bitumen.

Southeast of Rockville, on White creek, we find a greenish shale, with a concretionary sandstone, which in some places becomes a conglomerate in the upper part of the layers. When not concretionary, it is fit for grindstones. Sandstone appears in nearly all the ravines in this neighborhood.

The bed of the Genesee river, at the Transit bridge, is in a mass of very fossiliferous sandstone, some portions of which are slightly conglomerated.

At Hull's mills, near Angelica, the rocks are exposed in the bank of the creek, for fifty feet or more in height. They consist principally of shale, which contains the fossils common to the Chemung group, and among others, the large *Pecten-like Avicula*. The lower portion of the mass is a hard grey sandstone, containing in some parts, great numbers of fossils, among which *Delthyris* and *Strophomena* are most abundant. This sandstone has been quarried for building; it is durable, and presents a very good appearance.

About a mile and a half south of Angelica, sandstone has been quarried, though the greater portion of the rock exposed is shale. The sandstone has been used in the construction of a mill near the quarry; though, when first quarried, it is extremely friable, and scarcely coheres. Like most sandstones of this region, it contains a large proportion of moisture.

The sandstone along Van Campen's creek was quarried by Judge Church, and used in building more than thirty years since; it still remains firm, though somewhat iron-stained from the decomposition of pyrites.

At Philipsburgh, two and a half miles south of Hobbieville, we find a change in the rocks, which is indicated by their fossils more than their lithological character. Green shale is the predominating portion of the mass; with some thin strata of sandstone, it occupies the bed of the river for an eighth of a mile, and, together with the vertical bank, presents a thickness of forty feet or more. Above Philipsburgh, on the Genesee, rocks similar in character occur in several places in the bed and bank of the river. At Vandermark's creek, five miles from Philipsburgh, we find the green shale, not so highly fossiliferous, and with it thin courses of coarse-grained sandstone, containing abundance of a large species of *Delthyris*. This fossil occurs in a rock of similar texture in many places of the same elevation, and may be found to constitute a definite point, or to mark the termination of some group; certain it is that along this line we find scarcely any fossiliferous rocks above it.

The next place south of Vandermark's creek, where rocks are seen, is on Dike creek, near Wellsville, at an elevation of sixty or seventy feet above the Genesee, and between fifteen hundred and sixteen hundred feet above tide water. The rock at this place consists principally of grey sandstone, embracing a brick red or brownish mass six or eight inches thick. This is composed of sand, or rounded particles of quartz, with much argillaceous matter, splitting into laminæ half an inch or an inch in thickness, and is so highly impregnated with iron that it stains the hands nearly as much as the öolitic ore of Wayne county, but is not, like that, unctuous to the touch. It is considered by the inhabitants as a stratum of iron ore; but its specific gravity proves the proportion of metal to be too small ever to repay working. Single joints of crinoidea occur in this and the grey rock below. On close inspection, the materials of this mass appear to have been subjected to much wearing action, and many specimens exhibited numerous fragments of bones, apparently belonging to fish, and similar to those found in the red sandstone on the Tioga.

This rock, examined here and several miles south, is succeeded by a mass consisting of greenish grey sandstone, often appearing as if deposited from opposing currents, and in all respects resembling that succeeding the red sandstone on the Tioga. In examinations further south, I have not been able to discover the red sandstone, neither along the Allegany and its tributaries; and I am informed by Mr. Horsford, that he saw nothing of it in his journey down that river as far as Warren, Pa., which brings us to the northern limits of the coal.

The strata above the red rock at Wellsville, those on the Shenunda creek and towards the Pennsylvania line, contain no fossils. The mass greatly resembles that above the red sandstone elsewhere; and the great elevation of the points examined, considered with the difference in altitude between this and the Tioga, may lead us to expect these rocks in place as far north. This sandstone is elsewhere associated with the conglomerate, occasional fragments and boulders of which are found in the elevated lands of Steuben, and the eastern part of Allegany.

About three or four miles south of Wellsville, the side hill and valley east of the Genesee are strewed with masses of the same, consisting of small and large pebbles of white quatrz with coarse sand. From the great numbers of fragments, we would infer the rock to be in place near by, and in a former section this position was given to the conglomerate; and though from careful investigation I am not able to find it in this vicinity, the position is undoubtedly correct; for it appears on the hills west of the Genesee, in Scio, and several other points. Its thickness, however, is not so great as I had supposed from its extending over so great a surface. In Scio, it is found on the high grounds near the sources of some small streams flowing into the Allegany and Genesee. For the most part the rock appears in large detached masses, being divided by the joints into rhombic blocks; one of these measured forty-four by sixty feet, and fifteen feet in thickness. Approaching the rock in place, the masses are larger and closer together, being but slightly moved out of place, and the spaces between them diminishing from a distance of five or six feet to fissures of a few inches. The sides of the blocks appear water-worn, or deeply weathered; and the upper surfaces slope in the direction of the hill, probably from the removal of the rock beneath. The mass seems to have contracted on desication; and the joints, since enlarged by the percolation of water from above, form, within the rock, passages of greater or less extent, communicating with each other. This mass is composed of pebbles of crystalline quartz, white or rose-colored, from one to two inches in diameter, and generally elongated or egg-shaped. In the early settlement of the country, this rock was used for mill stones; but in much the greater part the pebbles are too large, and it is too friable for this purpose: its use is now superseded.

Previous to visiting this place, I was informed that a bed of coal two feet thick had been found beneath this conglomerate, and it was represented as having been used in the blacksmith's forges. On further inquiry, I could not learn that such a bed was known; the only person who could give any information of its existence, had seen small pieces not more than one-half inch in diameter.

This is the only rock seen on the surface, between Wellsville on the Genesee, and Bolivar.

In the town of Genesee, about three miles north of the Pennsylvania line, and near the centre of that town, the conglomerate, essentially the same as at Scio, occurs on the highest hills.

On the Little Genesee, a few rods north of the Pennsylvania line, sandstone and shale with fossils appear in place; this is at nearly the level of the stream, two or three hundred feet below the conglomerate. I saw, also, some detached masses, resembling the red rock at Wellsville, and a reddish soil which may be caused by the outcrop and disintegration of the same stratum. Along the southern line of the county the rocks are interrupted by the valley of the Oswaya creek, and thus we have no means of tracing their continuation or immediate connection with those of Pennsylvania.

At several places in the western part of this county, as at Cuba, we find rocks of shale and sandstone similar to those already described, and quarries are opened to some extent.

West of the village of Cuba is another more extensive quarry on the land of Judge Chamberlayne; this affords sandstone in thicker masses, and better fitted for building than the others.

Between Cuba and Friendship, rocks scarcely appear in place, though they are not far beneath the surface. In most of the high grounds of the southern counties the soil is shallow, the substratum being but a few feet beneath it.

CATTARAUGUS COUNTY.*

The general surface of Cattaraugus county maintains about the same elevation as Allegany; the Genesee in the former, and the Allegany river in the latter, also take their rise at about the same altitude, and continue their course with nearly the same descent, though flowing in nearly opposite directions. Although this county is crossed by numerous streams of considerable size, still there are few situations where a good view of the rocks can be obtained. The valley of Ischua creek, which extends nearly across the county from north to south on its eastern side, exposes the strata only in a few places. The Cattaraugus creek pursues its course for the whole distance, in the outcrop of the strata, consequently developing but one or two rocks.

The rocks of this county are a continuation of the same groups noticed in Allegany county. The Portage group forms the northern boundary of the county, and is exposed along the

* The details of this county are mostly extracted from Mr. E. N. Horsford's Report. Annual Report of 1840.

Cattaraugus creek. This is succeeded by the same shales and sandstones as before noticed in Allegany. There appears, however, a general diminution in thickness of all the masses to the westward; and many which in Allegany are of great thickness, appear here much diminished.

Notwithstanding that the rocks are exposed at few places, still, from the great elevation of the country, and the thinness of drift or alluvium, they are found at moderate depths below the surface.

This county is among those of the Fourth District distinguished for their deep and extended valleys, and their ranges of elevated hills. The proportion of uneven surface throughout, but particularly in the southern part, is somewhat greater than in either of the counties of the same range, directly east.

The general direction of these valleys is the same as that of the large valleys farther east--from north to south. Toward their northern extremes, the beds of most of them expand gradually into plains of considerable width, limited by acclivities of gentle ascent on either side; while some branch into smaller and more irregular valleys. They become, also, more and more shallow, to the north. But in their continuation southward, their depth constantly increases, the hills become more elevated, and the declivities more precipitous. The summit of some of the highest points of land cannot be less than eight hundred feet above the low grounds of the surrounding valleys.

Along the northern border of the county, there is spread out a body of alluvium totally distinct in character from that prevailing in the southern portions; and the difference between the two is manifest, as well in the vegetation with which they are clothed, as in the materials of which they are composed. The ravines and gorges of the one have fewer evergreens, and of these the hemlock is the most abundant, while the valleys of the Allegany and its tributaries are distinguished for their forests of pine.

No region of this State, and probably none of any other in the Union, was originally covered with an equal amount of valuable timber. Some of the trees have measured two hundred and thirty feet in height, and five of them have been known to furnish an hundred "lumberman's" logs. Shingles and boards for the supply of the whole western world, from one extreme of the Union, Louisiana, quite half way to the other, have been manufactured in the shingle shanties and saw-mills upon the Allegany and its tributaries.

The lands of the valleys, and indeed of the entire county, with the exception of here and there limited areas, are susceptible of cultivation. The only swamps worthy of notice are the Conewango and the large one northeast of Waverly. Clay underlies a considerable proportion of these, and, we were informed, the whole of the former. Deep ditchings would reclaim large portions, if not the whole of both, and will, without doubt, as the country around becomes more settled, be adopted. Hitherto, the lands having upon them groves of timber, and contiguous to mill-sites, have been more valued for the lumber they furnished, than for the crops they might have been made to produce. The occupation of the lumberman, however, must soon be much less productive than at present, and ultimately give way to the duties of the husbandman. When it shall, and when the lands of the valleys enjoy the cultivation given to the flats of the Genesee and Mohawk, there are portions of Cattaraugus that will present fine farms and yield valuable incomes.

The beds of clay, marl, tufa, bog-iron and manganese, and the swamps are mostly in the depressions of the alluvium.

The surface soil is a yellowish loam, chiefly composed of disintegrated sandstone and shale. It has been washed down from the hill sides and cliffs, by rains and the melting of snows, and emptied into the streams which, in their overflowings, spread it out upon the low lands of the valleys. It is the principal soil of the Allegany valley, and of the flats along the Cattaraugus creek.

Clay, in shallow beds, is found more or less in the valleys, but to no extent was it seen upon the higher lands. That of the Conewango is by far the largest seen. It is observed at Randolph in several places, and probably underlies a great portion of the immense lowlands and swamps. It is seen a mile west of Waverly in strata, and alternating with gravel and sand in an alluvial hill directly south of Waverly village. It is found about a mile south of New-Albion, a hundred yards from the mouth of a tributary to the stream, along which the road passes.

In the towns of Great-Valley and Little-Valley, the "sags" or depressions in which the clay is formed, contain more or less extensive bodies of peat. The largest is upon the land of Mr. Sweetland. About ten acres are spread over by the bog; and the depth of peat varies from a foot or two near the margin, to more than twelve towards the centre. As a manure, and as a substitute for coal and wood, this bed in particular, and the smaller ones in proportion to their extent, must become of value. For the improvement of lands, the peat may be appropriated immediately and with great profit on most farms.

The occurrence of peat is generally indicated by the growth of dwarfish evergreens, and rank swamp herbage, and by the elasticity of the crust which supports them.

There is an extensive bed of marl about two miles from Lodi, upon a small branch of the Cattaraugus creek. It lies southeast from the village, and about a quarter of a mile from the mouth of the branch. A kiln has been in operation a number of years, and several thousand bushels are burned annually.

In the east part of Otto, upon the land of Mr. Sias, a bed of marl covers between three and four acres, and is from a few inches to four feet deep. About one thousand bushels have been burned annually. With this marl there are no foreign substances, except now and then a little vegetable mould, which all disappears in the process of burning. Estimating the area at three and a half acres, and the average depth at one foot, we have 122,500 bushels, a quantity that will supply the demand, should it increase to three thousand bushels annually, for forty years to come.

A small bed of tufa furnished a few kilns with lime in Dutch hollow, in the town of Ashford, but is now nearly exhausted. A number of small beds have been found near the residence of Mr. Sias, and we were informed that a bed of some extent had been discovered in

New-Albion. Near the mouth of the Canaseraulic a bed has been found, and another near Zoar, with several intermediate ones but all are small and have not been worked to any extent.

Upon the land of Mr. Hancock, in Freedom, a bed covering a considerable portion of three acres, has been opened. The better portions of it are nearly exhausted, though much yet remains that may be advantageously used for agricultural purposes. From 3000 to 6000 bushels have been burned annually for the last twelve years. There is another large one in the north part of Freedom, owned by Mr. Sherman. Four miles southeast of Randolph, on the land of Judge Leavenworth, a small bed has been found.

Taking the whole together, there are in the county materials, of marl and tufa, enough to furnish immediately 300,000 bushels of lime.

Beds of bog iron ore are found in many little swamps and lowlands in different parts of the county. Across the river from Olean, masses containing several cubic feet have been excavated.

The *earthy oxide of manganese* or *wad*, was found in different parts of the Conewango and Little valleys. More was seen upon the land of Mr. Bush, in Randolph, than in any other place. It is accumulated in nodules, in some places, from the size of a shot, up to that of a walnut. In other places, it is seen adhering to fragments of sandstone, scattered throughout the soil. It has not yet been found in quantities sufficient to be of value.

Near Lodi, nodules of iron pyrites are found in considerable quantities, in the upper portions of the gravel alluvium, underlying the loam of the valley.

Trappean, hornblendic, gneissoid, granitic and sienitic, and some other boulders, are the representatives from more northern latitudes. One boulder of hypersthene was seen at the sulphur springs near Randolph. Two boulders of iron ore, resembling the specular ore of St. Lawrence county, were found on the south branch of the Cattaraugus, near Little's mills. One weighs thirteen pounds. Both have been procured for the State Collection.

Salt springs or licks are occasionally found. Several near Rutledge attracted attention in the early settlement of the town, from the numbers of deer who came to "*lick*" about them. Near one of these a shaft was sunk, in the hope that lower down the strength of the brine would be found greater. The proportion of salt was, we are informed, about a teaspoonful to a pail of water.

The *Oil spring*, of Freedom, is, in many respects, like that of Cuba in Allegany county. Its diameter is somewhat less, and the quantity of oil which in a given time rises to the surface is, in proportion to its extent, the same.

Carburetted hydrogen is emitted at this spring, in small quantities. It is observed to escape from almost all waters, either stagnant or running, in the county. It is seen bubbling up through the waters of most large springs. The only place where the quantity is sufficient to maintain a constant flame, is at the mouth of a small stream coming in to the Cattaraugus, against the Missionary house, about five miles above Lagrange.

Sulphur springs are occasionally met with. One upon the land of Judge Leavenworth, near Randolph, is pretty strongly impregnated.

The *conglomerate* is the highest rock in the series that has yet been observed in the State. Immense blocks of it are found at Chipmuck ripple on the Allegany river, and near Judge Wright's, southeast of Ellicottville; also between Napoli and Little-valley, on the Jamestown and Ellicottville stage road, near Judge Leavenworth's, and at numerous other localities. But the places where it is seen *in situ* are comparatively few, and only upon the very highest points of land. One, five miles south of Olean; two between Great-valley and Little-valley, and several south of the Allegany, comprise all in this county concerning which information was obtained. The locality best known is about seven miles south of Ellicottville, and one and a half west of Great-valley post-office. It is known as the *Rock city*. It is approached along a ridge extending from the base to the top of the hill, of gradual ascent, and terminating at an elevation of not less than six hundred feet. Other hills, upon the opposite side of the valley, and of less altitude, were determined by Col. Hawley to be above six hundred feet in height.

From the abundance of timber in Cattaraugus, little need of good building stone has hitherto been felt, and, consequently, little exploration has been made for valuable quarries. Of those opened in different parts of the county, the greater part will be found noticed in the list which follows.

The quarries at Olean contain micaceous sandstone, and an olive shale, which is concretionary. The stone at the lower quarry are coarse; while at the one some fifty feet above, they are of a finer grain. The underpinnings and cellar walls of many buildings in Olean have been obtained from them. A quarry owned by Mr. Pratt, in a small alluvial hill, a hundred rods down the river from the quarries above noticed, is nearly exhausted. In a ravine which is entered just south of Pratt's quarry, there are found masses of a coarse sandstone, like that alternating with the conglomerate which is seen a few miles farther south. These masses are strewn along the ravine its entire length. The same rock occurs in several places along the Allegany, in huge fragments, and is seen to be of the most durable character, from the angular form of the masses, notwithstanding their long exposure to the action of the current. From examinations made in Pennsylvania, its true place is ascertained to be in the lower part of the conglomerate.

Nine miles below Olean, sandstone, slightly concretionary, has been quarried for the filling up of dams and other purposes.

The *Ischua stone quarries*, lying almost wholly in the town of Machias, contain stone with which there are none other in the county to be compared, either for beauty when dressed, for the facility of quarrying, or for durability. They are a coarse sandstone, disposed in massive and in thin layers, of such thickness, that blocks for every desirable purpose, from heavy columns to thin flagging stone, may be easily procured. Butler's quarries, three miles north of Franklinville, have been most extensively worked. The foundation walls of Irvine Hall, Ellicottville, were here procured. The quarries are in the visible outcrop, which extends for a considerable distance.

All the important quarries in this county were enumerated in the Annual Report of 1840, and, therefore, need not be repeated in this place. They afford but little variety; and, from what is known of the same group of rocks here and elsewhere, no other economical or valuable products are to be expected from these rocks than the ordinary quarry stones.

CHAUTAUQUE COUNTY.

The general face of the country in this county resembles that of all the southern counties in the district. It differs in some degree, however, in its soil, which is of a loamy character in a greater proportion than many others. The hills, although of the same nature, are less elevated, either from the general elevation having originally been less, or that the abrading action has been more effective. The latter may perhaps be the cause, as the proportion of hard materials is less than farther east, and there is also evidence that the rocks all grow thinner on going westward, and in Ohio the highest rocks of Chautauque county are but a few hundred feet above Lake Erie.

It has been ascertained from surveys, that the highest parts of this county do not attain so great an elevation, by two hundred feet, as some parts of Cattaraugus and Allegany. The broad valley of the Conewango on the east side bounds the county by a depression of five hundred to eight hundred feet lower than the high hills; while on the north, the deep gorge of the Cattaraugus creek is even lower than that of Conewango. On the northwest side we descend, in the distance of five to eight miles, from an elevation of about two thousand feet above tide water, to Lake Erie, (which is five hundred and sixty feet above the sea,) nearly all the descent being in the first three or four miles. This is a remarkable feature in Chautauque county, and one which can only be accounted for by supposing the abrasion and removal of the materials once filling this space.

Another remarkable feature in Chautauque county, is the existence of the lake of the same name, the northern extremity of which is only eight miles distant from Lake Erie, and yet empties its waters by the Conewango, Allegany, Ohio and Mississippi into the Atlantic. This lake is sixteen miles long and twelve hundred and ninety-one feet above tide water, and seven hundred and twenty-six feet above Lake Erie. It is a beautiful sheet of water, bounded on its eastern side by gravelly sloping banks, and on the west by more level and in some places marshy shores. The channels of the streams flowing into the Allegany are all more than twelve hundred feet above tide; the valleys and hills range at all points between this height and two thousand feet.

To superficial observation there are few rocks to be seen in Chautauque county, but examinations made along the deep ravines prove the existence of all the great masses further east, and from the destruction of which the soil of the county is mostly produced.

Along the lake shore, from near Cattaraugus creek to the State line, we find the banks are perpendicular bluffs from ten to one hundred feet in height. Green shale alternates with the thicker courses of black, and beyond this the black shale increases in proportion as far as Portland harbor. Both green and black shale contain septaria, and more rarely, thin sandy layers, which are so numerous in the Portage group, constituting the flagstones further east. From Portland harbor to the State line we have similar slaty and crumbling shales, alternating with thick and thin courses of sandstone, all possessing a similar general character. Arriving at the State line, we are able to trace the same group in the deep ravines for two or three hundred feet higher before there is any marked change. Throughout the whole extent there are scarcely any fossils except fucoids, and these abound wherever the thin sandy layers occur.

All the northern part of the county below the elevation of fourteen hundred feet above tide water, or about eight hundred and forty feet above Lake Erie, is underlaid by the shale and thin sandstone of the group above mentioned. These rocks are distinguished from those above by the almost entire absence of all fossils except fucoids, as well as the greater predominance of shale. In the southern part of the county the rocks of this group are not seen, having passed below the level of the lowest valleys.

All the southern part, as well as the higher portions of the northern part, are occupied by the Chemung group, readily known by the great number of shells of the genera *Strophomena*, *Orthis*, *Delthyris*, *Avicula*, *&c.* which characterize it every where. In this group the proportion of sand increases over that below, and in its upper part the larger proportion is sandstone.

The rocks of this group can be seen to great advantage in the Chautauque creek, six miles above Westfield, and in the outlet of Chautauque lake below Jamestown. They can also be examined to some extent above Rice's mill on the Twenty-mile creek, and in many of the ravines along the Conewango and Cassadaga valleys. The strata are no where seen except in ravines or the banks of streams.

The extreme southern part of the county is comparatively low, rising to less elevation than the middle portions.

Many of the hills are capped with conglomerate, which is the highest rock in the county. From the portions remaining, the rock appears to have been originally of variable thickness; in some places not more than five or six feet, and in others fifty or sixty feet. Where the rock is free from pebbles, it is known by being more friable than any of the sandstones below; and also by the lines of deposition being at varying angles, as if acted upon by currents from different directions. In such cases it forms a good building or underpinning stone, easily dressed, and readily obtained in blocks of large dimensions. It is, in fact, almost the only stone in the southern part of the county which can be obtained more than a few inches in thickness.

The principal places where it is quarried are, upon the top of a hill about two miles from Ashville; another quarry four miles north of Panama, and again one mile northwest of this. From these places, considerable quantities of the rock have been taken. It is associated with a few inches of the coarse conglomerate.

On the north side of Chautauque lake, it occurs on the land of Mr. Young; also on the land of Mr Barnard and Mr. Preston, passing from Ellington centre to Cassadaga creek; and again farther north, on the land of Mr. Strong, three miles north of Ellery centre. In all these places it is found only in loose blocks scattered thickly over the surface for a small extent, and evidently the remains of a once continuous stratum.

At Panama the conglomerate occurs upon both sides of the stream between the upper and lower village, and follows the eastern slope of a hill for more than half a mile. Where I measured it upon the stream, it was about sixty feet thick. It lies in huge masses sixty or seventy feet long by twenty or forty wide and thick, with deep fissures between. Sometimes the masses are so arranged that these fissures form caverns; and one place I was shown, is so excluded from sunlight that snow and ice remain during the summer. These masses diminish in size and frequency towards the south, and soon disappear.

Four miles northwest of Panama, on the land of Mr. Field, the conglomerate and sandstone are found covering the ground to considerable depth. The whole is composed of fragments, most of them small, which are piled irregularly one above the other, as if rolled down from a higher eminence. The situation is at the foot of a hill upon the western side. Several miles west of this place, in Clymer, there is a locality of this sandstone, which has formerly been quarried for grindstones, and also for other purposes.

About three miles southeast of Panama, on the east side of the valley of the Little Broken Straw, the conglomerate is found on the land of Mr. Lloyd. Still further east, on lot 13, land of Mr. Vosburgh, the sandstone occupies the surface of two or three acres, outcropping on the northern and eastern sides of the hill. In digging a well near the summit of the hill, the same rock was found. It was covered with a layer of "fine beach sand;" the rock beneath was fractured, and the surface worn and smooth.

It is nearly impossible to indicate every point where this rock may be found; those mentioned have been personally examined; other places probably occur, but the hills are frequently covered with forests and without road. The only remaining places to be noticed, are two hills in the southeast corner of the county, on either side of Case Run, which I visited on my way south to Warren. The mass, consisting mainly of sandstone, with little conglomerate, lies scattered over the sides of the hills and upon the tops, in huge blocks, the thickest noticed being about thirty feet. This locality is on a range of elevated ground which extends southward between the Allegany river and Conewango creek; the conglomerate and grey sandstone accompanying it, are seen, with some interruptions, nearly the whole distance to the point where these two streams meet. Six miles south of the State line, there is a thin bed of coal, apparently resting upon the conglomerate.

The soil of Chautauque is principally of two characters. That resulting from the decomposition of the rocks in place, is a clay loam mixed with angular and unworn fragments of the harder portions of the rocks, and known as the "flat gravel." This occupies all the hills and a large portion of the higher ground.

The materials of this soil are coarser as we descend beneath the surface, and below are frequently composed of large angular masses, closely impacted together, and forming a mass of variable thickness, lying upon the surface of the rock beneath. Where in such cases the surface of the rock below is level, it is scratched and worn smooth, evidently from the materials having been moved along its surface. In one place near Portland harbor, in opening a quarry, a considerable quantity of this kind of material was removed; the larger masses fit for rough walls were left, and the finer thrown into the lake; the quantity thus reserved was sufficient to have covered the whole surface, when packed closely, to the depth of four feet, though the original depth of the whole was only five or six feet. Numerous similar instances appear in the bluffs of gravel along the lake; the moving force seems to have torn up the surface layers, and to have pressed them onward, accumulating in power and quantity, lifting the strata for great distances, bending and breaking the uplifted edges, and leaving them in all manner of contortions, with rounded gravel above and below. In some instances the gravel is forced under the uplifted edge of a stratum to the distance of many feet.

The valleys are covered with a soil consisting of fine loam and gravel of rounded materials, which has been derived from more northern rocks. Many of the lower valleys have evidently been overflowed with quiet water, from which the fine loamy deposits have been made.

The small lakes, Bear lake, Cassadaga lake and Mud lake, have once been much more extensive; and by successive drainage, they have left marks of their subsidence along the sloping hills around them. The valleys of the Cassadaga and Conewango creeks have evidently been extensive lakes, as would appear both from the nature of the materials in the bottom of these valleys, and from the evidences along the elevated grounds bordering them, as also from the narrow outlets worn through rocky strata.

In the valley of the Chautauque lake, we find satisfactory evidence of its former greater elevation in ridges or terraces of gravel and sand; these are particularly well defined upon the north side. On examination, about the outlet, the cause of this greater elevation is found to have been the obstruction of its former outlet, which was nearly in an easterly direction from the Cassadaga; whereas now, by the accumulation of large deposits of gravel, it is turned in a southerly direction, and only joins the Cassadaga valley by a channel excavated through the solid rock. This direction is seen very clearly by examining its course on a map, and the effects of the wearing action upon the rocks are still visible at Dexterville below Jamestown.

At the time the original outlet was obstructed, the waters of the lake must have been raised to more than thirty feet above the present level, overflowing for a great distance the low valleys on its western side and its northern extremity, and which exhibit clearly the evidence of such condition from the almost level deposits of fine alluvium which cover them.

Deposits of marl are less numerous in Chautauque county than in the counties farther east. The largest deposit of this kind is in Cassadaga lake and the marshes which nearly divide it into two portions. This marl has been used for several years for burning into lime, of which 2000 bushels are annually made. There is a bed of marl and tufa at the southern extremity of Chautauque lake, near Dexterville.

In many places, recourse is had to large boulders and transported fragments of limestone for burning into lime. One of these masses, found near Forrestville, yielded one hundred and fifty barrels of lime. A few miles southeast of Fredonia, a large mass of the water limestone was found, which burned into quicklime of a dark color. This gave rise to the belief of the existence of the same rock in place in the neighborhood, but it will not be found south of the limestone terrace in Erie county.

In the southwest corner of the town of Clymer, and within a few rods of the Pennsylvania line, Mr. Beardsley has opened a quarry which affords good grindstones. The rock is of great extent, and can be easily quarried for all the supply required. It is of the same stratum as that quarried in Freedom in Cattaraugus county, and in Rushford in Allegany county. The same is also to be seen in the western bank of the Little Broken Straw, below Panama. It is here characterized by a species of fucoid, found also at Freedom and Rushford.

Few of the layers are thick enough to afford good building stone, though there are some quarries of this kind in the Portage group. The principal which I have seen in Chatauque county, are near Forrestville, and about four miles from Fredonia, on the line of the railroad. The rocks from the two quarries near the railroad have been used in constructing the arches over the streams for the passage of the road, and in the public works at the harbor of Dunkirk.

Quarries have been opened at Shumla on the Canadawa creek, and at Laona on the same stream. The mass at Laona is about five feet thick; the upper three feet often forming but a single course, thus affording blocks of large dimensions. It is highly bituminous, and petroleum is seen on the water which rises from the earth in the vicinity of the rock. Going southward this mass becomes much thinner, and at Westfield there is no appearance of it, except in a layer of about one foot thickness, and considerably changed in character. It appears to have been deposited in a depression of the strata below, which causes it to grow thinner on either side.

About three miles south of Fredonia, there is a quarry of shale and sandstone from which some blocks have been obtained of about a foot in thickness; these are succeeded by shale and thin layers of sandstone.

The rocks occupying the high grounds of the southern part of Erie and the northern part of Chautauque afford excellent flagging stones, some of them of large dimensions. Those about Boston, in Erie county, are commonly eight to ten feet long and ten to twelve broad, and sometimes are obtained of twice these dimensions. Near Westfield, in Chatauque county, these flagging stones are obtained of very large dimensions, often fifteen or twenty feet in length, with a width of ten or twelve feet. The surfaces of these are rippled in large waves. The same courses of rock are very extensive, and everywhere furnish this material.

The localities enumerated under the head of Conglomerate, afford excellent building stone of any required dimensions. From some of these places large blocks of stone for pillars, etc. have been taken to Mayville, Dunkirk and Buffalo.

Carburetted hydrogen gas is every where common in the higher rocks of New-York, and in Chautauque county is unusually abundant. In many places the escape of this gas is accompanied with petroleum, which forms a pellicle upon the surface of the water, indicating the escape of the gas; in other places the gas rises alone, and in many places there may be seen considerable quantities of petroleum where no gas escapes.

At Laona, petroleum and gas both escape from the surface, and from the rocks and earth beneath the stream; and there are several other localities where the same phenomena may be seen along the outcrop of the sandstone, which is quarried on the line of the railroad. Near Forrestville there is a copious discharge of this gas, which it is contemplated to convey to the village for the purpose of lighting it. The village of Fredonia is lighted with this gas, which issues from the shale forming the bed of the stream passing through the place. The light-house at Portland harbor is illuminated with this gas, which rises from a stream three-fourths of a mile north.

In the conclusion of this chapter, I would say, that while I have intended to omit nothing that can be regarded as important to the interests of the inhabitants, or aiding them in the knowledge or direction of their available wealth, I have omitted details which can be of no present utility, and which may, by seeming to attach undue consideration to things which are only contingent and prospective, have a tendency to mislead. For example, masses of beautiful stone, marble, beds of peat, marl, etc, I have not calculated by the cubic foot or yard, as if already worked out and sold; whence the farmer or speculator, regarding only the ultimate value of his wealth, increases his price according to this essentially false estimate. For it must be considered that years are required to consume a marl bed, a peat bog or a marble quarry; that the income depends on the demand; and though its stated value may be realized in twenty or fifty years, the capital invested in its purchase might, in the mean time, and otherwise employed, yield fourfold. Like the products of a cultivated farm, the returns are constant and slow, differing from that only in the circumstance that it is not inexhaustible.

I would not be understood as attaching little importance to such property. To the farmer, the value of a marl bed or a peat bog is immense; but I would say, that geologists, when occupied in such objects as calculating the value of a mass, in dollars, while they degrade their science, defeat their own purpose; they mislead those who are guided by their representations, and foster the very spirit which their researches should allay, viz. *the mania of speculation.* If such a course is pursued, it requires no great foresight to perceive that want of confidence will prevail, and geology be ranked with the art of the adventurer with the mineral rod. Besides, there is confessedly room for error in estimating the contents of a bed or vein. In the fourth district, we know that beds of limestone, marble, grindstone grits, etc. are liable to thin out within a few rods, or they may continue for miles: in this state of the case, it is very unsafe to predict or infer that one stratum will extend for a distance of several miles because another one has been found to do so, when we know the greater number do not.

The available resources for agriculture and trade, of the northern range of counties, consist in iron ore, gypsum, marl, muck, limestone, sandstone, etc. Those of the middle range consist of gypsum, limestone, marl, muck and some less important objects.

In the southern range, sandstone for all purposes of building, marl for lime, and muck for improvement of the soil, are the principal resources. The inflammable gas is turned to some account in a few places, but no mineral wealth can be expected from any part of these counties. The products of the soil are the great source of prosperity in this district, and the region is abundantly fertile to supply all the reasonable wants of man.

In order to follow out the plan, and to accomplish the objects of this work, it now remains to trace the New-York rocks in their western continuation, to show some of the changes undergone throughout their immense extent, the different phases under which they are to be sought and recognized, and the influence of such lithological variations manifested in the character of the imbedded fossils.

CHAPTER XXIII.

*On the identity of the Rock Formations of the Western States with those of New-York.**

Knowing that the different rocks and groups, as developed in the Fourth District, extended far to the westward, covering vast tracts of country, it was natural to feel a desire to examine them more minutely, and to draw my own conclusions from personal observation regarding their relative position. In the year 1841, I undertook a tour through the Western States, as far as the Mississippi river, having for my object the identification of the rocks and groups of New-York with those to which different names had been given by the Western Geologists. No extended attempt of this kind had been made from actual examination and comparison, so far as I know; and the inferences from published reports, and the occurrence of certain fossils, had not proved satisfactory. The formations of the West, as described, did not correspond with the order as established in New-York; and the discrepancy could only be accounted for by supposing the thinning out of some important formations, or the occurrence of others not there existing.

The similarity of some of the western formations with those of New-York, was first pointed out by Mr. Vanuxem, whose observations were published in the American Journal of Science and Arts in 1829. He identified the lower rocks of Ohio, Kentucky, and Tennessee, with the Trenton limestone, from the occurrence of many of the same genera and species of fossils common to both. I was referred by him to some localties which were important in settling the questions of identity or difference, and I am indebted to the same source for information of the existence of the Birdseye and Trenton limestones at Frankfort in Kentucky.

Having, in New-York, adopted certain subdivisions or groups of the strata, which are strictly in the order of nature, it became a matter of much interest, to ascertain how far the same subdivisions would hold good in distant localities, where there was evidently great change in lithological characters. In employing geographical names for groups or individual rocks, it is desirable to know the locality of greatest development for the whole country; and when this is ascertained, the name should be adopted. But until the extent and comparative development of each rock is known, perfect local names cannot be prefixed; and as a step

* This article is essentially extracted from a paper published in Transactions of the Association of American Geologists and Naturalists, Vol. 1, page 267.

toward the perfection of this nomenclature, the place of greatest development in the district under consideration should give the name.

This examination westward also afforded a good opportunity of testing the value of fossil characters, when applied to the same strata extending over wide tracts of country; and the results will be seen, as we proceed, to have been mostly satisfactory. The value of lithological characters at the same time was found to fail in a great degree, and though in some cases persistent, yet alone they would be found insufficient, and often lead to erroneous conclusions. From the investigations made in New-York, we had learned that groups, which at one extremity of the State are of great importance and well characterized by fossils, cannot be identified at the other extremity; and the same is more emphatically true of single rocks.

The Niagara group, so well defined by the topographical features of the country, as well as by both its fossils and lithological characters, no one has yet attempted to identify to the east of Little-Falls. Almost the same may be said of the Onondaga salt group and the Medina sandstone; while on going in the opposite direction, we find several important members of the Helderberg series entirely wanting west of Cayuga lake, and the Oriskany sandstone existing only in patches here and there.

The undisturbed range of these deposits, with the great extent of unbroken outcrop bordering the Ontario valley and its continuation along the Mohawk, has enabled us to acquire a very perfect knowledge of the changes in the character of strata in their east and west extension. While such changes have taken place in important groups, others of less apparent importance and of much less thickness are found remarkably persistent.

In making my examinations westward, the groups and individual rocks of New-York, as adopted in the annual reports, were made the basis of reference.

The Lake Erie shore, from the New-York and Pennsylvania line (a point to which previous investigations had extended) to Cleveland, presents nothing of peculiar interest, being occupied by the rocks of the Portage group, which for the most part are destitute of fossils, except the remains of marine vegetables and a few *Goniatites*. The accompanying section (Pl. XIII) extends from Cleveland to the Mississippi river, and no rock is represented which was not actually seen. Westward, from Leavenworth, Indiana, it passes a little north of the line examined, in order to present the great limestone formation on the Mississippi, as a more prominent feature than further south, it being low and obscure near the mouth of the Ohio.

The rocks seen near Cleveland, Ohio, are perfectly identical with those of the middle portion of the Portage group, or Gardeau flagstones, being a continuation of the same as traced from New-York along the lake shore. In following the road to Cuyahoga falls, the Portage sandstone, or upper part of the group, is seen at Newburgh, and is there underlaid by green shale. These are equivalent to the Waverly sandstone of the Ohio Reports, as was afterwards ascertained by visiting the quarries at Waverly. From Newburgh we pass over the shales and sandstones of the Chemung group, till we arrive upon the conglomerate which is well developed at Stow and Cuyahoga falls.

This conglomerate, which, so far as I could discover, is identical with the outliers of a similar mass in the southern part of New-York, is the fundamental rock of the great Coal formation throughout the greater part of the western country, appearing everywhere, either as a coarse sandstone or a pebbly mass, and affording an unerring guide to the proximity of coal. Some portions of the mass at Cuyahoga falls are destitute of pebbles, and furnish a fine reddish or brownish sandstone, used for building. The greater part, however, is composed of coarse materials, with white quartz pebbles. This character is exhibited in great perfection along the road from Stow to Cuyahoga falls, and in the vicinity of the former village. Just below the falls, its junction with the shales and sandstones of the next group is well exhibited. In the lower part of the conglomerate, at this place, my friend, Mr. Newberry, has obtained a large number of fossil plants, with the fruit of several species. They are imbedded in a friable brown sandstone, highly stained by iron, and though mostly casts, are in a state of good preservation. I afterwards obtained some similar fossils, from conglomerate near Deer creek, below Leavenworth, Indiana.

Although usually destitute of fossils, this conglomerate possesses some characteristic marks which may serve to distinguish it at very distant points. Among these, in New-York, are thin seams, often apparently concentric, of hydrated peroxide of iron, crossing the mass at various angles, or curved and contorted. Sometimes these appear as small nodules which desquamate on exposure, or when struck with the hammer. In such cases the outer portions only are composed of the hydrated peroxide, while the inner part is still a carbonate of iron, the change having probably been effected by the percolation of water. At Cuyahoga falls, I saw some beautiful exhibitions of these iron seams, and this character continues in every locality, in greater or less degree, as far as examined westward; the ore frequently forming nodules or accretions.* From what I was able to learn from other observers, in Michigan, there is a considerable quantity of similar ore in the same situation in that State.

In the vicinity of Cuyahoga falls, the conglomerate may be seen passing beneath the coal which is worked in several places in that neighborhood; the principal mines which I saw, are those on the farm of Henry Newberry, Esq. Below the falls the Chemung group is distinctly characterized, containing, however, few fossils compared with the same further east. I obtained enough to convince me of its identity, and I have since received from Mr. Newberry several others, which at that time I did not see. The most abundant fossil is a species of *Strophomena*. Beside this, there is an *Atrypa*, a *Cypricardia*, an *Orbicula*, a *Lingula*, a small *Crinoid*, and one or two undescribed forms.

At Akron, the rocks of the Chemung group appear beneath the conglomerate, which is there in its lower part a coarse grey sandstone. The same fossils as before noticed, occur on a small stream by the side of the canal, below this village.

Passing south from Akron to Greentown, I came to beds of coal, succeeded by a dark-colored shaly limestone, which abounds in fossils. Among these were two or three species

* See the description of this rock, chapter vii, pages 287 and 288, of this Report

of *Delthyris*, several of *Atrypa*, a *Productus*, and crinoidal joints in great numbers. A limestone holding this position among the coal beds is a very interesting circumstance, when taken in consideration with the absence of any limestone representing the Carboniferous of Europe. One species of the *Delthyris*, also, is very similar, if not identical with Sowerby's figure of *Spirifera attenuata*; and the other fossils have all the aspect of those figured by Sowerby and Phillips from the Carboniferous limestone of England. A similar rock appears in the southern part of the State, where I obtained some of the same as fossils at Greentown. It also appears in several places in the vicinity of Canton.

Passing to the south and west along the road to Columbus, we soon leave the Coal formation, and come upon the groups below. These present few important features, except a gradual thinning in that direction, and the almost entire absence of fossils. The Chemung becomes scarcely distinguishable from the Portage group, and both are known in the Ohio reports as the Waverly sandstone series. From beneath these, pass off all that remains of the Hamilton group and Marcellus shales, the whole known as the black bituminous shales of the Ohio reports, and possessing, as a whole, the character of the Marcellus shale of New-York. I was not so fortunate as to meet with fossils in any part of this mass examined, though they do occur in some places. This rock was traced nearly to Columbus; and a short distance to the west of that place, the Corniferous limestone of New-York appears, presenting its characteristic fossils. This mass is the upper part of the Cliff limestone formation of Dr Locke, the name by which it is generally known in Ohio.* The localities where I saw this rock exhibited less hornstone than is usual in New-York, but the position and fossil characters were unequivocal.

After ascertaining the existence of the Corniferous limestone, and the middle and lower members of the Cliff limestone, for some distance west of Columbus, an offset was made into the coal region of the southern counties, and the line of observation again taken up on the Ohio river at Portsmouth.

In following down the river, the limestones appear rising from beneath the shales, as represented in the section. Numerous localities are presented in the river bank and ravines, where the blue limestone exists in great force; the most interesting, before reaching Cincinnati, are in Adams county, Ohio, and Maysville, Kentucky. An examination of the fossils at Maysville convinced me of the identity of the Blue limestone of Ohio, and the Hudson-river group of New-York. The evidences of this identity are the following: The mass consists of green shale or marl, alternating with courses of bluish crystalline limestone of a peculiar aspect, resembling that associated with the Clinton group of New-York, particularly the portion containing *Pentamerus oblongus*. Thin layers of grey sandstone occur, sometimes separate, and at others attached to the limestone in wedge-form masses, and always containing a species of fucoid, which I had learned to consider a characteristic fossil in New-York.

* See Report on the Geology of the southwestern counties of Ohio, by Dr. JOHN LOCKE. *Ohio Geological Reports*, 1838.

Further examinations brought to light the *Pterinea carinata*, two or more species of *Cypricardia*, a *Strophomena*, *Cyrtolites ornatus*, and the *Bellerophon bilobatus*, as well as the abundant little shell (*Orthis testudinaria?*) *Orthis striatula*. The latter fossil ranges through the Hudson river group in New-York, as it does through the Caradoc sandstone of England. This association of fossils, with the peculiar aspect of the limestone, and the presence of sandstone with fucoids, seemed indubitable proof of the position of this mass. Neither the character of the rocks, nor of the fossils, indicates the Trenton limestone to which heretofore it has been referred. Numerous other fossils, unknown in New-York, are found at Maysville, the most abundant being several species of *Orthis* and *Delthyris*.

The cliffs of Cincinnati were next examined, and the same evidence, in a higher degree, brought forth. At this place I met Dr. Locke, who gave me every information relative to the limits of the two formations, Cliff and Blue limestones, as known in Ohio, and I afterwards derived great assistance from his Report on the Geology of this part of the State. I was also fortunate in meeting, at this place, with several gentlemen who were zealously engaged in exploring the rocks of the vicinity, and who voluntarily aided me in my objects. From Mr. J. G. Anthony, Mr. Clark, Mr. Carley, and Mr. Buchanan, I received many characteristic fossils of the locality.

The section made there at this time presented the following features:

On the Kentucky side of the river, at the water level, (May 8th, 1841,) the rock seen was a green shale with thin laminæ of crinoidal limestone, containing few fossils. Among these the *Triarthrus Beckii* is the most prominent, and with fragments of *Isotelus*, and a few imperfect shells, were all that I obtained.* In New-York, the *Triarthrus* is never found below the Utica slate, and is a characteristic fossil of that mass; though it does occur somewhat rarely in the lower part of the Hudson river group. Taken in connection with other circumstances, and the character of the fossils in the succeeding rocks, it seems a fair inference that this is the equivalent of the Utica slate, or at least not far above it.

At low water, on the Ohio, a lower rock appears; and though the specimens I have seen contain no unequivocally characteristic fossils, of the Trenton limestone, yet it may exist here, and Mr. Vanuxem informs me that he saw it in the valley of the Little Miami, a locality which I did not visit.*

Proceeding upward from the green shale with *Triarthrus*, we find a somewhat similar shale, with thin layers of sandstone, characterized by the presence of *Trinucleus* and *Graptolites*. Still above this we find alternations of shale, or marl, and limestone, with *Orthis striatula* in great abundance; with this shell and above it occur *Strophomena sericea*, *S. alternata?* *Pterinea carinata*, *Cypricardia angustifrons*, *C. modiolaris*, *Cyrtolites ornatus*, with a great

* Very careful and extensive examination is often necessary, in order to identify rocks by the presence of characteristic fossils. In the rocks of Cincinnati, Maysville, and other places, occur fossils of the Trenton limestone. Among them are *Orthis striatula*, *Strophomena* (*Leptæna*) *sericea*, *S. alternata?* *Bellerophon bilobatus*, *Favosites lycoperdon*, and others. The last named fossil occurs with *Bellerophon bilobatus* and *Orthis striatula* in the Caradoc sandstone of England. The *Calymene* of these rocks at the West, usually considered identical with the Trenton species, is probably distinct.

abundance of corals and other fossils. Among these are *Bellerophon bilobatus*, *Orthoceras*, and two or more species of *Orthis* similar to, or identical with, those of the Caradoc sandstone of England. Fragments of *Isotelus* are abundant, also a species of *Calymene*.

From the enumeration of some of the forms, it will be perceived that we have here an assemblage of fossils similar to that of the Hudson river group of New-York. For here, as in Ohio, the shales, with *Triarthrus*, are succeeded by green shales and slaty sandstones containing *Trinucleus* and *Graptolites*, with other fossils. The *Orthis striatula*, *O. callactis*, *Strophomena nasuta*, *Pterinea* and *Cypricardia*, are likewise characteristics of this group, as well as *Bellerophon bilobatus* and the same species of *Orthoceras*. *Strophomena sericea* occurs in Ohio, completely covering the surface of thin layers of limestone, as in New-York. In both places are seen thin courses, composed almost wholly of the stems of *Crinoidea*, and the species appear to be identical.

The remains of *Isotelus*, several species of which occur, have always been considered sufficient proof of the identity of this rock with the Trenton limestone of New-York, and these fossils have been chiefly relied upon. All the specimens which I saw, however, are of different species from those of Trenton. So that although certain species of this genus do occur in the Trenton limestone, and are characteristic of that formation, others are not necessarily so; and unless we take wide ranges in our groupings, we cannot depend on generic types. In this case the amount of evidence appears to be about equally divided between the Trenton and Hudson river groups; but since there are fossils decidedly typical of the latter, and since we know that in New-York they never occur in a lower position, we are compelled to admit that this formation is of the same geological age.

Besides the fossils enumerated, are many which do not occur in New-York; among these a beautiful crinoid and several species of *Delthyris*, *Atrypa* and *Orthis*. It should not be omitted, that in the hill-side at Cincinnati, we find, attached to the limestone beds, numerous thin wedge-form layers of sandstone, which usually contain a species of fucoid similar to one in the Hudson river group, and the same as that noticed at Maysville. Besides the fucoid, this sandstone contains a species of *Strophomena* similar to one of the same group in New-York.

From the evidence here adduced, it appears that in the West there is not so great a transition from the Black river and Trenton rocks to those above, as in New-York; and that, from the fact of the greater similarity of lithological character, and the occurrence of many important fossils, specifically and generically similar, throughout the mass, we may yet be inclined to consider the whole as one great natural group, exhibiting well defined lines of minor subdivisions. The termination of the Hudson river group, in New-York, is the first point of marked and unequivocal change in the fossil characters. Below this point there are many forms which pass from one rock to another upward, often rendering it almost impossible to decide what are to be considered as typical. In every case, however, certain species are entirely limited to the mass they occupy. The great range of some of these species through the lower rocks, with their total extinction at the termination, indicate a great change in the condition of the ocean. Such a change is further corroborated by the occurrence of a thick and extensive mass of conglomerate, which succeeds the Hudson river rocks in New-York, giving evidence of a period of disturbance. These suggestions are offered, not with any view to merge in one formation what can be regarded as decidedly distinct, but with the desire to offer some facts toward the foundation of general groups or classes, to which all the numerous minor subdivisions may be referred.

The junction of this group with the cliff limestone cannot be seen in the neighborhood of Cincinnati; but in passing down the river, the two appear in juxtaposition before reaching Madison, Indiana. In the Ohio reports, Dr. Locke refers to this place as exhibiting, in a very perfect manner, the contact of the two rocks, cliff and blue limestones, which are well seen in the deep cutting for the railroad one mile southwest of the village, and in a ravine still further below.

The fossils of the blue limestone at this place illustrate the same view as at Maysville and Cincinnati. The *Pterinea carinata*, with one or two species of *Cypricardia*, are common; while *Strophomena*, *Orthis*, and others, abound in the middle portions, together with the *Atrypa capax* of Conrad, a species not seen at Cincinnati. Large numbers of *Cyathophylli* occur of a species different from any of the higher rocks. Near the junction of the blue and cliff, which latter is strongly contrasted in color, as well as other characters, there occurs a stratum of twenty-five feet thickness, of a greenish grey sandy shale, containing *Cypricardia modiolaris*, and numerous spherical masses of coral, (*Porites?*) which lie in two courses, or ranges, near the top of the mass, and separated by a few feet of shale from each other. Some of these masses attain a large size, being three or four feet in diameter, while others are but a few inches.

The lower member of the cliff limestone, at this place, is a calcareo-siliceous mass, with green stripes and spots, and crumbling on exposure to the air. It appears quite destitute of fossils, so far as I could discover. About fifty or sixty feet above the base of this mass, I noticed a strong ferruginous exudation; but the point being at the junction of the rock with the loose materials above, I was unable to discover any ore in place. This rock, which plainly succeeds the shales and limestones equivalent to the Hudson river group, is marked by patches and laminæ of green shaly matter, strongly resembling some portions of the intermediate mass between the Medina sandstone and the Clinton group, being an intermixture of the green shale of the one, and the sandy matter of the other.

Time, however, did not admit of going into detailed examinations, regarding the individual rocks, or groups, composing the cliff limestone, the object being a general identification of larger subdivisions. From examinations made at a short distance from this place, I learned that the friable sandy mass just noticed was succeeded by a harsh, porous limestone, apparently magnesian in composition, and possessing the general characters of the Niagara limestone in New-York. At this place I was unable to find any fossils save a few crinoidal columns, which gave to the rock much the appearance of the lower part of that at Niagara falls and Lockport. The examinations of this rock in other places, where I found fossils, and was able to trace the succession upwards, left no doubt of its identity with the Niagara rock.

It should be remarked, that soon after leaving Cincinnati, the rocks are seen to dip to the west or southwest; and at Madison, the base of the cliff limestone has approached within one hundred and fifty or two hundred feet of the river. From this point it continues to dip in the same direction, gradually approaching to the river level, and finally disappearing beneath it at Louisville, or the Falls of the Ohio. The river, at the time, being high, did not permit an examination of the rock directly at the falls; but the excavation of the canal below Louisville has developed, in the loose fragments, the character of the rock, which consists, apparently, of the water lime, and perhaps some portion of the Onondaga salt group, with the limestones above. The most satisfactory exhibition, however, was a few miles further up the river, where the rocks are very well exposed. Along the line of railroad, and in the banks of a small stream, about three miles from Louisville, the same rocks are seen. The highest mass at this place, contains a species of *Calymene** characteristic of the corniferous limestone of New-York, as well as several shells equally so; among these, a peculiar variety of the so-called *Atrypa prisca*; and a species of *Strophomena*; both shells are confined to this mass. Below this was seen a rock with *Favosites* and *Cyathophylli*, which could be identified with no other rock than the Onondaga limestone, possessing all its essential features, both as regards lithological and palæontological characters. Passing from this over strata resembling the lighter colored portions of the water-lime series of New-York, we came upon a drab-colored mass, in thin layers, abounding in *Catenipora* and *Favosites*; and below this a lighter or ash-colored limestone, in thick courses, destitute of fossils. Such, simply, was the order in which the rocks were examined at this place, and from which collections were made.

From the examinations made here, at Madison and other points, the unavoidable conclusion is, that in the cliff limestone we have the Helderberg series of New-York; or at least the two persistent members, Onondaga and Corniferous, with the Water-lime, and, perhaps, a meagre representation of the Salt group, together with the Niagara limestone. It seems conclusive, therefore, that the Cliff formation, as defined in Ohio, embraces all the existing formations from the Corniferous limestone to the Clinton group inclusive, that formation having been detected in this State, and one of its most important fossils in New-York (*Pentamerus oblongus*) is abundant in Indiana and Iowa.

After making these investigations in the vicinity of Louisville, I had the gratification of seeing, in the cabinet of Dr. Clapp, at New-Albany, many of the fossils common to the rocks of New-York, and which fully confirmed my views relative to the position of those examined. These fossils were principally from the rock at the falls of the Ohio. From comparing my observations of other rocks with those made by Dr. C., I became still further convinced of the identity of different portions of the formations of the West with those of New-York,† and that the limits of many of the rocks were as well marked there as at the East.

* *Calymene crassimarginata* of this Report, page 172.

† From a letter of Dr. Clapp to the Philadelphia Academy of Natural Sciences, dated February, 1842, I am happy to see that his views regarding the identity of the rocks of that region with certain formations of New-York, essentially correspond with what I had expressed in the American Journal of Science of January preceding.

Above the limestones last described, we meet with a "black bituminous shale," which, from position, seems to be the equivalent of the Marcellus shale of New-York,* and is the only representation of that rock, the Hamilton group and Genesee slate ; for we pass directly from this to the green shales and slaty sandstones of the Portage group or Waverly sandstone series of Ohio. In the examinations made in these rocks for several hundred feet upwards, no change from the Portage to Chemung groups could be identified, fossils for the most part being absent. I should not omit to state, however, that in passing beyond these greenish slaty rocks to a more micaceous and ferruginous yet friable sandstone, I found several shells which bear close analogy, if not absolute identity, with the Chemung species. But finding afterwards, in other parts of this sandstone, shells evidently belonging to carboniferous types, I was led to question the inference as to absolute identity.† Further investigations proved that this sandstone, in passing upwards, became interstratified with beds of limestone, and thin courses of oolitic limestone with fossils occurred in several places. These latter were not persistent, but in some places several inches thick and soon disappeared entirely, or left only a line of calcareous matter, marked by the presence of *Producta*. Still higher in this rock are some quarries, where a mass of limestone eleven feet thick is wrought for building stone. The lower part of this mass is a compact oolite, while the upper is rather coarsely crystalline with fragments of fossils. Below this, and separated by a course of sandstone of several feet in thickness, is another thick bed of limestone, and the whole is succeeded above by sandstone like that below. The height of these quarries above the black shale is four hundred and fifty-four feet ; and the thickness of shales and sandstones between this point and the main limestone above, is fifty or sixty feet more.‡

These rocks I had denominated *subcarboniferous* ; and although the fossils and the character of the intercalated beds of limestone indicate the commencement of the same era as the carboniferous limestone, yet it requires that a limit should be fixed between what is to be strictly referred to the carboniferous period, and older deposits. The grey sandstone here spoken of contained, in numerous localities, a large species of *Productus*, resembling *P. hemispherica*, a carboniferous fossil ; while there seemed to be a gradual transition from rocks of the Chemung group to those above, indicating no cessation of deposition, and scarcely a change in lithological character, except the occurrence of thin beds of limestone.§

* Near New-Albany, this shale is one hundred and four feet thick, "in other situations it is only fifty feet thick." — *Second Ann. Rep. of Geological Survey of Indiana*, p. 15.

† The fossils referred to as similar to those of Chemung, are a species of Delthyris, a Strophomena, an Atrypa, and an Inoceramus. After examining a more extensive collection from the same situation, made by Mr. W. C. Redfield in Medina county, Ohio, I find that there are several species identical with those of the Chemung group in New-York, and others which are entirely distinct.

‡ The thickness given was furnished me from the surveys of road engineers in a letter from Dr. Clapp, of Sept. 2d, 1842.

§ I find, in reference to the Report of Dr. Owen on the Geology of Indiana, that he has denominated the rocks here described, as well as the succeeding limestone, "Subcarboniferous." The limestone following is denominated in its different parts by Dr Owen and Dr. Troost, as Oolitic, Pentremital and Archimedes limestone.

Pursuing my investigations down the Ohio from this place, I found that the grey sandstones with intercalated limestone were succeeded by a thick and persistent mass of limestone, presenting features unlike any of the limestones seen in New-York or Ohio. By reference to the section, this limestone will be seen extending eastward to the vicinity of New-Albany, Indiana, and passing beneath the level of the river, near Leavenworth, about fifty miles below. It is visible, forming a cliff along the river, for nearly the whole of this distance, where it passes under the conglomerate, or its representative, a coarse grey sandstone, showing diagonal lines of deposition, with seams and nodules of hydrate of iron. This limestone reappears upon the river in several places between Leavenworth and the Wabash, at some of which examinations were made. Beyond the Wabash it reappears and continues to the Mississippi river, forming a low cliff often for many miles in succession. On the Mississippi, above the junction of the Ohio, it soon appears, forming at first but slight elevations, but soon rising into cliffs of from one hundred to two hundred feet in height. It presents this character of cliffs nearly to St. Louis, beyond which place it does not rise so high, but continues in view as far as the Rock river, and extends up this stream beyond Dixon's ferry. From this rapid sketch it will be seen, on reference to the map, that this limestone occupies an extensive area east of the Mississippi river, and stretching westward its limits were unknown. On the south of the Ohio it is known to extend into Tennessee, and from the Reports of Prof. Rogers, it is a very extensive and important rock in Virginia. It thus becomes equally important with any of the great limestone formations heretofore described in this country, in regard to position and extent. When it shall become more generally known, it will be found a prominent horizon for the proximity of the coal strata, as, in its absence, is the conglomerate further east.

The examination of this limestone at Leavenworth, gave the following characters: The lower part of the rock is compact and fine-grained, breaking with a smooth conchoidal fracture. This portion has been used for lithographic stones, and for small pieces serves the purpose very well. Above this portion the character is somewhat irregular, with light-colored chert or hornstone, which is often translucent. I was unable to find any fossils thus far upward, in the mass at this place. Above the cherty layers the rock becomes coarser grained or semi-crystalline, and contains numerous fossils of the genera *Delthyris*, *Atrypa*, and large numbers of the *Pentremites*. The most remarkable fossil of this portion of the rock, and which occurs just above the fossils named, is the *Archimedes* of Lesueur, a singular coral, appearing as an expansion somewhat like the *Retepora** twisted spirally round an axis; or rather, the edge of the coral, by thickening and folding, forms the axis. This curious fossil always holds the same position in the rock, the character of which differs from that above or below, being often ferruginous or yellowish in color and fine-grained. This portion of the rock contains, besides the *Archimedes*, one or two other corals, and one or more species of *Crinoidea*.

This is again succeeded by a beautiful light-colored oolitic mass, containing numerous fragments of fossils, the principal of which are *Producta*, some perfect specimens being obtained. A *Trilobite*, a portion of the head of which resembles an *Asaphus*, also occurs in

* I am informed by Mr. LYELL, that Mr. LONSDALE regards this fossil as a species of his genus *Fenestella*.

this part of the rock. It is a very persistent mass, being seen at numerous and distant points. Its character as an oolite is as perfect as specimens from Bath, in England; and its chalky and fissile nature, considered alone, would almost induce one to regard it as a more recent formation. Its position, however, cannot be mistaken; for, about one mile below Leavenworth, it is seen passing beneath the grey sandstone before mentioned. At this point, without any intermixture of the two deposits, we pass from a pure oolitic limestone to an equally well characterized quartzose sandstone.

This limestone was again examined near the mouth of Oil creek, Indiana, where it presents the same essential characters as described, and the same order of the parts. Opposite the mouth of Little Blue river, on the Kentucky side, the junction of the limestone and conglomerate presents a singular siliceous aggregate, containing abundance of shells, and having somewhat the character of buhrstone. From this place to the Wabash, there was little of interest to be seen; the rocks approaching the shore in many places, indicated along the whole distance the existence of the great Coal formation of the Illinois or Wabash basin. From the section, it will be perceived that the Wabash flows in the depression of a synclinal axis, and from thence the strata gradually rise to the westward.

The limestone soon rises from beneath the river level, and continues in view nearly to the Mississippi, being obscured only by superficial accumulations. After ascending the Mississippi for some distance, the rock again appears. The great valley, or "American bottom," is bounded on either side by abrupt cliffs of this limestone: the river meandering in its course from side to side, sometimes runs at the base of the perpendicular rock; while the opposite side presents a broad level bottom land, covered for the most part with luxuriant forests of primeval growth. These cliffs form some of the most picturesque scenery, and, with the small shot towers upon the overhanging margin above, suggest the idea of stupendous castle walls of cyclopean architecture, crowned with the sentinel's towers.

Between the point of its first appearance on the Mississippi and its final disappearance near the mouth of Rock river, I examined it at numerous points, and always found a very uniform lithological character, which alone is sufficient to distinguish it from all other rocks, and enable one to identify it with its commencement in Indiana. The fossils, however, are constant and unerring guides, which leave no room for doubt. The rock, on fresh fracture, has a peculiar light grey color, much of it crystalline: while other portions are compact and fine-grained, presenting the appearances described at Leavenworth.

At St. Louis I obtained several fossils, principally corals and crinoidëa; all of which, so far as I know, differ from those found in any lower rock. Dr. B. B. Brown, of St. Louis, politely presented me with specimens of *Producta*, from his cabinet, which were found in that vicinity, and which corresponded with the British *P. Martini*. Having since had an opportunity of examining a small collection of fossils from the carboniferous limestone of England, in the Lowell Institute, I found many of the same species as those of this great formation, leaving no doubt of the identity of the two. The difficulties, therefore, in the way of comparing our rocks with those of Europe, seem in a fair way to be cleared up; and we learn, that among all our limestone formations, in the eastern part of the United States, the true carboniferous limestone is wanting, its fossils appearing only in a few places in shale and sandstones associated with the coal strata.

For the greater part of the distance along which this limestone was seen, it is but slightly inclined, often appearing horizontal. The only deviation of importance noticed, is near Herculaneum, on the Mississippi river. At this place there appears to have been an extensive uplift in a northeast and southwest direction, elevating the strata at an angle of thirty degrees; and from the existence of one or two small islands, seems, at some remote period, to have obstructed the course of the river. From the shallow water at this place, the uplift appears to have been of more recent origin than the excavation of the river channel, otherwise there appears no reason why the depth here should not be as great as in other places.

Along the Mississippi river the common fossils are a large species of *Delthyris*, with a smooth *Orthis* or *Atrypa*, in form like the *A. concentrica* of the lower rocks, but larger; these appear at numerous localities which I had opportunities of examining. Several species of *Productus*, with the larger valve very much arched, and the upper one concave and slightly wrinkled, are constant, and good guides for this mass. My friend Dr. Owen has figured some of the common forms in the American Journal of Science.* Residing upon this formation, his opportunities of investigation are ample, and we may expect that his zeal will lead to the full development of its interesting organic contents.

After leaving the carboniferous limestone, near the mouth of Rock river, the coal and associated rocks appear, and beyond this point the lower limestones; the intermediate rocks not being seen. There is evidently either an abrupt synclinal axis, or fault, which has brought up the lower masses. From want of sufficient time to investigate this point, I was unable to determine the precise cause, or amount of change. The contrast between the two limestones thus brought into proximity, is very striking; the grey or ashen color is exchanged for a brown or iron-stained rock, harsh to the touch, and composed of small crystalline grains. The mass rises in broken or detached knobs or pinnacles, presenting a ragged and irregular outline, in place of the uniform cliff formed by the higher limestone. In tracing this limestone up the river as far as Galena, its lithological character is the same as that of the middle and upper portions of the Niagara limestone, and all its associations are the same. The cliffs in many places, particularly on the river above Dubuque, have all the appearance of those at the Falls of Niagara, so far as regards lithological character, weathering, etc. Above the town of Dubuque, this rock (cliff limestone) rests upon the blue limestone, which, according to Dr. Owen's statement, is much thinner here than in Ohio; but not having traced it to its termination below, I am unable to speak from personal observation. Specimens which I saw from the lower part of this rock about Praire du Chien, indicate the presence of the Trenton and Black river limestones, by the large Orthocerata and other fossils. From a section made by Dr. Owen, it appears that there are beds of sandstone, interstratified with, and underlying the blue limestone.

* Vol. xliii, page 14.

It is in the Cliff formation, as before described, that the lead ores of Illinois, Wisconsin, and Iowa are found, a part only of the rock yielding these ores. This portion appears to correspond to the Niagara limestone; the upper part of the "cliff rock," which represents the Helderberg series, being destitute of metallic veins. Although the rock contains few fossils, these indicate its position to be the same. The *Catenipora*, which in New-York occurs far more abundantly in the Niagara limestone than in any other rock, is found here in great abundance, with *Aulopora* and a few other fossils. The next fossiliferous group below the lead-bearing rock on the Mississippi river, is that corresponding to the Hudson river group. If the Clinton group exists, it has there become so incorporated with the rocks above, as to be overlooked as a distinct formation. This point requires examination, and it is possible that some representative of the group may be found there. Being a very variable assemblage in New-York, it would not be surprising to find it under another aspect, or even incorporated with the Niagara group, as far west as the Mississippi. Its last appearance in New-York, on the Niagara river, is in the form of a mass of limestone twenty-five feet thick, with about four feet of shale below; the limestone at this point has lost the sandy and impure character which it has further east, and assimilates more with the lower part of the Niagara limestone The only fossil met with in this mass on the Niagara river, was the *Delthyris radiata*, which is found extending through the shale above, and in the lower part of the limestone.

In crossing the country from Galena to Chicago, few opportunities offered of examining the strata except at detached points. The only rocks seen on the direct route are the two limestone formations, the lower including Niagara and Helderberg, and the upper the Carboniferous; and, from the great extent of level country, I was unable to see the intervening rocks.

I had an opportunity of examining the rocks on the northern and northeastern shores of the southern peninsula of Michigan, but my observations were too cursory to admit of any thing like a connected view of them. The limestones of the Helderberg series, principally the Corniferous and Onondaga masses, form the rocks of many of the bays and harbors; characteristic fossils of these masses being recognizable in those examined. At Mackinac, the upper part of the Onondaga salt group, and possibly a small portion of the Water-lime group, form all the rocks seen. The former is partially altered from its usual characters in New-York, some parts exhibiting the large angular cavities, the whole appearance being that of a vesicular mass; and had the cavities been spherical instead of angular, it would have been referred to igneous origin. This mass being isolated, renders it difficult to trace its connection with those appearing to the south and east of it; but from its great similarity to the Salt group of New-York, and from its apparently passing beneath those representing the Helderberg series, no doubt remains as to the propriety of this reference.

The exhibition of strata along the line of the section given, illustrates some very interesting points in the geology of our country, and proves the existence and order of succession in certain rocks, and their equivalents over wide areas; offering us facts which will still further enable us to solve the problem of the condition and character of the ocean during the earlier geological periods.

The great extent of almost undisturbed strata affords an opportunity for the most satisfactory investigations, throughout all this country. The anticlinal axis which is crossed by the section near Cincinnati, is an important feature. By the elevation of this axis, the higher rocks have been removed, and the two great coal basins of Ohio and the Wabash valley (formerly in all probability constituting one) are thus separated from each other. This axis extends in a direction northeast and southwest; and passing along the western part of Ohio, and crossing Lake Erie near its western extremity, it gives origin to the numerous islands of this part of the lake. It extends onward into Canada, and I understand from the Messrs. Rogers, that they have traced it far northward in that province. To the southward it passes through Kentucky and Tennessee, and at Frankfort, in the former State, elevates the Trenton and Birdseye limestones above the level of the river.

The section crosses a synclinal axis which runs nearly parallel to the great anticlinal one, but its extent is unknown to me. The Wabash flows in this depression, which brings the coal-bearing strata below the level of the Ohio river, at its junction with the former. From this point the strata are seen to rise to the westward as far as the Mississippi; but beyond, little is known of them. From the occurrence of extensive coal deposits in Missouri, it may be presumed that the strata decline to the southwest, but I have no data from actual observation on which to found an opinion.

From the necessarily hasty examinations made during this tour of exploration, which was extended over a large area, it was impossible to give that minuteness of detail, which is desirable before the subject can be considered complete. All that was attempted was to trace the great groups of New-York westward, and, if possible, to identify them with those known by different names in that part of the country. If any light has been thrown upon this question, or if only some few points of identity have been established, the object will have been accomplished. In this vast field there is room for all the laborers that can be found for half a century to come; and I doubt not, from the numerous and efficient observers now at work in this region, upon their native or adopted soil, that all the most important details will soon be wrought out.

From the want of a well defined and acknowledged basis in the West, it would always have been difficult, if not impossible, to establish the identity from that direction eastward; and it requires a knowledge of the New-York rocks, in their wide geographical range and undisturbed position, to settle satisfactorily the place of the western rocks.

From the facts here stated, the conclusion seems unavoidable, that the character of fossils is, sometimes, as variable as lithological characters; in fact, that the species depend in some degree upon the nature of the material among which they lived. Fossil characters, therefore, become of parallel importance to the lithological; and, in order to arrive at just conclusions, both must be studied in connection, and localities of proximity examined. In the cases of the Hudson river group of shales and sandstones, in passing from New-York to Ohio, the lithological character is almost entirely changed; and at the same time, also, the most prominent and abundant fossils are unlike those of that group in New-York. More careful examination, however, reveals the fossils which characterize this group at the east, and also at the same time some obscurely similar lithological characters. Similar lithological changes, accompanied by like changes in fossils, occur in more limited districts within the State of New-York.

The most marked and important changes, however, appear to be in the higher rocks of the New-York system. The Hamilton group and Marcellus shale, which in New-York have a thickness of one thousand feet, have diminished to one hundred where last examined; and from being the group most prolific in fossils, as it is in New-York, it has become entirely barren of them. The rocks forming the Portage and Chemung groups, which in their greatest development in New-York are scarcely less than three thousand feet in thickness, and in Pennsylvania much more, have, in Indiana, diminished to as many hundred. The upper of these groups, from being extremely fossiliferous, has become almost destitute of these characters; so that, at the furthest extreme examined, they furnish but an equivocal guide. In these groups, lithological character is more persistent than fossils, and it requires a knowledge of the superposition to identify them satisfactorily. The greater thickness of these sedimentary deposits, and the greater development of fossils occurring at the same point, proves the organic forms to have flourished in a litoral position; and beyond these points, where the thinning of the strata indicates a greater distance from the shore, the fossils diminish, and at the more distant and deeper points are not found at all. There is no evidence of denudation in these instances; and if there had been, the parts left would have retained the same fossils—had it ever contained them—as they do further east.

Throughout that part of the ancient ocean now occupied by Ohio, Indiana, Michigan, Illinois, and even to the west of the Mississippi, there appears to have been comparatively a small number of living forms existing from the period of the final deposition of the Helderberg limestones, to the commencement of the Carboniferous period; while in New-York, during the same period, there were a greater number of forms and individuals than in all the preceding periods. Without desiring to diminish the value of fossil characters as means of identifying strata, it must still be acknowledged, that similar conditions in the bed of the ocean, and, appararently, similar depth of water, are required to give existence or continuation to a uniform fauna; and when we pass beyond the points where these conditions existed in the ancient ocean, we lose, in the same degree, the evidences of identity founded upon fossils. Some species, it is true, have lived onward through successive depositions, often of very different nature; yet, at the same time, these may not have had a very wide geographical range. In the case before us, some species have lived during the deposition of all the rocks from the Hamilton through the Chemung groups, and yet they have never extended themselves as far westward as Ohio and Indiana, although the nature of the deposits there was as favorable to their existence as in New-York.

For the distance of one hundred or two hundred miles from the shores of the present continents, the forms may be similar—we know not but they are; still, who can say what changes may occur, or whether any exist in the depths a thousand miles from land? From the nature of sedimentary deposits, it can be only the finer parts that ever reach to great distances from their origin; and, reasoning thus, the fauna of the deep and distant parts of the ocean, if any exist, would be uniform, not being liable to destruction or change of condition from the rapid invasion of variable deposits like those near the shore. The deposition of a coarse sandstone or conglomerate succeeding to a shaly mass, would in all probability destroy the greater number of living forms as far as it extended. But at the same time, the finer materials produced by the same cause, would extend far beyond the limits of the coarser; and thus approximating, in some degree, to the lower mass, the fossils might be continued long after they were destroyed at another point.

One of the most interesting changes in the products on going westward, is the great increase of carbonate of lime, and the diminution of shaly and sandy matter, indicating a deeper ocean or greater distance from land. The source of the calcareous deposits is thus shown to have been in that direction, or in the southwest; while the sands and clays had their origin in the east, southeast and northeast, producing, during long intervals, a turbid condition in the waters of these parts, unfavorable to the production of calcareous matter, and the formation of chemical deposits. In New-York we are evidently upon the margin of this primeval ocean, as indicated in the character of the deposits as well as organic remains; the southwest unfolds to us a portion of greater depth and more quiet condition.

CHAPTER XXIV.

On the identity of the New-York Formations with those of Europe. Table of equivalents in American strata.

Something has already been said upon the identity of the rocks of New-York with those of Europe, and particularly with those of England and Wales. From the very fully illustrated work of Mr. Murchison, we are made acquainted with many fossils holding the same relative position in the rocks of England that similar species do in this country. The general lithological characters of many of the successive strata correspond with those of New-York, and it is very natural that we should endeavor to find sufficient resemblance to identify them as of the same geological periods. For the great systems this has already been done, and there remains no doubt but the sedimentary rocks of New-York correspond with those of the Silurean and Old Red systems, as described in the *Silurian Researches*. If the Devonian is to be regarded as a distinct system, we shall find its representative in the Chemung and Portage groups, with, perhaps, a part of the Hamilton Group. In New-York, however, as already stated, no subdivisions can be made which are entitled to the name of systems.

In regard to the identity of minor subdivisions, some obscurity still exists; though there can be no doubt of their correspondence, in all important particulars. When we more fully investigate the organic contents of our rocks, we shall doubtless find many more species common to the strata on both sides of the Atlantic.

In the rocks of the United States, there appears to be a much greater number of fossils than in rocks of the same age in Europe. In many instances, too, it happens that the typical species, upon the other side of the Atlantic, are very rare or obscure in New-York and elsewhere, and from the multitude of other forms, they might almost be overlooked. We have, however, made great advances in identifying individual formations and strata, and our progress in this respect is very gratifying.

The following tabular arrangement corresponds, very nearly, with the relative position of the rocks of the two systems in Great Britain and New-York:

Subdivisions of the Rocks of the New York System.	Subdivisions of the Silurian and Old Red Systems in Great Britain.
Old Red sandstone.	Old Red sandstone.
1. Chemung group.	
2. Portage group.	
3. Genesee slate.	Upper and Lower Ludlow rocks, including the Devonian System of Phillips.
4. Tully limestone.	
5. Hamilton group.	
6. Marcellus shale.	
7. Corniferous limestone.	
8. Onondaga limestone.	
9. Schoharie grit.	
10. Cauda-galli grit.	
11. Oriskany sandstone.	
12. Upper Pentamerus limestone.	
13. Encrinal limestone.	Wenlock rocks.
14. Delthyris shaly limestone.	
15. Pentamerus limestone.	
16. Water-lime group.	
17. Onondaga salt group.	
18. Niagara group.	
19. Clinton group.	
20. Medina sandstone.	
21. Oneida conglomerate.	Caradoc sandstone.
22. Grey sandstone.	
23. Hudson-river group.	
24. Utica slate.	Llandeilo flags.
25. Trenton limestone.	
26. Birdseye and Black-river limestones.	These formations are not as fully recognized in Great Britain as in New-York.
27. Chazy limestone.	
28. Calciferous sandrock.	
29. Potsdam sandstone.	

There are many reasons for including the Nos. 7, 8, 9 and 10 in those equivalent to the Ludlow formation; but in some places, the upper of these contains fossils which are characteristic of the Wenlock rocks.

The Niagara group is evidently referable to the Dudley period, which is a part of the Wenlock formation.

We are compelled to include in the rocks equivalent to the Caradoc sandstone, the Clinton group, from the occurrence of *Pentamerus oblongus* in great numbers, and in a condition precisely similar to the same fossil in the impure limestones of the Caradoc formation. From the occurrence of large numbers of fossils in the Hudson-river group identical with those of the Caradoc sandstone, there remains no doubt of its equivalency with that formation.

The Utica slate (and perhaps the upper part of the Trenton limestone) may be regarded as an equivalent of the Llandeilo flags, mostly from similarity of lithological character; but one or two fossils being known in New-York, which are identical with those of the latter formation.

The formations below the Trenton limestone appear not to be recognized in England and Wales, with the same distinctness, or in the same degree of development as in New-York. They are probably equivalent to some of the rocks included in the Cambrian system, and which doubtless will yet be more fully recognized.

That there should be important differences in the character of sedimentary deposits, at such great distances, is not surprising; indeed, it is more astonishing that there should be so great a degree of similarity, when we consider the circumstances under which they were produced. It has been shown, in the last chapter, that upon our own continent, within the distance of a few hundred miles, great changes occur in the nature of the sedimentary strata; changes which almost prevent a recognition of the same formations, and which are at the same time accompanied by a different association of organic remains, showing that the nature of the sediment influenced the character of the living forms. Absolute similarity, therefore, in all the lithological and fossil characters is hardly to be expected in any two points at remote distances from each other.

The differences which the same strata present at distant points, and the comparative degree of development which formations exhibit, have given rise to a diversity of nomenclature, in different parts of the United States. The surveys in progress required the adoption of provisional names at least, and these have been given, generally according to the nature of the rock, or from some locality where its characters were best developed. From the different Reports I have constructed the following Table, which may, perhaps, be of use in comparing the formations of different parts of the country, and in reading the respective reports.

Tabular arrangment of lower American strata, showing the equivalency of those known by different names in the several States.

New-York Survey.	Pennsylvania and Virginia Surveys.	Ohio Survey.	Michigan Survey.
1. Potsdam sandstone.	No. 1.	Wanting.	
2. Calciferous sandrock.	No. 2.	Wanting.	
*3. Black-river and Birdseye limestone.	No. 2.	Blue limestone and marl formation.	
*4. Trenton limestone.	No. 2.		
5. Utica slate.	No. 3.		
6. Hudson river group.	No. 3.		
7. Oneida conglomerate.	No. 4.	Wanting.	
8. Grey sandstone.	No. 4.	Wanting.	
9. Medina sandstone.	No. 5.	Wanting.	
10. Clinton group.	No. 5.		
11. Niagara group.	Part of No. 6.	Part of Cliff limestone.	
12. Onondaga salt group.		This formation is but partially developed in the southwest part of the State, but more extensively in the northern part.	Mackinac limestone, grey, sandy and porous limestone.
13. Water limestone.	Included in No. 6, if existing.	Wanting, or not recognized in the western States.	In this series are included the Little Traverse bay limestone, Black bituminous limestone, Blue limestone in thick regular layers. Thunder bay limestone?
14. Pentamerus limestone.			
15. Delthyris shaly limestone.			
16. Encrinal limestone.			
17. Upper Pentamerus limestone.			
18. Oriskany sandstone.	No. 7.		
19. Cauda galli grit.	No. 7.		
20. Schoharie grit.			
21. Onondaga limestone.		Upper part of the Cliff limestone.	Corniferous limestone.
22. Corniferous limestone.			
23. Marcellus shale.	No. 8.	Black slate.	Shales. Black aluminous shale.
24. Hamilton group.	No. 8.	Wanting, or but partially developed.	
25. Tully limestone.		Wanting.	
26. Genesee slate.	No 8?	Wanting?†	
27. Portage group.	No. 9.	Waverly sandstone series.	Soft, light colored sandstones. Argillaceous slates and flagstones of Lake Huron. Sandstones of Point Aux Barques
28. Chemung group.			

The State of New-York presents a better opportunity for defining the limits of the several subdivisions of the system, than any point yet observed to the west and south. The different members are more numerous, but at the same time they are usually well marked, either by lithological characters or organic contents, and often by both together. It seems impossible to adopt any subdivision of strata which shall hold good, and at the same time be easily recognizable over wide areas; and under these circumstances, the more minute are our dis-

* I am not aware that these two rocks appear in Ohio, although they do in Kentucky, and the name adopted in the Ohio Reports are intended to embrace them.

† I have been disposed to consider the Black slate or shale of Ohio, in some places, as a partial development of the Genesee slate of New-York.

tinctions, the better able are we to seize upon obscure relations at distant points, and turn them to our advantage in the identification of strata. We have learned that a formation which on the Mississippi is a limestone, is, on the Hudson, a shale and sandstone; yet in the former place we may detect some obscure traces of slate and sandstone, while in the latter we often meet with beds of impure limestone. The same or similar changes occur in other formations.

In the names adopted thus far, there is nothing to prevent the formation of a harmonious nomenclature for all our rocks; while to the inhabitant of New-York, and other States, the local names with which he has become familiar may be retained and used without detriment to the progress of the science.

CHAPTER XXV.

CONCLUSION.

In concluding this Report, we are naturally led to take a retrospective view of the condition of the surface of this portion of our planet during the accumulation of these sedimentary deposits. We behold a wide expanse of ocean, which received these materials from adjoining land, and upon the bed of which flourished the myriads of living forms which were successively imbedded in the strata, until finally the whole emerged a vast continent from beneath the sea. We find at one time the evidences of a quiet ocean, with clear waters, abounding in corals and shells; and at another, a turbid condition in which all these forms ceased to exist. Long periods of repose were succeeded by disturbances which changed the whole scene, and then followed new creations and new materials of deposition.

It is universally acknowledged among geologists, that these immense sedimentary deposits could only have accumulated beneath the waters of the ocean, during an incalculable period of time, long anterior to the present condition of the surface. Now in order to furnish materials for such formations, we must conceive of the existence of continents where no vestige of them now remains; from the abrasion and destruction of these, and from the transporting power of rivers and ocean currents, the materials composing them were reduced to the state of pebbles, sand, and finely comminuted mud, which were widely diffused and gradually or rapidly precipitated upon the ocean bed. The varying nature of the deposits proves to us that these elevated lands frequently changed their condition or outline, or that new sources of materials were opened to the destroying and transporting agencies. Sometimes, however, there is little variation for a long time: the same sources supplied the material; the same agents, with unchanging intensity, removed and distributed it widely over the bed of the ocean; while, again, within a short period, its nature is entirely altered, or a new source brings in matter of a different kind to mingle with the hitherto uniform deposit. The disturbing forces that sometimes long slumbered, seem often to have broken out suddenly with renewed energy, changing the whole condition in a short space of time.

Notwithstanding all this, however, the unity of the series is never broken; and although, during certain periods, all living things inhabiting the ocean were exterminated, the violence and disorder that prevailed at the sources of these deposits never prevented the gradual and quiet deposition at distant points. The change from one rock to another is rarely abrupt: there is usually a mingling of the products of both; and lime, sand and clay are found in all their varying proportions. Still the great uniformity in mineral character of certain deposits is very remarkable. The black and green shales of some of the higher rocks of the New-York System can be traced over an extent of a thousand miles, while specimens from either extremity are scarcely distinguishable.

The conditions of this ancient ocean bed are as clearly proved by the nature of these deposits, as is the character of any small stream from the nature of the detritus it transports. The varying depth is marked upon the strata, and the clear or turbid state of its waters is indicated by the character of the formation and the kind of living things that then flourished. We are able to recognize portions which were raised above the surrounding ocean, and even the direction of the waves is as perfectly preserved as upon a modern sea beach.

The evidences of this condition have been pointed out as we progressed. We have seen that the strata from the Hudson to the Mississippi are composed of materials which could only have been deposited from water, and that they contain organic remains which could only have lived upon the bed of an ocean. It is necessary, then, to conceive of a period when all that portion of our continent, now occupied by these rock formations, was covered with water.

The chief source of our sedimentary deposits must have been from the east or southeast; and from this direction the sand of the earliest formation was distributed over the bed of the ocean, together with fragments and pebbles of rock. Calcareous springs issued from the margins of the sea, and mingled their products with the arenaceous matter. For a period the abrading and transporting process was in a measure suspended, and corals and shells took possession of the limpid waters of the ocean; these constructed their habitations, and lived quietly through myriads of ages. Their perfect structures and comminuted remains constitute a limestone formation which flanks the great primary nucleus of New-York, and, extending into Canada, spreads out westward over almost the entire width of the continent. This condition ceased with the deposition of the Trenton limestone; the bed of the ocean subsided, and a deposit of carbonaceous mud rendered the waters turbid with its wide diffusion, while few living forms existed during the period of its accumulation. Again the transporting power became more energetic, or new sources were opened, and sand became mingled with the mud; the latter gradually ceased, and gave place to sand alone; and towards the close of this period, the disturbing influences and the transporting power had reached their acme, and the formation is terminated by a coarse conglomerate, indicating a period of storms and tempests. During this time were deposited the shales and sandstones of the Hudson-river group, terminating with the Grey sandstone and Oneida conglomerate.

After this a new source of materials is opened; and apparently from a mud volcano, in the midst of this ocean, is poured forth rapidly a vast deposit of mud and fine sand charged with ferruginous matter. No vestiges of living forms are found till towards the close of the period, when the mud had in a great measure given place to sand; and here only a few appear. In this period are included the marls and shaly sandstones of the Medina formation. To these succeed finely levigated mud; but it soon alternates with arenaceous and calcareous deposits, and even with coarse conglomerate over limited areas, showing the changing condition of the ocean, and the nature of the sedimentary and chemical products. Large quantities of hydrate of iron are spread over extensive areas, mingled with the fragments of organic remains. The whole presents a group of Protean character, indicating the fluctuating nature of the deposits, and the disturbance at the source of the materials. Still, over a large portion of the country where it is exposed, the influence of those disturbing causes did not extend, and we have all the phenomena indicative of a quiet deposit in a moderately deep ocean. Such are the materials of the Clinton group.

The Niagara group commences in New-York with a deposit of finely comminuted mud, while at the west it is almost entirely calcareous. Its attenuated northern and eastern extremity in New-York reaches nearly to the Hudson river; while, pursuing it westwardly, it expands to an enormous thickness, and covers a vast area in the valley of the Mississippi. For an almost incalculable period of time, this part of the ocean bed could have suffered little change, nor have been disturbed by inundations of sedimentary matter. The whole expanse must have been one broad blue ocean, with its infinity of coral groves, among which lived the shells and crustaceans; and here, in sheltered nooks, the crinoideans reared their beautiful and gorgeous heads, and above them shone the bright tropical sun. But this period of repose is suddenly broken; the ocean bed sinks down, and an overwhelming inundation of mud is spread out over a large portion of its before limpid waters. The whole family of corals, shells, and crustaceans are alike exterminated. Nor is it mud alone that here operates as a destroying agent of the organic forms; the deposit, doubtless ejected from a huge mud volcano, is charged with saline matter, and corroding acids, which would alone destroy all organisms. This vast mass of calcareous mud formed the marls and shales of the Onondaga salt formation.

Towards its close, calcareous matter becomes intermingled in an increasing proportion, and a few shells appear. At last the turbid ocean becomes clear, when again the corals commence their habitations, and with myriads of shells, and crustaceans, continue through an immense period of time, disturbed, it is true, by an inundation of sand and mud, forming the shale of the Cauda-galli grit and Oriskany sandstone, which, in some parts within their range, destroyed many of the living beings. This, of all periods, seems to have been the most prolific in its growth of corals; and numerous species abound, not only throughout New-York, but far westward to the Mississippi river, showing, over an extent of a thousand miles, a uniform depth and condition of the ocean; and like the barrier reefs of modern seas, giving birth and shelter to myriads of living creatures, whose destruction formed the rocky strata.

66*

With this condition of things terminated the Helderberg series of limestone, the last of the important calcareous formations in New-York. The ocean bed again subsided, and a deposit of dark mud was gradually precipitated upon it, while few organisms existed. Gradually vitality increased; the dark carbonaceous mud became intermingled with calcareous matter; living forms were multiplied, and, if possible, became still more numerous than in any preceding era; the sea emphatically teemed with life, and the individuals of many species can only be enumerated by myriads. Soon, however, sand became intermingled with the fine materials; a gradual change in the organisms supervened, and finally the sand predominated; and throughout a long period, the accumulation consists of alternate deposits of argillaceous and arenaceous matter, or an intermixture of both, the whole abounding in organic forms. During this period were accumulated all the materials forming the Marcellus shale, the Hamilton group, and the Portage and Chemung groups. At the termination of the latter, a greater change supervened; and though the formations are not widely different, all the previously existing organisms disappear.

Look, however, at this time, to that great portion of this ancient ocean, now occupied by the States of Ohio, Michigan, Indiana, Kentucky and Illinois, and even far west beyond the Mississippi. From the period of the final deposition of the Helderberg limestone, to the commencement of the Carboniferous era, this vast expanse was comparatively a solitude. Instead of the busy multitude thronging every part of the sea farther east, this was cold, dark and deep; presenting no beautiful corals, or the still more beautiful crinoideans, and with but few of the shells of the eastern waters, it more resembled a primeval ocean where vitality had but just assumed its place among the laws of nature.

Beyond the termination of the New-York system, we might follow the successive formations through the Old Red Sandstone and Carboniferous periods, which exhibit the same changes throughout, as before described. In the latter system, we perceive the formation of an immense deposit of limestone at the west; while at the east, the ocean was accumulating only sand and clay. The same general law will be observed to exist in all the previous formations; the proportion of calcareous matter constantly augmenting, and the arenaceous and argillaceous matter decreasing in a westerly direction.

Such has been the mode of formation of the successive deposits, forming the subject of this Report; the operation of the same laws, and the influence of the same agents, as are now active, have produced this stupendous accumulation of materials. Subsequent operations have dislocated, elevated and overturned the indurated strata thus formed, and, together with the action of water, have produced the modern detritus, the soil of the surface, the fragments and transported boulders.

The description of each rock has shown that the increment of fresh matter has almost uniformly been from an easterly direction, more especially of the purely mechanical deposits: this, according to a well known law of physics, must have first produced expansion in that direction, and consequently the eastern portion of our continent would first be elevated.

This is proved by the subsequent formations ; for while on the west the older rocks are extensively overlaid by deposits of the age of the Cretaceous formation, we find on the east that the Greensand of the same age occupies but a limited area, and but little elevated above the tide water, leaving, the extensive Palæozoic formations overlaid by no newer rocks, except in a few places and at low elevations by a recent Tertiary.

The same causes which have operated in the production of these formations are now active in abrading the materials of our present continent, and transporting them into distant parts of the ocean ; and though we witness no such extensive or gigantic agencies of transport, as must have existed during former periods, still the law is the same, and the ultimate effect will be attended with like circumstances.

The changes here enumerated, are but a few among the great series of changes which have brought the surface of the earth into its present condition ; which have formed the mountain chains, excavated the deep valleys, or piled up among its successive strata, materials fitted for our use and instruction. Every successive change has left its monuments, upon which is recorded the history of the past: that history shows the operation of a uniform law, the influence of a mighty design in the construction of the stupendous fabric on which we exist. And though we are not disposed to say, that the Creator has through all ages been fashioning and preparing the earth for the abode of man, or storing up its mineral treasures for his use alone, we can yet see the operation of his Divine law, and recognize in its harmonious adaptation the result of ETERNAL BENEFICENCE AND ETERNAL WISDOM.

TABLES

OF

ORGANIC REMAINS.

ORGANIC REMAINS OF THE MEDINA SANDSTONE.

ILLUSTRATION No. 1.—No. 5, page 46 of this Report.

Figs. 1 and 2. *Fucoides Harlani.* This is the most characteristic and widely diffused fossil of this rock. Its vertical range is very limited, holding a place usually near the upper part of the mass.

No. 2.—No. 6, page 48 of Report.

Fig. 1 and 2. *Euomphalus pervetustus*, HALL. *Cyclostoma pervetusta*, CONRAD (Geological Report for 1839, page 65); inadvertently written *Pleurotomaria pervetusta* at page 48.

Fig. 3. *Cypricardia alata*, H. *Unio primigenius*, C. (Geological Report of 1839, page 66.)

Fig. 4. *Orbicula parmulata*, H. Lockport.

Fig. 5. *Lingula cuneata*, C. (Geological Report of 1839, p. 64.) Medina.

Figs. 6 and 7. Two views of *Bellerophon trilobatus*, *Planorbis trilobatus*, C. (Geological Report for 1839, page 65.) Medina.

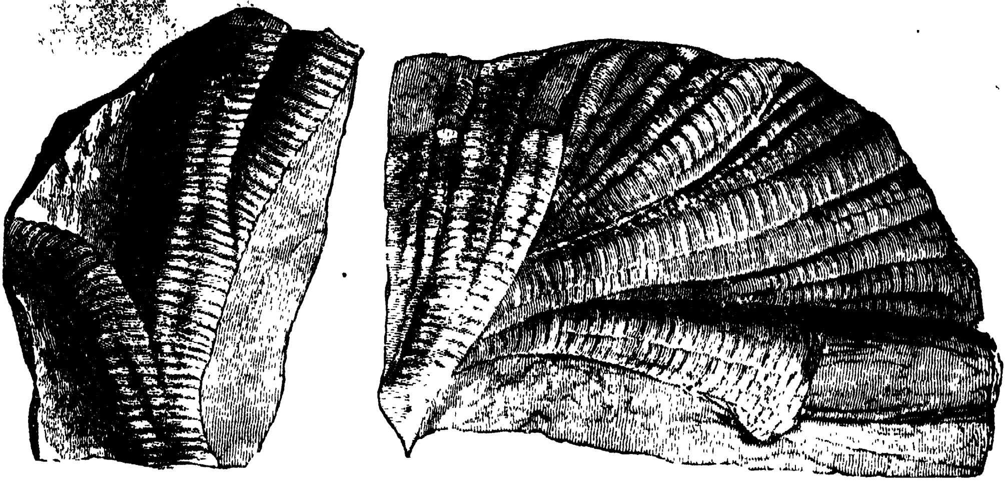
Figs. 8 and 9. *Cypricardia orthonota*, H. *Unio orthonota*, C. (Geological Report for 1839, page 66.) Medina.

No. 3—No. 10, page 52.

Lingula cuneata, as the shells appear when attached to the surface of sandy layers, in the grey sandstone of Niagara county.

ORGANIC REMAINS OF THE MEDINA SANDSTONE.

No. 1.



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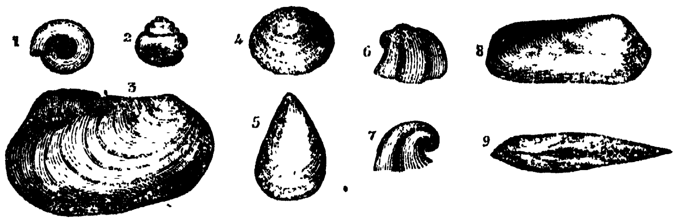


No. 3.

ORGANIC REMAINS OF THE CLINTON GROUP.

No. 4.—No. 14, page 69.

Fucoides gracilis, H. One of the most persistent and common fossils of the group.

No. 5.—No. 15, page 70 of Report.

Figs. 1, 2 and 3. *Pentamerus oblongus*. 1. The large variety, somewhat three-lobed. 2. A more circular form of the same shell. 3. A side view of a specimen intermediate in form to the other two. Rochester.

Fig. 4. Cast of upper valve of same fossil.

Fig. 5. Cast of lower valve.

Fig. 6. *Delthyris brachynota*, H. Reynolds's Basin, Niagara county.

No. 6.—No. 16, page 71.

Fig. 1. *Orthis circulus*, H. Two views—a beautiful striated circular shell, with a very small area. Reynolds's Basin, Niagara county.

Fig. 2. *Atrypa congesta*, C. (Jour. Acad. Nat. Sci. Vol. 8, page 265, plate 16, fig. 18.) Shell striated concentrically, and not with radiating lines as the figure would indicate.

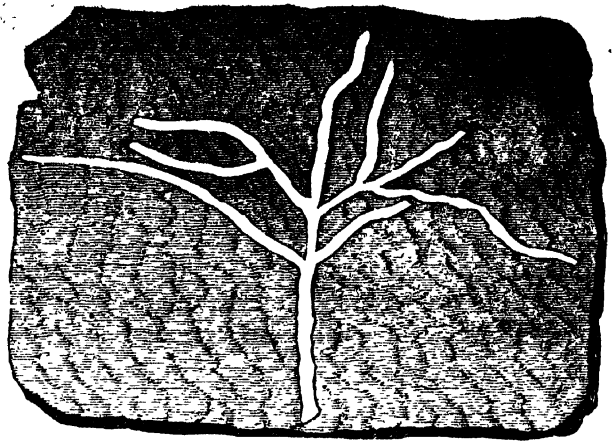
Fig. 3. *Atrypa nariformis*, H. A nearly smooth shell, somewhat concentrically striated, and with a few more prominent lines of growth. (Compare *Atrypa linguifera*—Silurian Researches, pl. 13, fig. 8.) Sodus Point.

Fig. 4. *Atrypa plicatula*, H. A small plicated shell, with three of the folds raised in front. Reynolds's Basin, Niagara county.

Fig. 5. *Crinoidal joint*, natural size and magnified. A widely distributed fossil, being known abundantly in New-York and Ohio.

ORGANIC REMAINS OF THE CLINTON GROUP.

No. 4.



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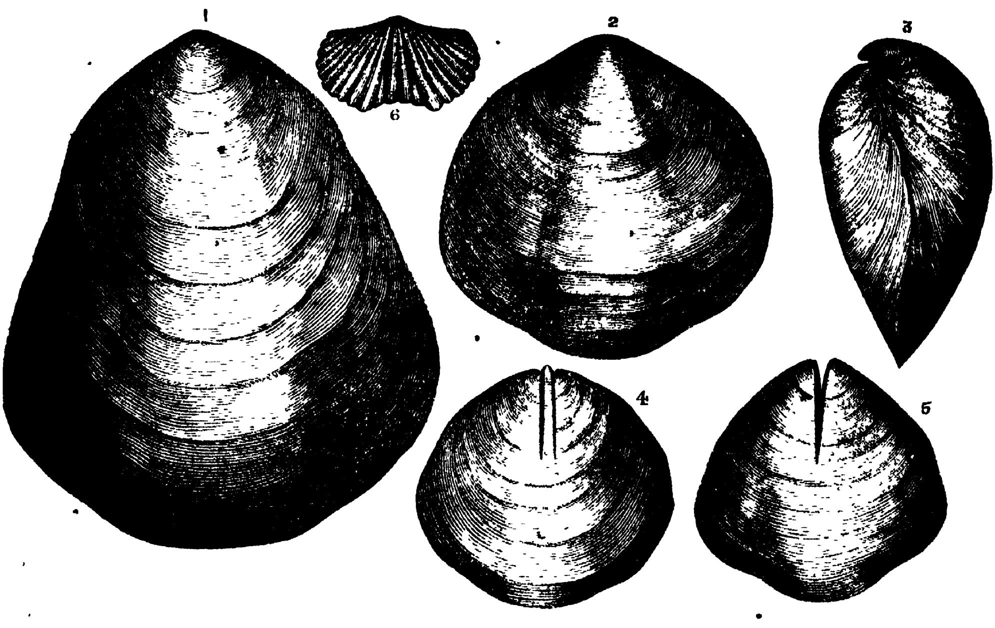

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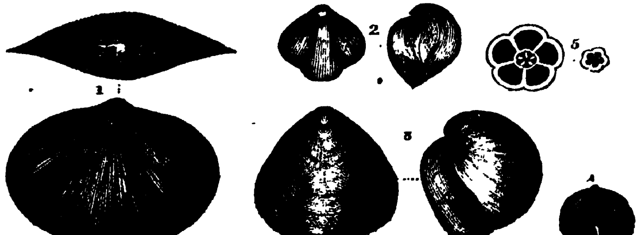


ORGANIC REMAINS OF THE CLINTON GROUP.

No. 7.—No. 17, page 72.

Fig. 1. *Orthonata curta*, H.
Fig. 2. *Nucula machæræformis*, H.
Fig. 3. *Cypricardia obsoleta*, H.
Fig. 4. *Nucula mactræformis*, H.
Fig. 5. *Avicula leptonota*, H.
Fig. 6. *Cypricardia? angusta*, H.
Fig. 7. *Lingula elliptica*, H.
Fig. 8. *L. oblata*, H.
Fig. 9. *L. acutirostra*, H.

} Shale of the Wolcott ore bed in Wayne county.

No. 8.—No. 18, page 76.

Fig. 1. *Strophomena elegantula*, H. Shell with elevated ribs and fine striæ between. It bears a considerable analogy to *S. sericea* and *S. transversalis*, but is quite distinct from either. Sodus Point.

Fig. 2. *Strophomena corrugata*, C. (Jour. Acad. Nat. Science, Vol. 8, p. 256, pl. 14, fig. 8.) Rochester.

Fig. 3. *S. cornuta*, H. A small neatly striated shell, armed with small rigid spines on the hinge line. Sodus Point.

Fig. 4. *Atrypa hemispherica*, (Silurian Researches, pl. 20. fig. 7.) Abundant in the green shale at Rochester.

Fig. 5. *Littorina cancellata*, H. Young shell. Sodus Point.

Fig. 6. — — " Old shell, with the markings worn off.

Fig. 7. *Posidonia? alata*, H. Green shale, Rochester.

Fig. 8 and 8 *a*. *Atrypa affinis?* Old and young shells. Sodus Point.

Fig. 9. *Calymene? trisulcata*, H. A small trilobite, with three furrows on each side of the middle lobe of the head. Rochester.

Fig. 10. *Agnostus latus*. Green shale, Rochester.

Fig. 11. *Tentaculites minutus*.

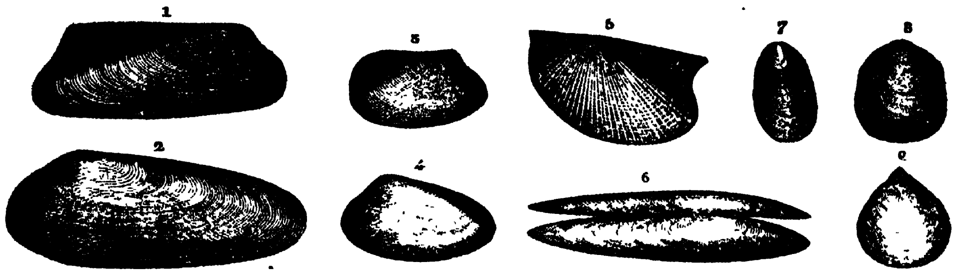
Fig. 12. *Graptolites Clintonensis*. An abundant form in the upper green shale of the group. Sodus Point.

No. 9.—No. 19, page 77.

Fig. 1. *Fucoides biloba*, Vanuxem (Geological Report, page 79).
Fig. 2. Tail of *Hemicrypturus*. " "
Fig. 3. Smooth crinoidal joint. " "
Fig. 4. *Lingula oblonga*, C. (Annual Geol. Report, page 65.)
L. Clintoni, Vanuxem (Report, page 78).
Fig. 5. *Strophomena depressa*. (*Leptæna depressa*, Dalman.)

ORGANIC REMAINS OF THE CLINTON GROUP.

No. 7.



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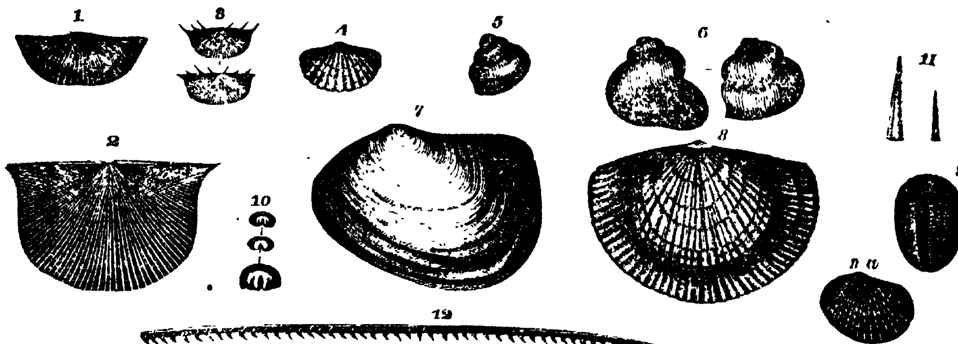

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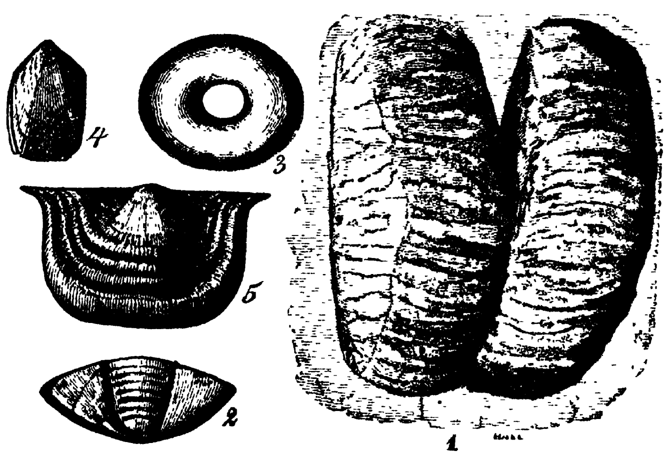


ORGANIC REMAINS OF THE NIAGARA GROUP.

No. 10. — No. 33, page 101.

Fig. 1. *Asaphus limulurus*, GREEN (Monograph, p. 48). Resembles and is perhaps identical with the *A. longicaudatus* of Murchison, and holds the same place in the series. Lockport.

Fig. 2. Head of *A. limulurus*. This portion of the fossil is abundant at Rochester.

Fig. 3. *Calymene Niagarensis*, H. Abundant at Lockport. Closely resembles in many respects the *Calymene senaria* of the Trenton limestone.

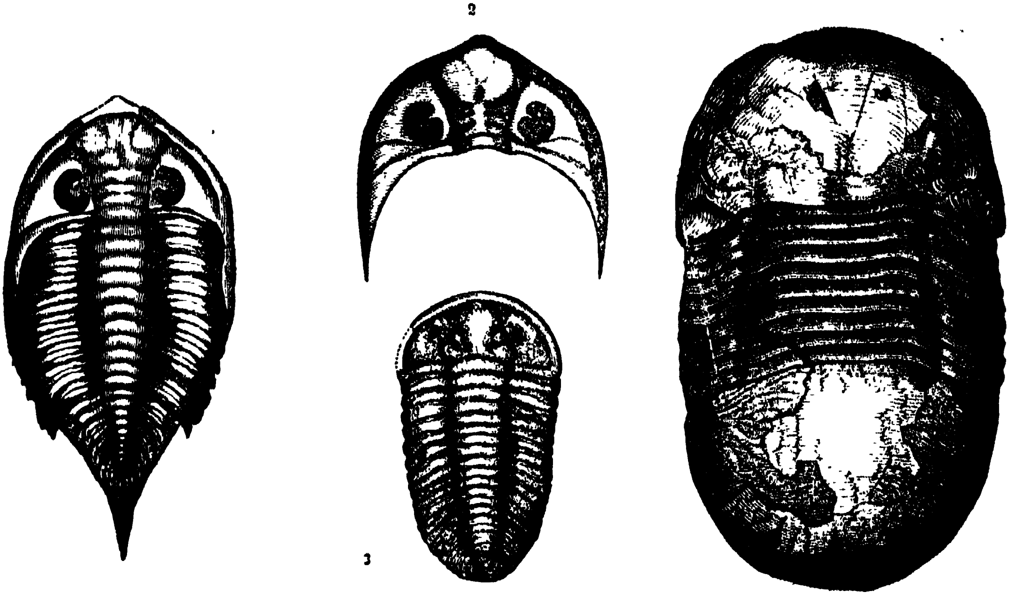
Fig. 4. *Bumastis barriensis*, (Silurian Researches, p. 656, pl. 7 bis, fig. 3, *a*, *b*, *c* and *d*; pl. 14, fig. 7, *a* and *b*.) The specimen figured is nearly twice the usual size, though there is one in the State collection one-third larger than the figure. Lockport.

No. 11. — No. 34, page 103.

Homalonotus delphinocephalus. (Silurian Researches, pl. 7 bis, fig. 1 *a*, 1 *b*.) *Trimerus delphinocephalus*, GREEN (*Monograph*, fig. 1, p. 82). This trilobite often attains the length of seven or eight inches, and very rarely twelve inches. Lockport.

ORGANIC REMAINS OF THE NIAGARA GROUP.

No. 10.



No. 11.

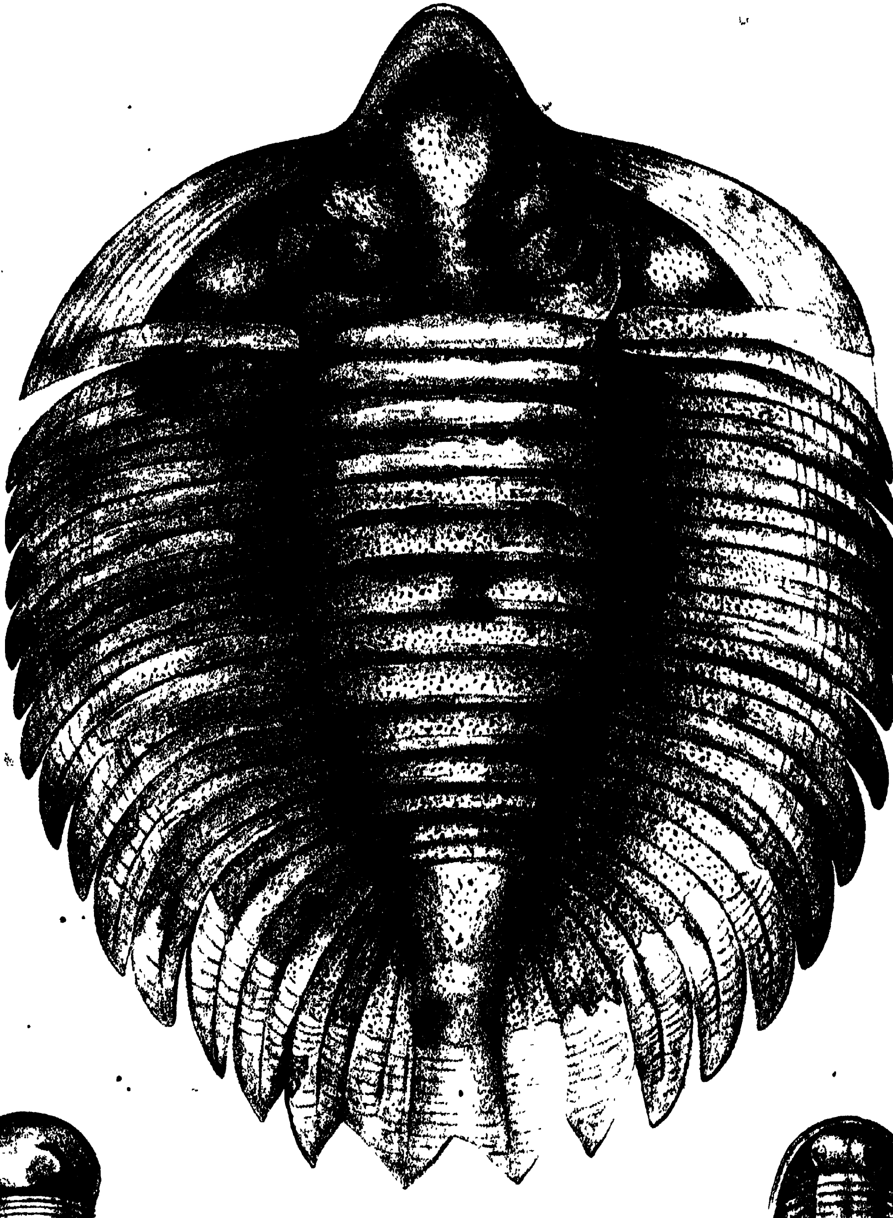
ORGANIC REMAINS OF THE NIAGARA

No. 19.

Fig. 1. *Platynotus Boltoni*, CONRAD, Annual Reports. (*Paradoxides Boltoni*, Bigsby. GREEN, Monograph, p. 60). This is one of the most rare and beautiful of the trilobites in the Niagara group. Lockport.

Fig. 2. *Bumastis barriensis*. Specimen of the ordinary size. Lockport.

Fig. 3. *Asaphus coryphæus*. (Jour. Acad. Nat. Sci. Vol. 8, page 277, pl. 16, fig. 15). Lockport.



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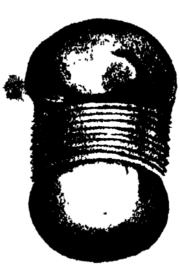
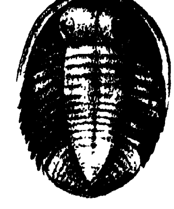


BUMASTIS BARRIENSIS !



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ORGANIC REMAINS OF THE NIAGARA GROUP.

No. 12. — No. 35, page 104 of Report.

Fig. 1. ***Strophomena subplana*, C.** (Jour. Acad. Nat. Sci., vol 8, page 258.) Lockport.

Fig. 2. ***Strophomena depressa*, *Productus depressus*, M. C. t. 459.** (*Leptæna depressa*, DALMAN. Swedish Transactions, p. 106, t. 1, f. 2; HISINGER, Petrefacta Suecica, p. 69, t. 20, f. 3. MURCHISON, Silurian Researches, p. 623, pl. 12, f. 2.) An abundant fossil in the shale of the Niagara group. Lockport.

Fig. 3. *Strophomena striata*, H. Common at Rochester and Lockport.

Fig. 4. ***Strophomena transversalis*** (*Leptæna transversalis*, DALM. l. c. p. 109, t. 1, f. 4; HIS. Pet. Succ. p. 69, t. 20, f. 5. Silurian Researches, p. 629, pl. 13, f. 2.)

No. 13. — No. 36, page 105 of Report.

Fig. 1. ***Delthyris Niagarensis*, CONRAD** (Jour. Acad. Nat. Sci. vol. 8, p. 261). Lockport.

Fig. 2 and 2 *b*. *Delthyris radiatus*. (*Spirifer radiatus*, M. C. t. 493. Silurian Researches, p. 624, pl. 13, f. 6.) Lockport.

Fig. 3 and 3 *b*. *Delthyris staminea*, H. (References, *Spirifer crispus?* Silurian Researches, p. 624, pl. 13, f. 8. *Delthyris crispa*, DALM. l. c. p. 122, t. 3, f. 6; HIS. Pet. Succ. p. 73, t. 21, f. 5). Lockport.

Fig. 4 and 4 *a*. *Delthyris decemplicata*, H. Lockport; and *Delthyris sinuatus*. (*Terebratula sinuata*, SOWERBY in Linn. Trans. Vol. 12, p. 516, t. 28, f. 5 and 6. *Delthyris cardiospermiformis*, HIS. *Anteckn.*, Vol. 4, t. 7, f. 6. DALM. *sur les Terebratules*, p. 124, t. 3, f 7. HIS. Pet. Succ. p. 74, t. 21, f. 9. *Spirifer cardiospermiformis*, VON BUCH *sur les Spirifers et Orthis*, t. 1, f. 7. *Spirifer sinuatus*, Silurian Researches, p. 630, pl. 13, f. 10) Wolcott.

Fig. 5. *Orthis flabellulum* (*a*)? (Silurian Researches, pl. 21, f. 8. *O. callactis*? DALMAN.) Lockport.

Fig. 6. *Orthis canalis*, (Silurian Researches, p. 630, pl. 13, f. 12, *a*; also pl. 20, f. 8. *Orthis elegantula*? DALMAN. VON BUCH *sur les Spirifers et Orthis*, pl. ii, f. 3, 4 and 5) Sweden, Monroe county.

Fig. 7, *a*, *b*, *c*. *Orthis hybrida*. (Silurian Researches, pl. 13, f. 11.) Sweden, Monroe county.

No. 14 — in part No. 37, page 108.

Fig. 1. *Atrypa imbricata*. (*Terebratula imbricata*, Silurian System, p. 624.)

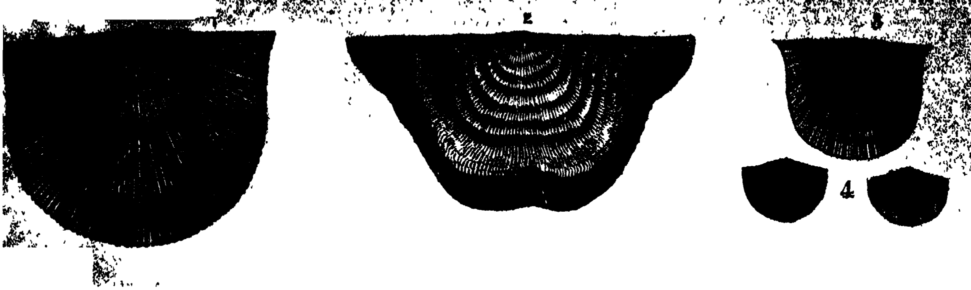
Fig. 2. *Atrypa*. (Species undetermined) Lockport.

Fig. 3, 4 and 4 *a*. *Atrypa cuneata*. (*Terebratula cuneata*, DALMAN. HISINGER. Silurian Researches, p. 625, pl. 12, f. 13.)

Fig. 5. *Atrypa nitida*, H. A very abundant species, but usually more or less distorted. Lockport.

Fig. 6. *Atrypa affinis*, (*Terebratula affinis*. M. C. t. 324, f. 2. *A. reticularis*, DALMAN, HISINGER, &c.)

No. 11.



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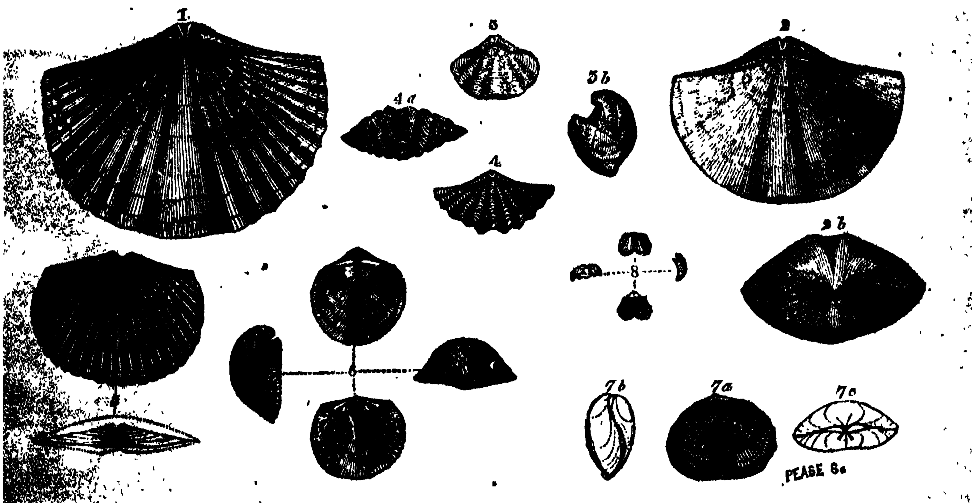

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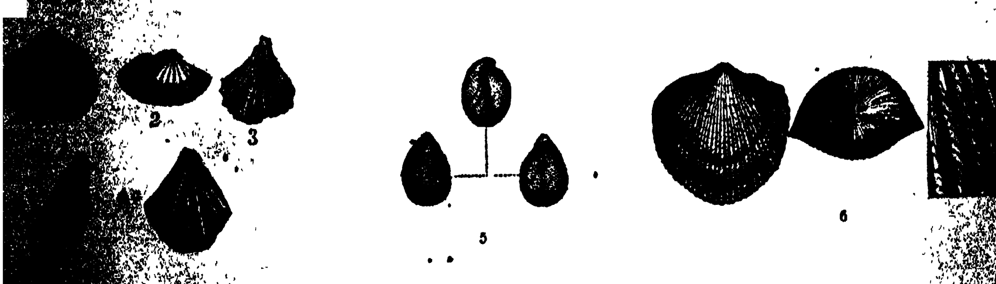

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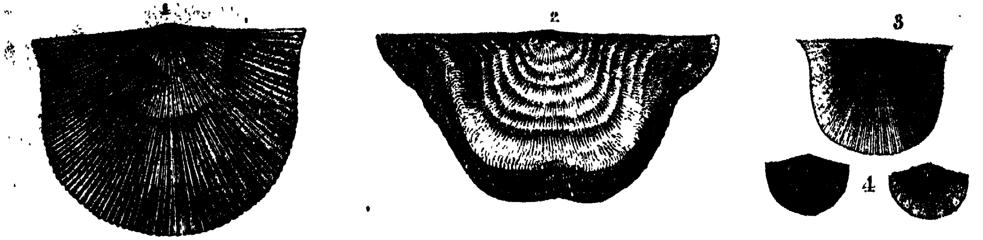

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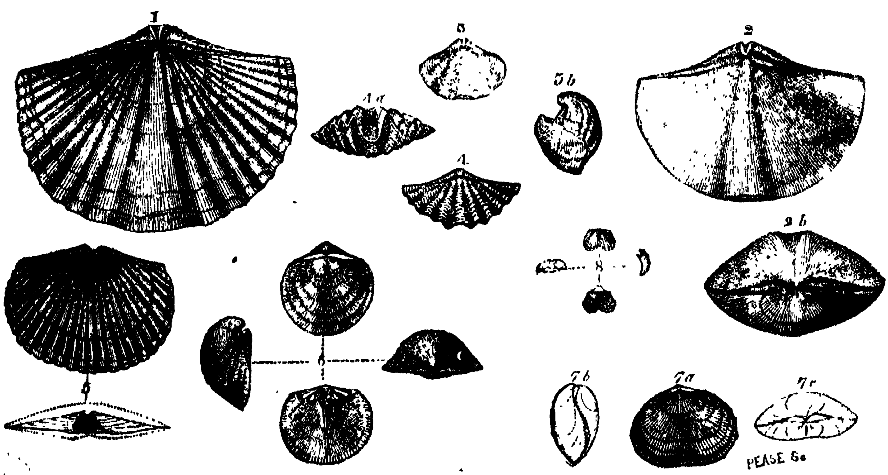

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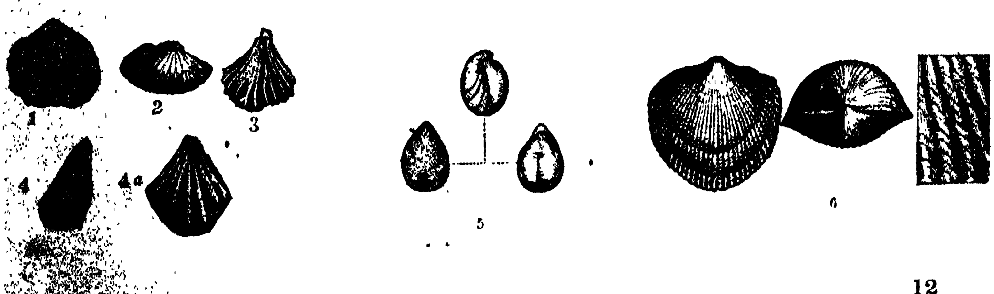


ORGANIC REMAINS OF THE NIAGARA GROUP.

No. 15. — No 38, page 108.

Fig. 1. *Orbicula? squamæformis*, H. Sweden, Monroe county. (Reference, Silurian Researches, p. 625, pl. 12, fig. 11 *a*.)

Fig. 2. *Lingula lamellata*, H. Lockport.

Fig. 3. *Orbicula corrugata*, H. Rochester.

Fig. 4. *Avicula emacerata*, CONRAD (Jour. Acad. Nat. Sci. vol. 8, p. 211, pl. 12, f. 15).

No. 16. — No 39, page 109.

Figs. 1 and 2. *Euomphalus hemisphericus*, H. Rochester.

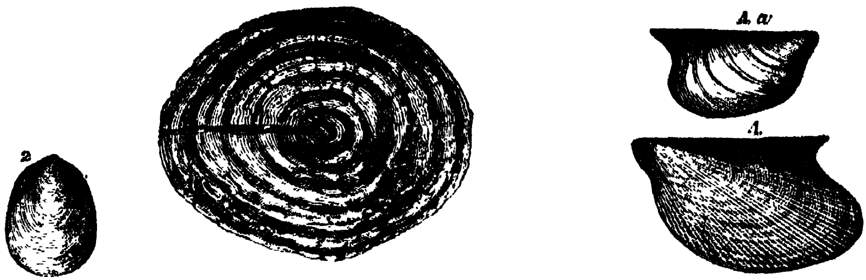
Fig. 3. *Cornulites arcuatus*, CONRAD (Jour. Acad. Nat. Sci. vol. 8, p. 276. pl. 17, f. 8).

No. 17. — No. 40, page 110.

Fig. 1. *Orthoceras annulatum?* (Reference *O. annulatum*, M. C. t. 133, Silurian Researches, pl 9, f. 5)

Fig. 2. *Conularia quadrisulcata*, MILLER (M. C. t. 260, f. 3 and 4 ; HIS. *Pet. Suec.* p. 30, t. 10, f. 5 ; Silurian Researches, p. 626, pl. 12, f. 22). Lockport.

No. 14.



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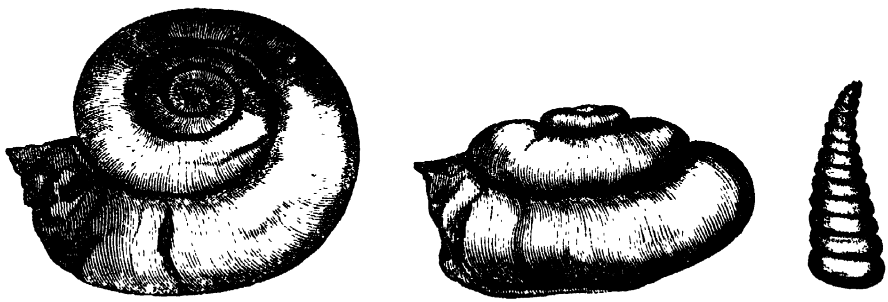

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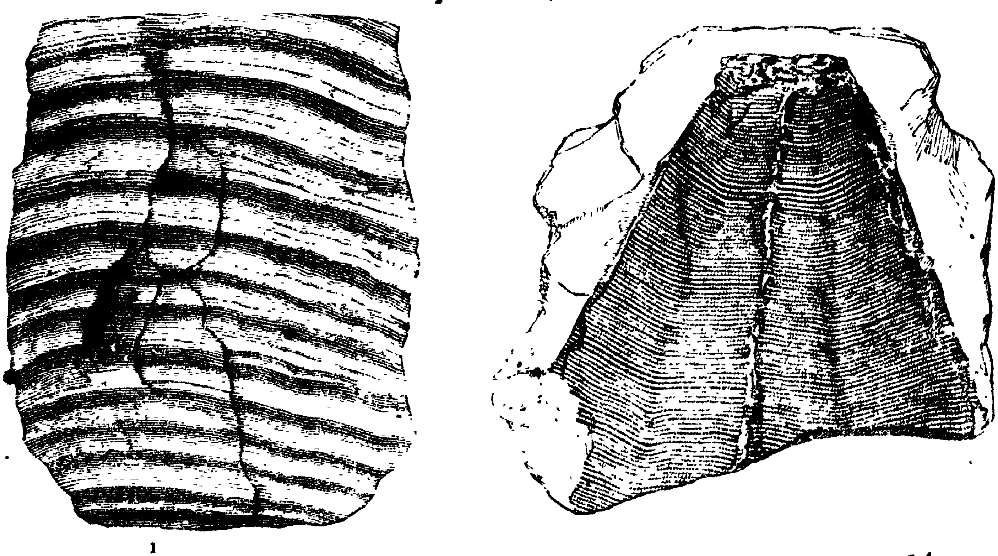

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14

ORGANIC REMAINS OF THE NIAGARA GROUP.

No. 17. — No. 41, page 111.

Fig. 1 and 2. *Caryocrinus ornatus*, SAY (Jour. Acad. Nat. Sci. vol. 4, p. 289). Lockport.

Fig. 3. *Cyathocrinites pyriformis*, (Silurian Researches, p. 672, pl. 17, f. 6. *Ichthyocrinus lævis*, CONRAD Jour. Acad. Nat. Sci. vol. 8, p. 279, pl. 15, f. 16.)

No. 18. — No. 41 (read 41 bis), page 113

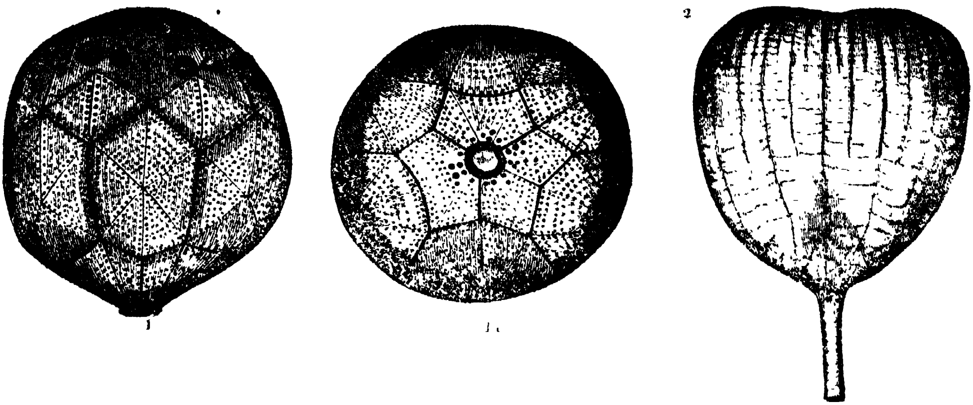
Fig. 1. *Hypanthocrinites cælatus*, H. Lockport.

Fig. 2. *Hypanthocrinites decorus*. (Silurian Researches, p. 672, pl. 17, f. 3.) Lockport. Broken off at the base of the arms.

Fig. 3. *Hypanthocrinites decorus*. Lockport.

Fig. 4 and 5. *Marsupiocrinites? dactylus*, H. Lockport.

No. 17.



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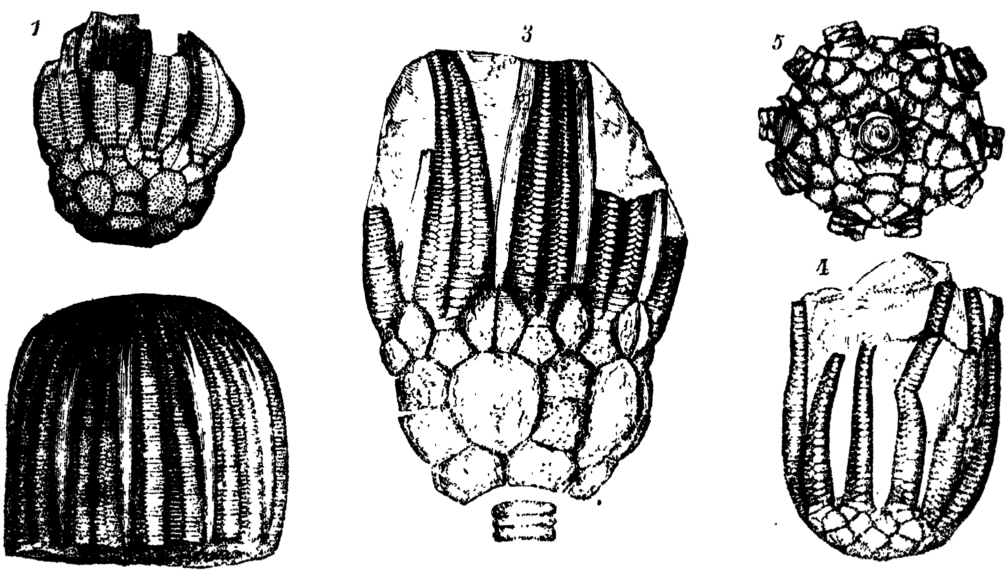


ORGANIC REMAINS OF THE NIAGARA GROUP.

No. 19.

Fig. 4. *Caryocrinus ornatus.*

Figs. 5 and 6. Interior structure of the plates.

Fig. 7. Part of a plate enlarged, showing the pores which communicate with the external surface.

No. 20.

Fig. 1. Anatomical structure of the *Caryocrinus ornatus.*

Fig. 2. Arrangement of the capital plates, showing the mouth composed of several conical plates.

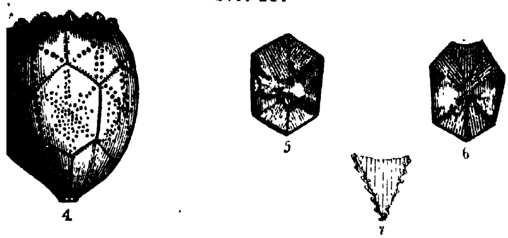
No. 21.

Fig. 4. *Cyathocrinus* —— ?

Fig. 4 *a.* Anatomical structure of the same fossil.

Fig. 5 *a. b.* *Cyathocrinus?* These two species have not been determined.

No. 19.



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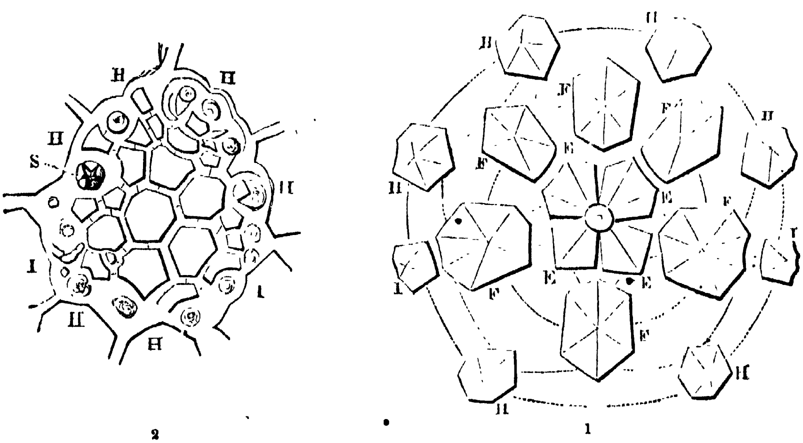

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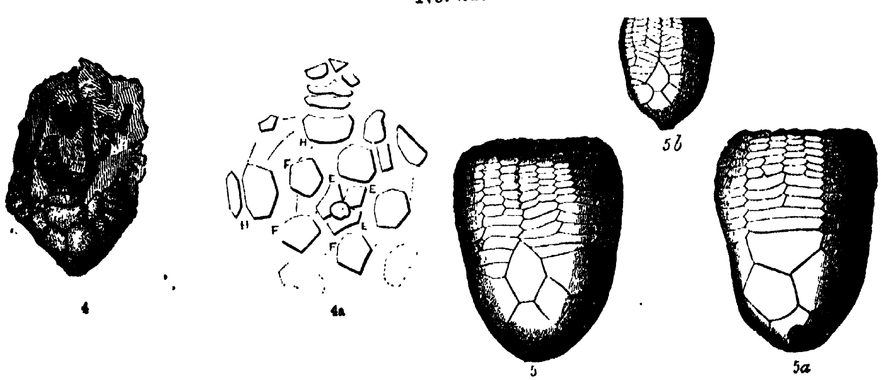

ORGANIC REMAINS OF THE NIAGARA GROUP.

No. 22.

Fig. 1. *Catenipora escharoides*, LAMARCK. (For synonymes and references, see Silurian Researches, page 685.) Very abundant and widely distributed. The upper part of the Niagara limestone.

Fig. 2. *Catenipora agglomerata*, H. A very distinct species from the last. Abundant at a single locality in Ogden, Monroe county.

Fig. 3. *Porites* —— ?

Fig. 4. The same fossil, mostly removed, leaving only the lines indicating the stages of growth. (See pages 86 and 91 of Report.)

No. 22.

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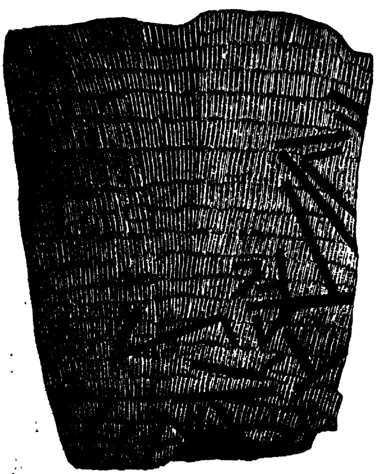

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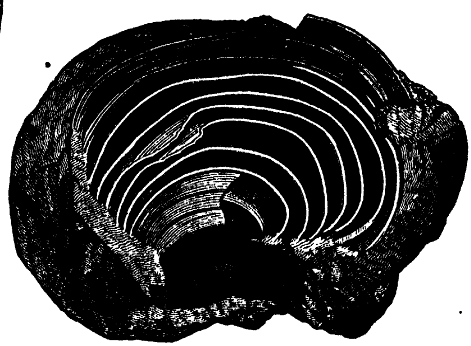

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ORGANIC REMAINS OF THE NIAGARA GROUP.

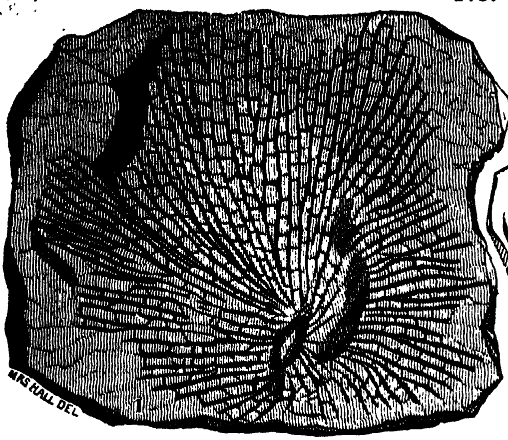
No. 23. — No. 42, page 115.

Fig. 1. *Gorgonia? reteformis*, H. Lockport.
Fig. 2. *Gorgonia?* —— ? These two are fossils in the shale at Lockport.

No. 24. — No. 43, page 116.

Fig. 1. —— ? This fossil, though very beautiful in its appearance, is obscure, and for want of time has not been decided. Lockport.
Figs. 2 and 3. A coral resembling *Isis*. Lockport.

No. 23.



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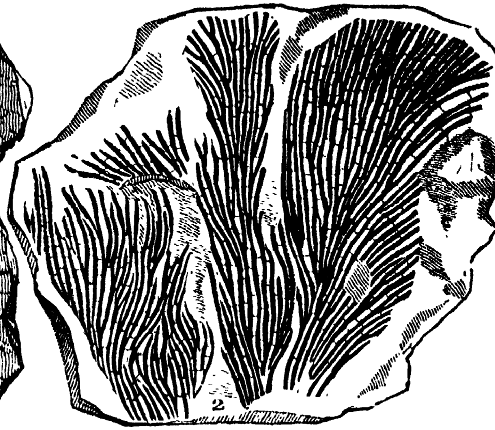

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No. 24.

ORGANIC REMAINS OF THE ONONDAGA SALT GROUP.

No. 25. — No. 54, page 137.

Fig. 1. *Cornulites*, n. s.
Fig. 2. *Orthoceras læve*, H.
Fig. 3. *Loxonema Boydii*, H.
Fig. 4. *Euomphalus sulcatus*, H.
Fig. 5. *Delthyris* —— ?
Fig. 6. *Atrypa* —— ?
Fig. 7. *Avicula triquetra*, H.

These all occur at a single locality, and but one other shell has been seen in the group. Two of these species are not satisfactorily ascertained.

ORGANIC REMAINS OF THE WATERLIME GROUP.

No. 26. — No. 58, page 142.

Fig. 1. *Delthyris plicatus*. *Orthis plicatus*, (Geol. Report Third District.)
Fig. 2. *Avicula rugosa*, Conrad (Annual Reports).
Fig. 3. *Tentaculites ornatus*. (See Silurian Researches, p. 628, pl. 12, f. 25.)
Fig. 4. *Littorina antiqua*, Conrad (Annual Reports).
Fig. 5. *Atrypa sulcata*, Vanuxem (Geol. Report).
Fig. 6. *Cytherina alta*, Conrad (Annual Reports).

ORGANIC REMAINS OF THE PENTAMERUS LIMESTONE.

No 27. — No. 25, Report of the Third District, page 117.

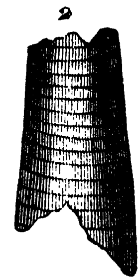
Fig. 1. *Pentamerus galeatus*. *Atrypa galeata*, Dalm.
Fig. 2. *Euomphalus profundus*, Conrad (Annual Geol. Report).
Fig. 3. *Atrypa lacunosa* ? This fossil is considered by Mr. Conrad as identical with the *Terebratula lacunosa* of Europe.
Fig. 4. *Lepocrinites Gebhardii*. The stems, one covered by a thick calcareous coating, and the other showing the rings.

ORGANIC REMAINS OF THE DELTHYRIS SHALY LIMESTONE.

No. 28. — No. 27, Report of Third District, page 122.

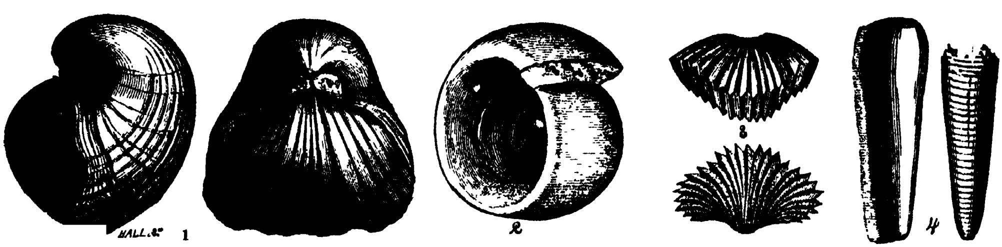
Fig. 1. *Strophomena punctilifera*, Conrad.
Fig. 2. *Strophomena radiata*, Conrad. These fossils occur in the Delthyris shaly limestone in central New-York, but at the west the *S. punctilifera* holds a higher position.

No. 25.



No. 26.

No. 27.



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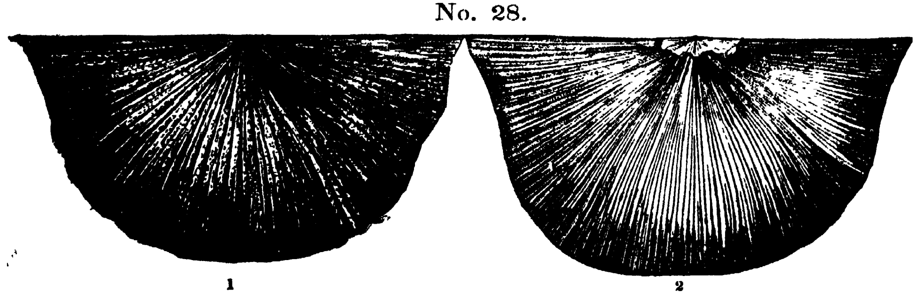


ORGANIC REMAINS OF THE ORISKANY SANDSTONE.

No. 29.—No. 59, page 148.

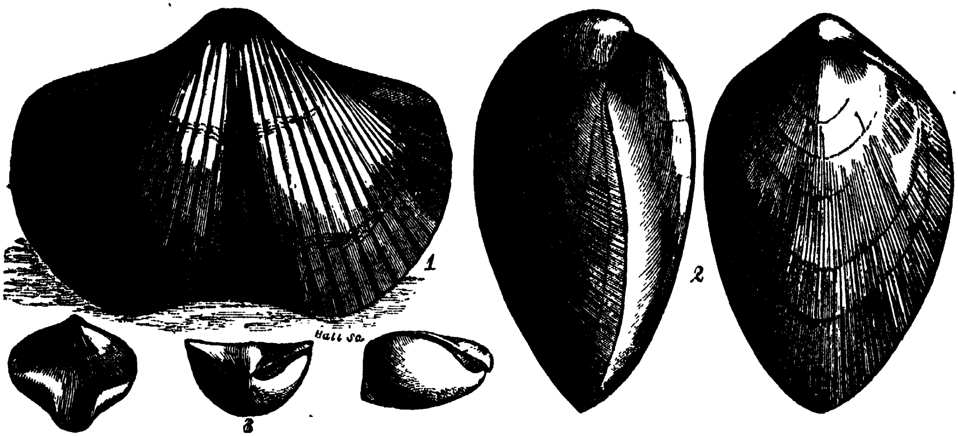
Fig. 1. *Delthyris arenosa*, CONRAD (Geol. Annual Report, 1839, p. 65).
Fig. 2. *Atrypa elongata*, CONRAD (Annual Report, 1839, p. 65).
Fig. 3. *Atrypa peculiaris*, CONRAD (Annual Report of 1841).

No. 30.—No. 60, page 149.

Fig. 4. *Atrypa unguiformis*, CONRAD. (*Hipparionyx proximus*, VANUXEM, Geol. Report, p. 124, fig. 4.)
Fig. 5. Cast of *Delthyris arenosa*.

The fossils of this rock are scarcely found in the Fourth District, except in loose scattered masses which are common in Seneca county. The rock is abundantly fossiliferous on the eastern shore of Cayuga lake.

No. 29.



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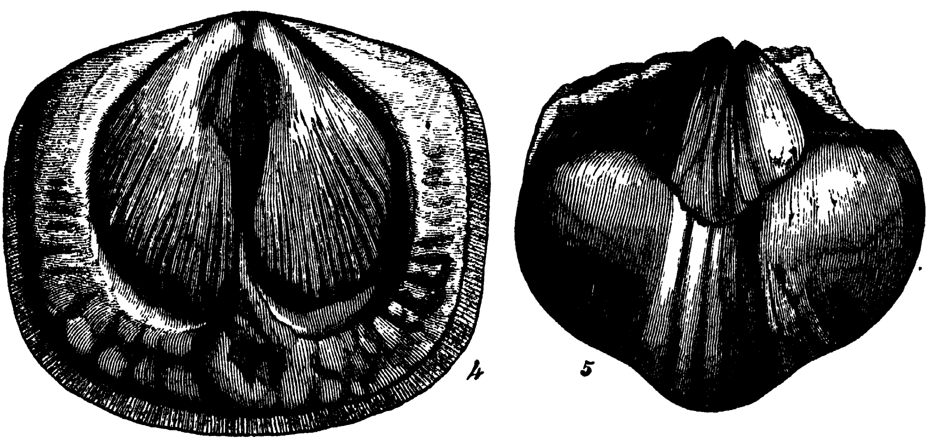


ORGANIC REMAINS OF THE ONONDAGA LIMESTONE.

No. 31. — No. 61, page 157.

Figs. 1 and 1 *a*. *Favosites alveolaris*.* Williamsville, Erie county.

Fig. 2. *Favosites gothlandica*. Williamsville.

Fig. 2 *a*. — — A single tube magnified twice, and presenting a double row of pores upon the side.

Fig. 2 *b*. A fragment from a honeycomb specimen, showing the transverse lamellæ. Williamsville.

Figs. 3, 3 *a*, and 3 *b*. Fragments of crinoidal columns, showing the pentapetalous canal and crenulated edges of the plates, etc. Williamsville.

No. 32 – No. 62, page 159.

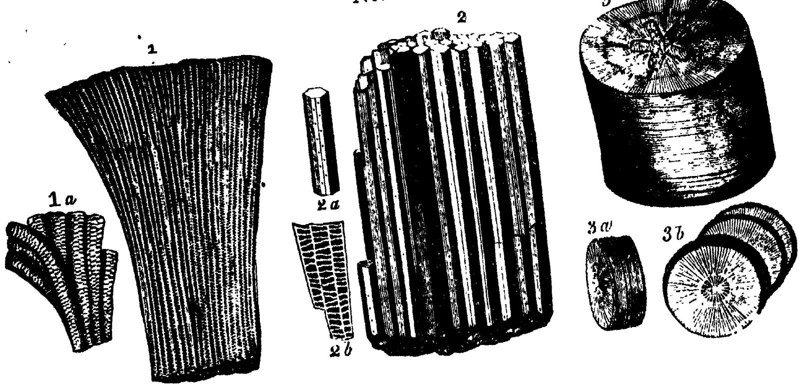
Fig. 1. *Favosites fibrosa?* Clarence, Erie county.

Fig. 2. *Astrea rugosa*, H. Le Roy.

* For synonymes and references of the genus *Favosites*, see Silurian Researches, pp. 681, 682 and 683; also GOLDFUSS, Petrefacta, Genus *Calamopora*.

ORGANIC REMAINS OF THE ONONDAGA LIMESTONE.

No. 31.



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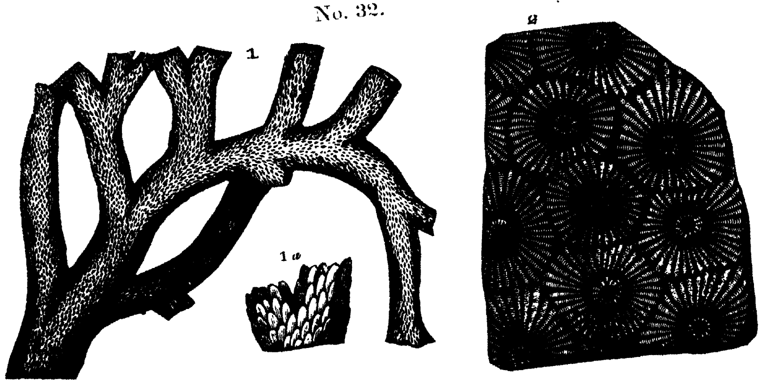


ORGANIC REMAINS OF THE ONONDAGA LIMESTONE.

No. 33. — No. 63, page 160.

Fig. 1. *Cyathophyllum* —— ? Caledonia.

Fig. 2. *Cyathophyllum dianthus*, (GOLDFUSS Petrefacta, p. 54, pl. 15, fig. 13, and pl. 16, fig. 1. Silurian Researches, p. 690, pl. 16, f. 12, 12 *a* to 12 *e*.) Caledonia.

Fig. 3. *Syringopora* —— ? The fossil is silicified, standing in relief upon the surface of the rock.

No. 34. — No. 3, page 132, Report of the Third District.

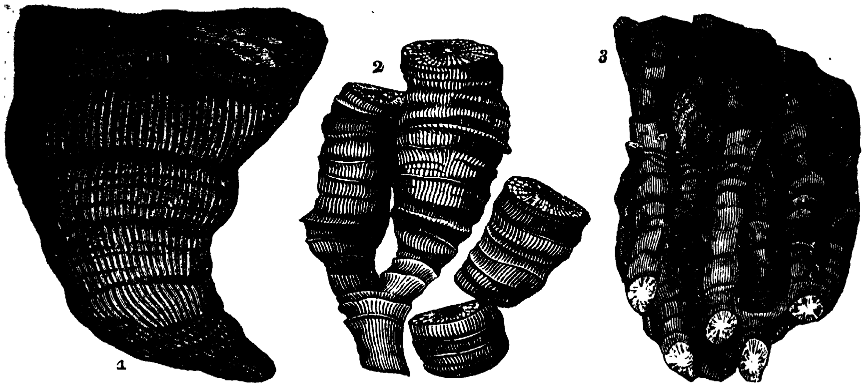
Fig. 1. *Pentamerus elongata.*

Fig. 2. *Hipparionyx* (*Atrypa*) *consimilaris.*

Fig. 3. *Delthyris undulatus.*

These fossils are not common in the Fourth District, though they have been seen at two or three localities.

No. 33.



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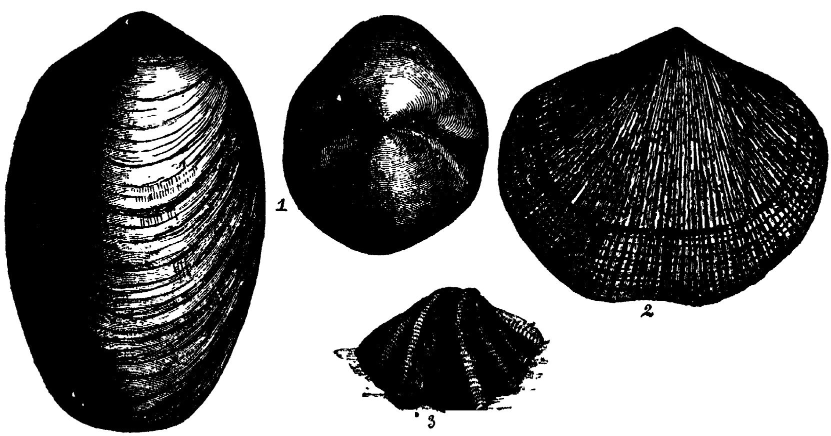


ORGANIC REMAINS OF THE CORNIFEROUS LIMESTONE.

No. 35.—No. 67, page 171.

Fig. 1. *Atrypa scitula*, H. Williamsville, Erie county.

Fig. 2. *Paracyclas elliptica*, H. Shell very closely resembling a *Cyclas*. Le Roy, Genesee county.

Fig. 3. *Strophomena acutiradiata*, H. Near Buffalo.

Fig. 4. *Strophomana crenistria*, H. Vienna, Ontario county.

Fig. 5. *Delthyris duodenaria*, H. Five miles east of Buffalo.

Figs. 6 and 6 *a*. *Pleurorhyncus trigonalis*, H. Williamsville.

No. 36 — No. 68, page 172.

Fig. 1. *Pterinea? carduformis*, H. Clarence Hollow.

Fig. 2. *Tentaculites scalaris*, Schlotheim (Silurian Researches, p. 643, pl. 19, f. 16).

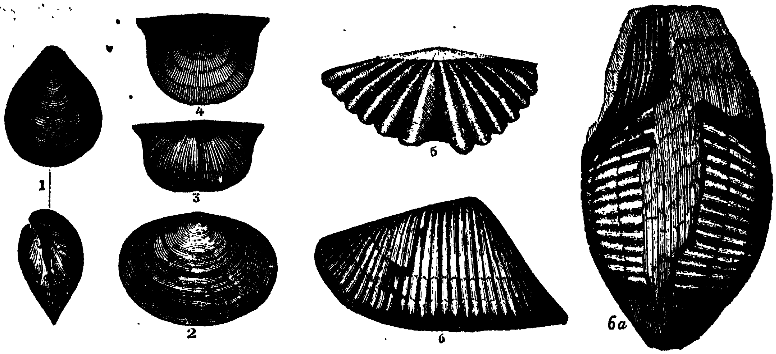
Fig. 3. *Orthonychia* ——. A new genus, from its resemblance to a claw or talon. There are several other species. Williamsville.

Fig. 4. *Euomphalus? rotundus*, H. Clarence Hollow.

Fig. 5. *Calymene crassimarginata*, H. A common and widely distributed fossil of this limestone. Williamsville.

Fig. 6. *Acroculia erecta*, H. Williamsville.

No. 35.



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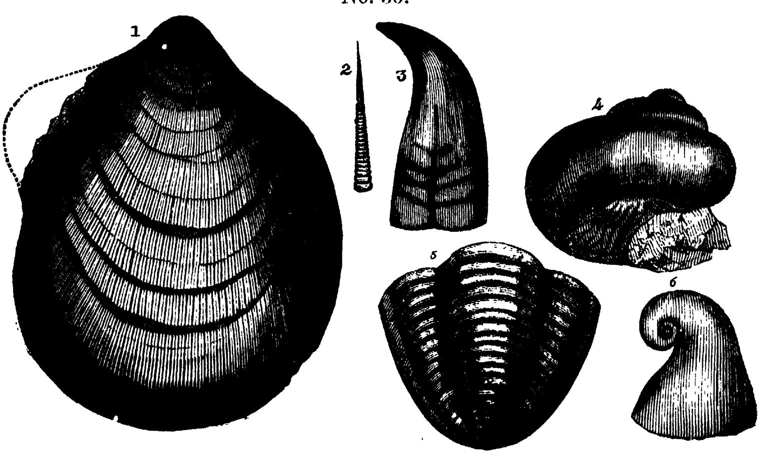


ORGANIC REMAINS OF THE CORNIFEROUS LIMESTONE.

No. 37. — No. 69, page 174.

Fig. 1. *Ichthyodorulite.* Undetermined. Victor, Ontario county.

No. 38. — No 70, page 175.

Fig. 1. *Odontocephalus selenurus*, CONRAD. (*Asaphus selenurus*, EATON. *Calymene odontocephala*, GREEN)

Fig. 2. *Cyrtoceras undulatum*, VANUXEM (Geol Report).

Fig. 3. *Strophomena undulata*, V. (Geol. Report).

Fig. 4. *Orthis lentiformis*, V. (Geol. Report).

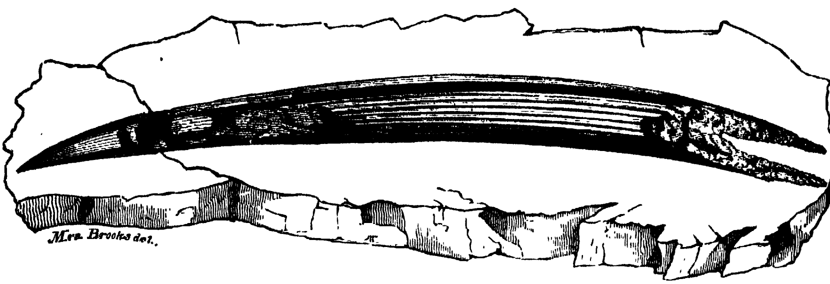
Fig. 5. *Atrypa prisca.*

Figs. 6 and 7. *Ichthyodorulite*, and section of the same.

Fig. 8. *Strophomena lineata*, CONRAD (Annual Reports).

The fossils of this illustration, with the exception of 3, 5 and 8, are not as abundant in this rock in the Fourth District, as those preceding.

No. 37.



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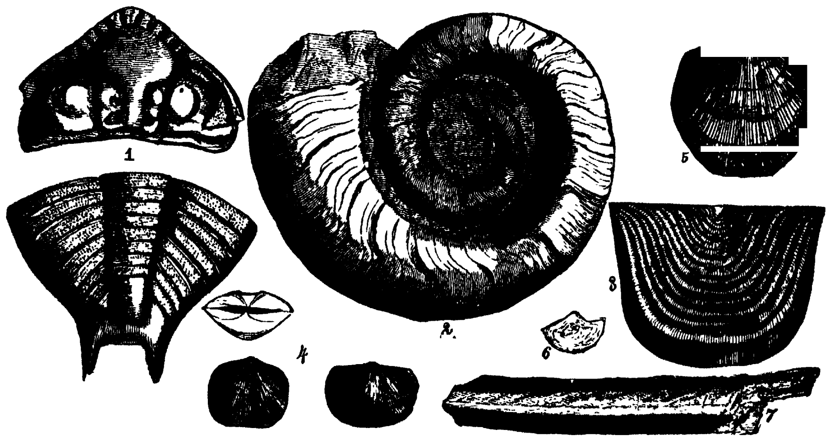


ORGANIC REMAINS OF THE MARCELLUS SHALE.

No. 39. — No. 71, page 180.

Fig. 1. *Orthoceras subulatum*, H. Bloomfield, Ontario county.
Fig. 2. *Strophomena setigera*, H. Avon, Livingston county.
Fig. 3. *Strophomena mucronata*, H. Avon.
Fig. 4. *Strophomena pustulosa*, H. Avon.
Fig. 5. *Avicula muricata*, H. Avon.
Fig. 6. *Avicula lævis*, H. Avon.
Fig. 7. *Avicula equilatera*, H. Bloomfield, Ontario county.
Fig. 8. *Orthis nucleus*, H. Avon.
Fig. 9. *Orbicula minuta*, H. Avon.
Fig. 10. *Tentaculites fissurella*, H. Avon.
Fig. 11. *Atrypa limitaris*, *Orthis limitaris*, VANUXEM (Geol. Report). Le Roy, Genesee county.

ORGANIC REMAINS OF THE HAMILTON GROUP.

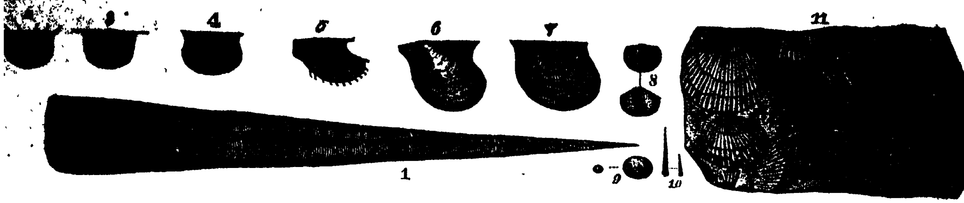
No. 40. — No. 78, page 196.

Fig. 1. *Bellerophon patulus*, H. Kidder's ferry, Cayuga lake.
Fig. 2. *Microdon bellastriata*, CONRAD (Jour. Acad. Nat. Sci. Vol. 8, p. 247, pl. 13, fig. 12).
Fig. 3. *Cucullea opima*, H. Seneca lake shore.
Fig. 4. *Nucula? oblonga*. Seneca lake shore.
Fig. 5. *Nucula lineata?* PHILLIPS (Palæozoic fossils, p. 39, pl. 18, fig. 64). Cayuga lake shore.
Fig. 6. *Tellina? ovata*, H. Seneca lake shore.
Fig. 7. *Nucula bellatula*, H. Ogden's ferry, Cayuga lake.
Fig. 8. *Cypricardia truncata*. (*Cypricardites truncata*, CONRAD, Jour. Acad. Nat. Sci. Vol. 8, p. 241, pl. 12, fig. 17. See Geol. Yorkshire, pl. fig.)
Fig. 9. *Modiola concentrica*, H. (See *Modiola semisulcata*, Silurian researches, pl. 8, fig 6.)

No. 41. — No. 79, page 198.

Fig. 1. *Turbo lineatus*, H. Ovid, Seneca lake shore.
Figs. 2 and 3. *Delthyris mucronata*, CONRAD (Annual Report of New-York Geol. Survey, 1841, p. 51). Eighteen-mile creek.
Fig. 4. *Atrypa prisca*. (*Terebratula affinis*, M. C. t. . *T. prisca*, VON BUCH; *T. reticularis*, BROWN, Lethea Geognostica. *Atrypa reticularis*, DALMAN. *A. affinis*, Silurian Researches.) Eighteen-mile creek.
Fig. 5. *Atrypa concentrica*, BROWN (Lethea Geog.) Eighteen-mile creek.

No. 39.



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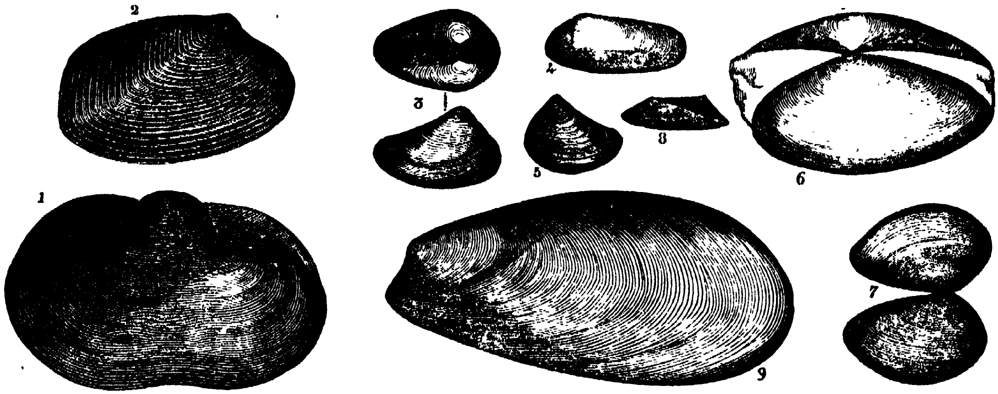

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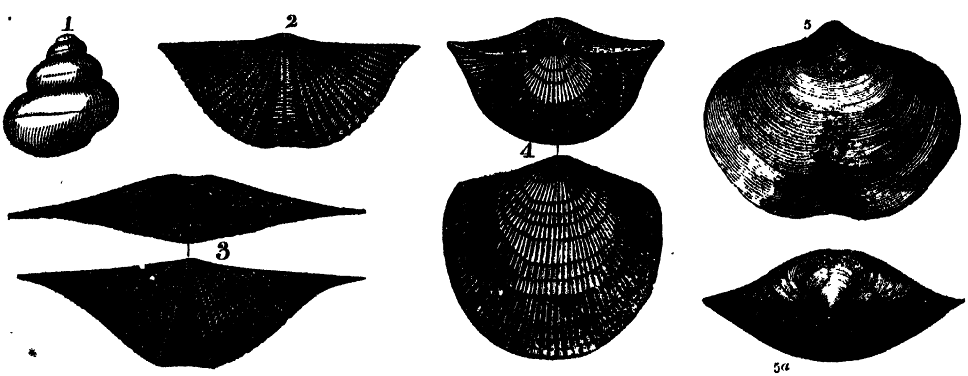


ORGANIC REMAINS OF THE HAMILTON GROUP.

No. 42. — No. 80, page 200.

Fig. 1 and 1 *a*. *Atrypa spinosa*, H. Specimens from Eighteen-mile creek, with the spines removed.

Fig. 1 *b*. A portion showing the imbricated lamellæ and concentric elevated lines.

Fig. 2. *Atrypa spinosa*, with the spines partially visible. Moscow.

Fig. 3. *Atrypa concinna*, H. Moscow.

Fig. 4. *Strophomena inequistriata*, Conrad (Jour. Acad. Nat. Sci. Vol. 8, p. 254, pl. 14, f 2). Moscow.

Fig 5. *Delthyris zigzag*, H. Moscow.

Fig. 6. *Calymene bufo*, Green (Monograph, p. 41). Moscow.

Fig. 7. *Cryphæus calliteles*, Green. Moscow.

Fig. 8. *Loxonema nexilis*, Phillips (Palæozoic fossils, p. 99, pl. 38, fig. 183. *Terebra nexilis*, Sowerby in Geol. Trans. 2nd series, Vol. 5, pl. 54, fig. 17). Seneca lake shore.

No. 43. — No. 81, page 202.

Fig. 1. *Avicula orbiculata*, H. Eighteen-mile creek.

Fig. 2. *Atrypa rostrata*, H. Eighteen-mile creek.

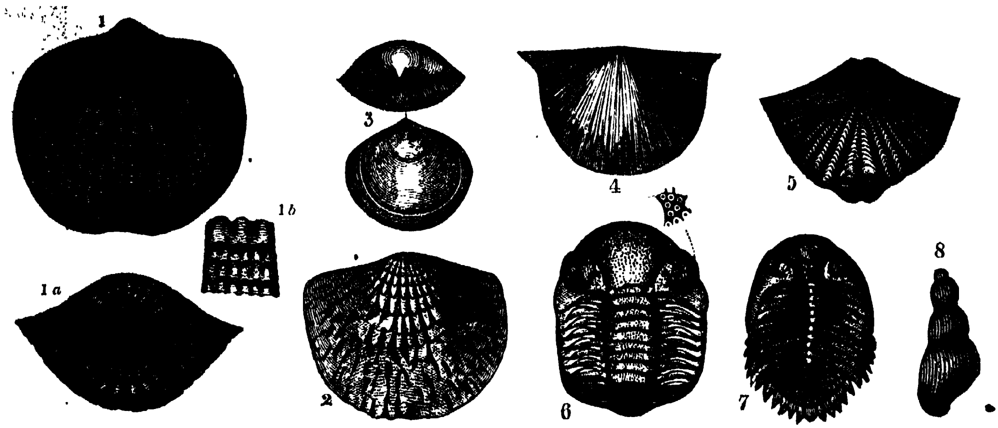
Figs. 3, 4 and 5. Undetermined species of *Atrypa*. Eighteen-mile creek.

Fig. 6. *Delthyris sculptilis*, H. Eighteen-mile creek.

No. 44. — No. 82, page 203.

Figs. 1 and 2. *Avicula decussata*, H. 1. A cast in limestone. 2. The shell preserved in shale.

No. 42.



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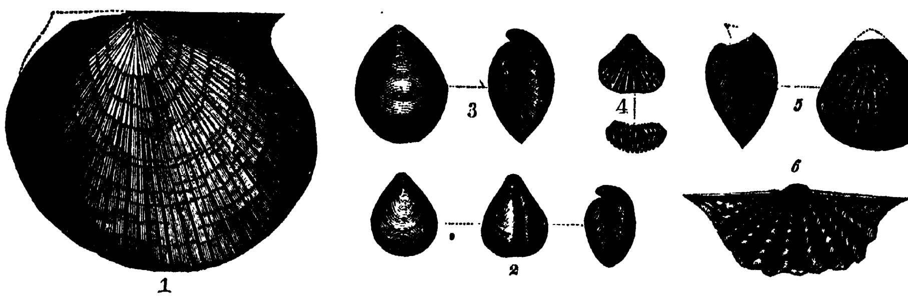

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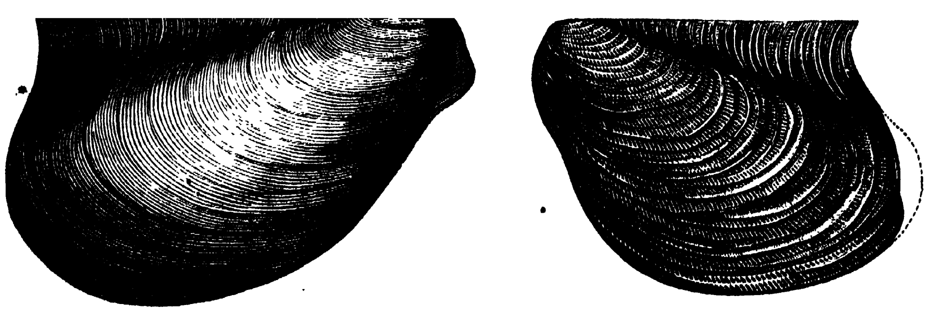


ORGANIC REMAINS OF THE HAMILTON GROUP.

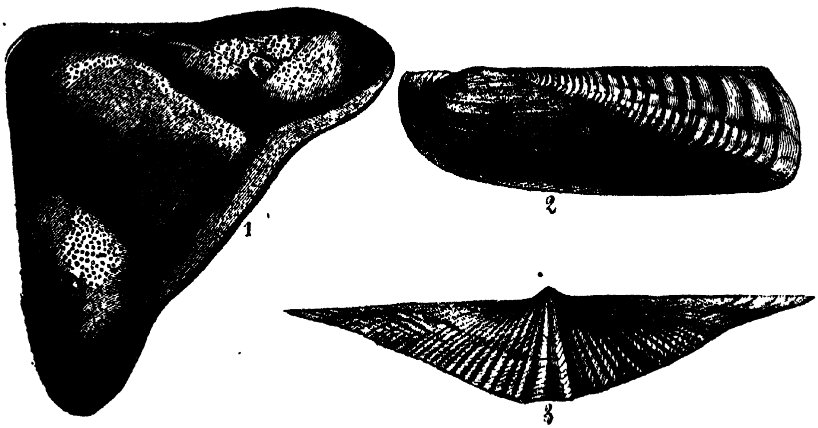
No. 45. — No. 84, page 205.

Fig. 1. *Dipleura Dekayi* (head), GREEN (Monograph, p. 79).
Fig 2. *Orthonota undulata*, CONRAD (Annual Geol Reports).
Fig. 3. *Delthyris mucronata*, CONRAD (Annual Reports). This is the common form of this fossil in the sandy shale of Eastern and Central New-York; at the west it is less elongated and more rotund. See figs. 2 and 3 of No. 41.

No 46. — No. 86, page 208.

Figs. 8, 8 *a* and 8 *b*. *Delthyris medialis*, H. Moscow.
Figs. 9 and 9 *a*. Two views of a young shell of the same species as the above. Moscow.
Fig. 10. *Delthyris fimbriata*, CONRAD (Jour. Acad Nat. Sci. Vol. 8, p. 263).
Fig. 10 *a*. Cast of the upper valve of the same fossil.
Fig. 10 *b*. A small portion of the shell magnified. Moscow.

No. 45.



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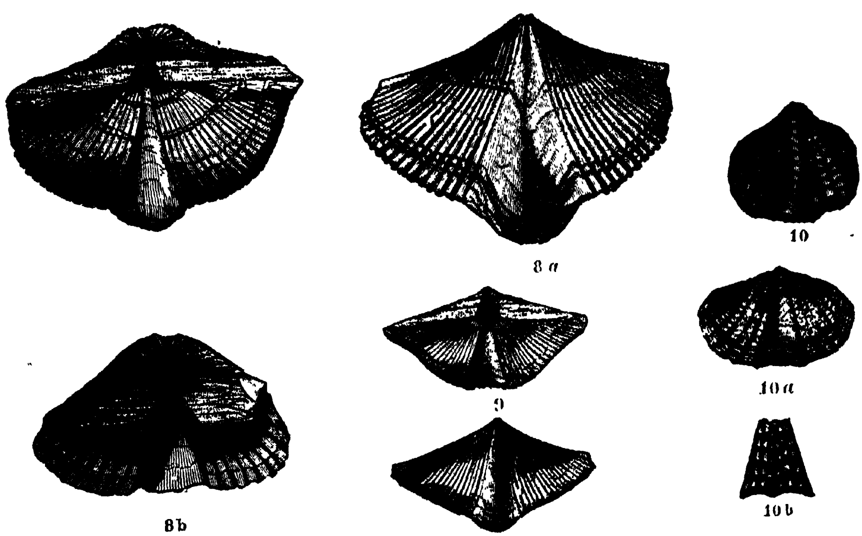


ORGANIC REMAINS OF THE HAMILTON GROUP.

No. 47. — No. 85, page 207.

Fig. 1. *Delthyris granulifera.*

Fig. 1 *a*. End view of the same, showing the spiral coil within the shell. Pavilion, Genesee county.

Fig. 1 *b*. A specimen with a more extended hinge line. Moscow.

Figs. 1 *c* and 1 *d*. A younger shell of the same species. Pavilion.

Figs. 2 and 2 *a*. *Delthyris congesta*, H. Seneca lake shore.

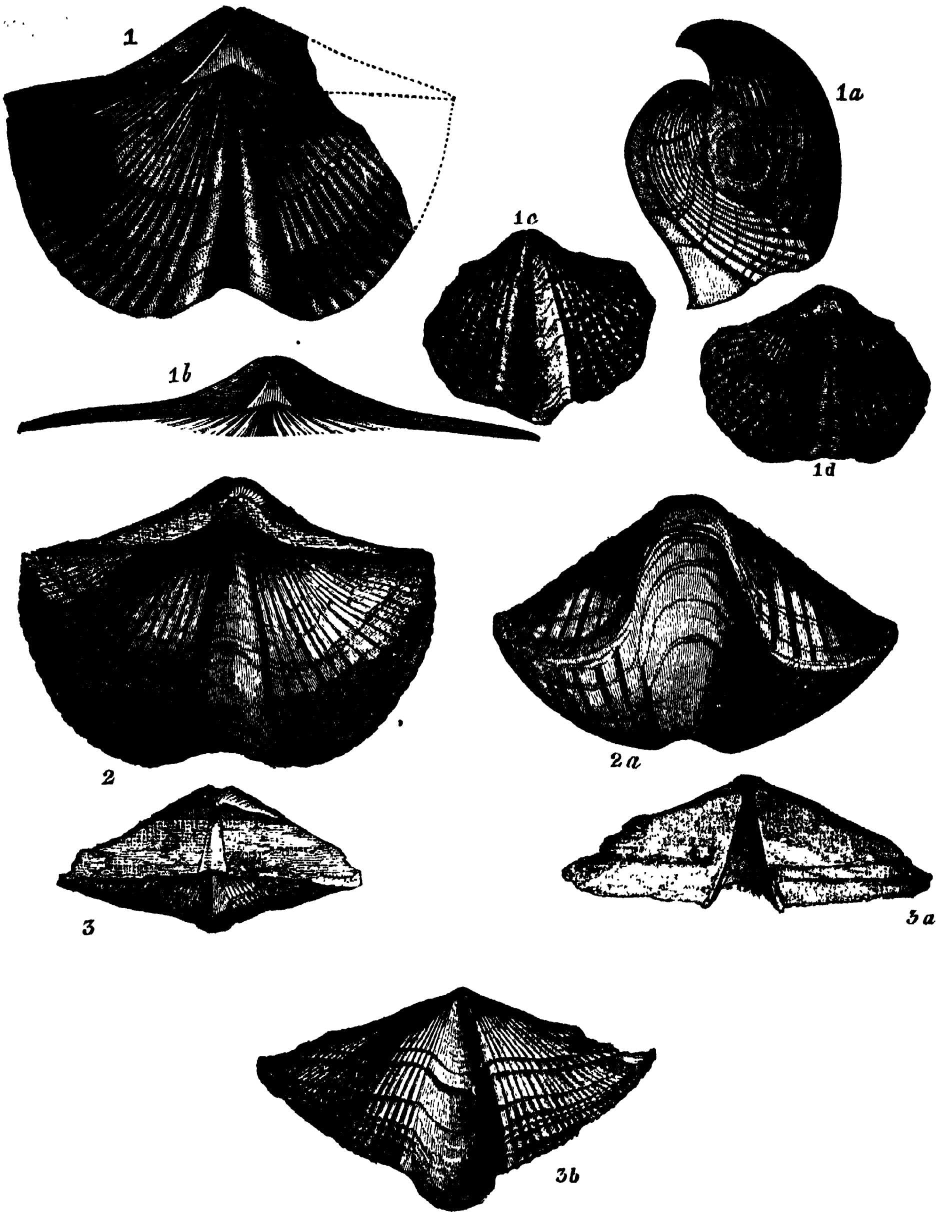
Fig. 3. *Delthyris mucronata*, H. View of the hinge.

Fig. 3 *a*. Area of lower valve.

Fig. 3 *b*. Lower valve. Moscow.

ORGANIC REMAINS OF THE HAMILTON GROUP.

No. 47.



ORGANIC REMAINS OF THE HAMILTON GROUP.

No. 48.—No. 87, page

Fig. 1. *Cystiphyllum cylindricum*, with *Aulopora tubæformis* attached. (LONSDALE in Silurian Researches, p. 691, pl. 16 bis, f. 3, 3 *a* and 3 *b*.)

Fig 2. *Cystiphyllum id*, a smaller specimen, with the bases of crinoidal columns attached. Eighteen-mile creek.

Fig. 3. *Strombodes helianthoides?* (PHIL. Palæozoic fossils, p. 11, pl. 5. f. 13. *Cyathophyllum helianthoidum*, GOLDFUSS, Petrefacta, pl. 20, f. 2.) York, Livingston county.

Fig. 4. *Strombodes distortus*, H. Moscow.

Fig. 5. *Strombodes? rectus*, H. Moscow.

Fig. 6. *Strombodes simplex?* H. This fossil resembles the *S. plicatum*, but is apparently distinct.

No. 49.

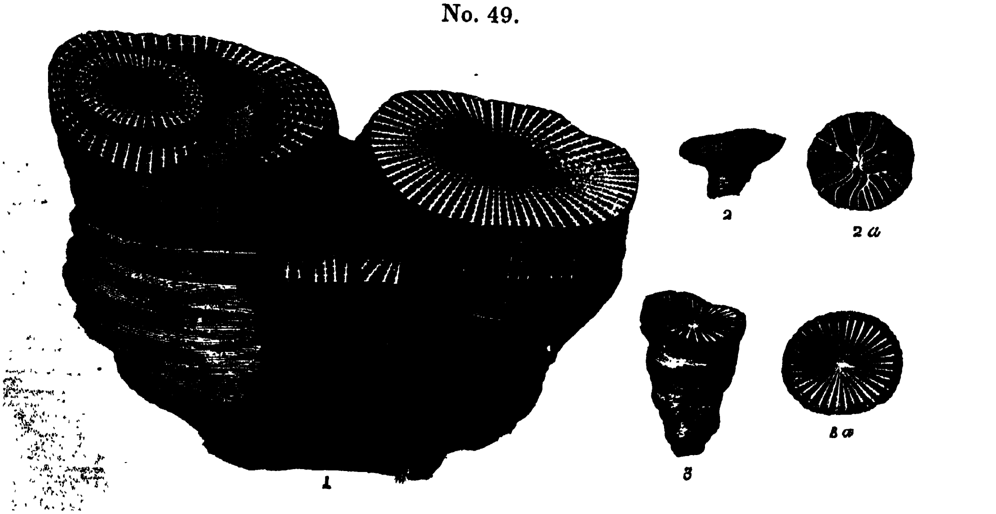
Fig. 1. *Cyathophyllum* (*Strombodes?*) *turbinatum?* (GOLDFUSS, p. 56, pl. 16, fig. 8.) York, Livingston county.

Fig. 2 and 2 *a*. *Strombodes* —— ? A young individual. York.

Fig. 3 and 3 *a*. *Cyathophyllum* —— ? A rare but strongly marked species. Moscow.

No. 48.

No. 49.



ORGANIC REMAINS OF THE TULLY LIMESTONE.

No. 50. — No. 92, page 215.

Fig. 1. *Atrypa cuboides?* (Reference, SOWERBY, Geol.Trans. 2d series, Vol. 5, pl. 56, f. 24. PHILLIPS, Palæozoic fossils, page 81, pl. 31, f. 150. Pages 215 and 216 of Report.)

Fig. 2. *Orthis resupinata*. (PHILLIPS, Palæozoic fossils, p. 67, pl 27, f. 115. *Spirifera resupinata* of the same author; Geol. of Yorkshire. *Terebratula resupinata*, Sow. Min. Conch. t. 325. *Anomites resupinatus*, MARTIN. *Orthis Tulliensis*, Report of Third District, page 163.)

Fig. 3. *Atrypa lentiformis*, VANUXEM (Geol. Report, page 165).

Fig. 4. *Atrypa affinis*. (For synonymes and references, see page 198 of this report.) This fossil is partially a cast, with the shell remaining on the edges which are compressed.

Fig. 5. *Atrypa cuboides?*

ORGANIC REMAINS OF THE GENESEE SLATE.

No. 51. — No. 94 and 95, pages 222 and 223.

Figs. 1 and 2. *Avicula fragilis*, H.

Fig. 3. *Strophomena setigera*. See fossils of the Marcellus shale.

Fig. 4. *Tentaculites fissurella*. See fossils of the Marcellus shale.

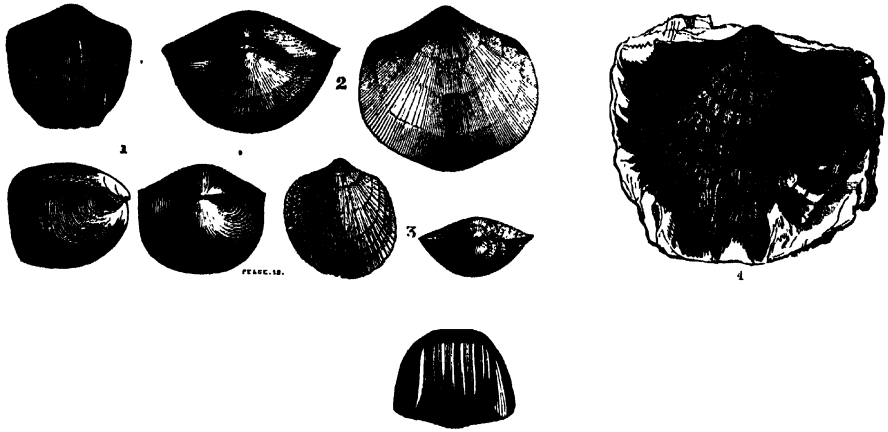
Fig. 5. *Lingula spatulata*.

Fig. 6. *Lingula concentrica*.

Fig. 7. *Atrypa quadricostata*.

Fig. 8. *Orbicula lodensis*. The four last figures are from the Report of the Third District.

No. 50.



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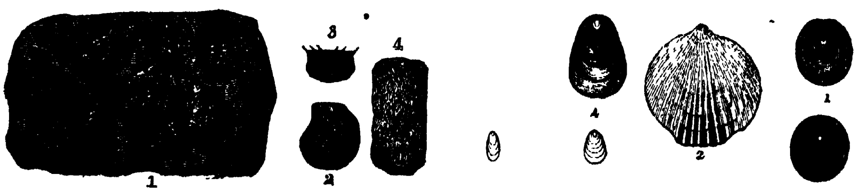


ORGANIC REMAINS OF THE PORTAGE GROUP.

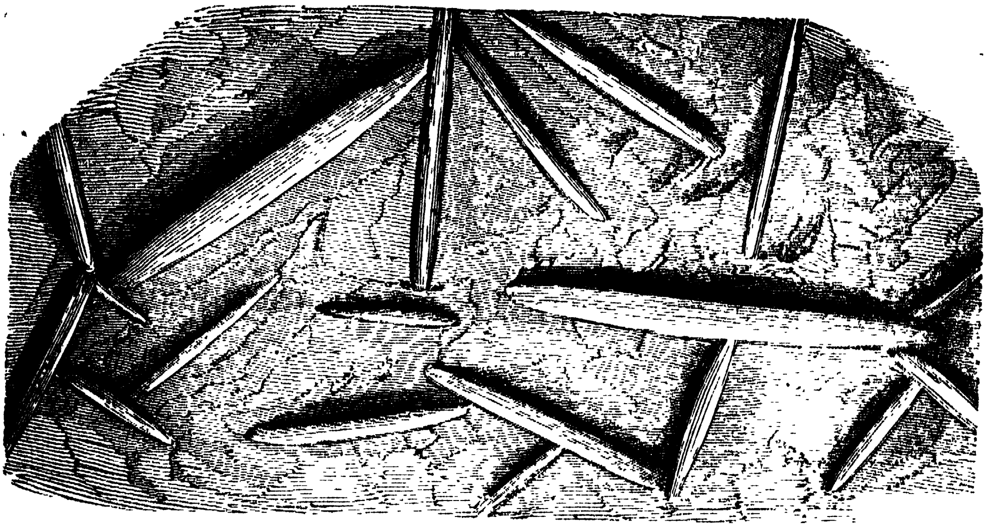
No. 52. — No. 104, page 241.

Fucoides graphica. Flagstones of Gardeau.

No. 53. — No. 105, page 242.

Fucoides verticalis. Sandstone of Portage.

No. 52.



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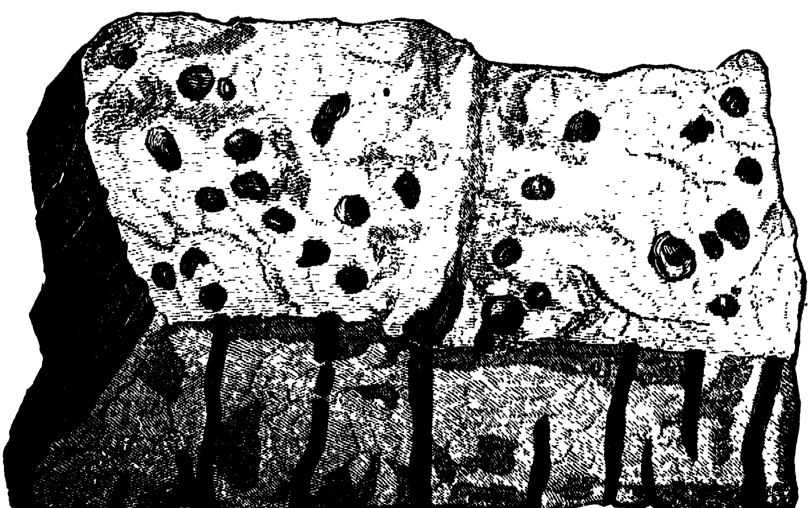


ORGANIC REMAINS OF THE PORTAGE GROUP.

No. 54. — No. 106, page 243.

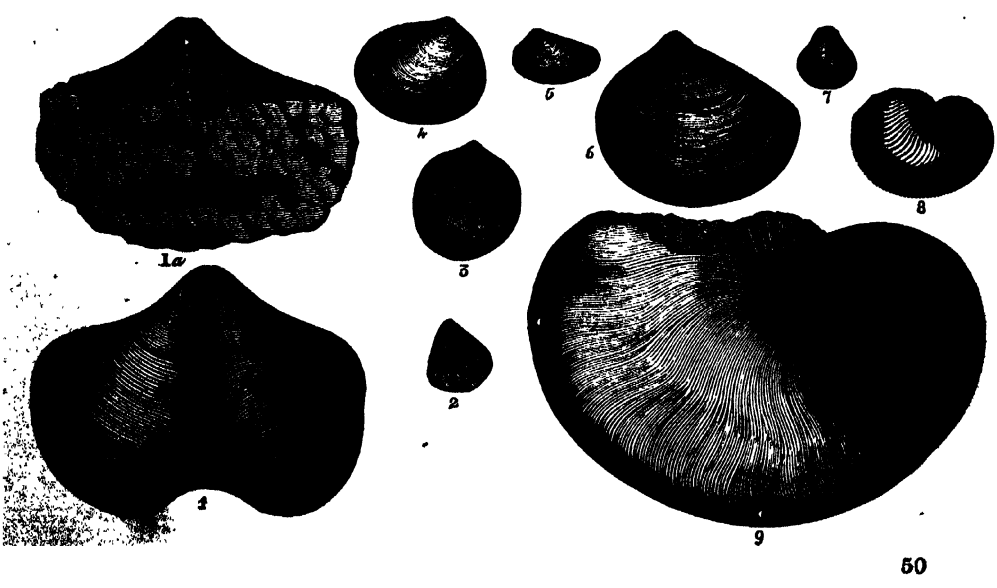
Fig. 1 and 1 *a*. *Avicula speciosa*, H. Cashaqua shale, on Cashaqua creek.
Fig. 2. *Ungulina suborbicularis*, H. Cashaqua creek.
Fig. 3. *Bellerophon expansus ?* (Silurian researches, pl. 5, fig. 37.) Cashaqua creek,
Fig. 4. *Orthoceras aciculum*, H. Cashaqua creek.
Fig. 5. *Clymenia? complanata*, H. Cashaqua creek.
Fig. 6. *Goniatites sinuosus*, H. Cashaqua creek.
Fig. 7. *Pinnopsis acutirostra*, H. Cashaqua creek.
Fig. 8. *Pinnopsis ornatus*, H. Cashaqua creek.

No. 55. — No. 107, page 245.

Fig. 1 and 1 *a*. *Delthyris lævis*, H. Western shore of Cayuga lake.
Fig. 2. *Cardium? vetustum*, H. Shore of Lake Erie.
Fig. 3. *Orthis tenuistriata*, H. Crooked lake shore.
Fig. 4. *Lucina? retusa*, H. Lake Erie shore, in Chautauque county.
Fig. 5. *Nucula lineolata*, H. Occurs with the last.
Fig. 6. *Astarte subtextilis*, H. With the last.
Fig. 7. *Bellerophon striatus ?* Bronn. (Phillips, Palæozoic fossils, pl. 40, f. 198.) With the last on Lake Erie shore.
Fig. 8. *Goniatites bicostatus*, H. Chautauque county.
Fig. 9. *Goniatites sinuosus*, H. As above, fig. 6. Chautauque county.

No. 54.

No. 55.



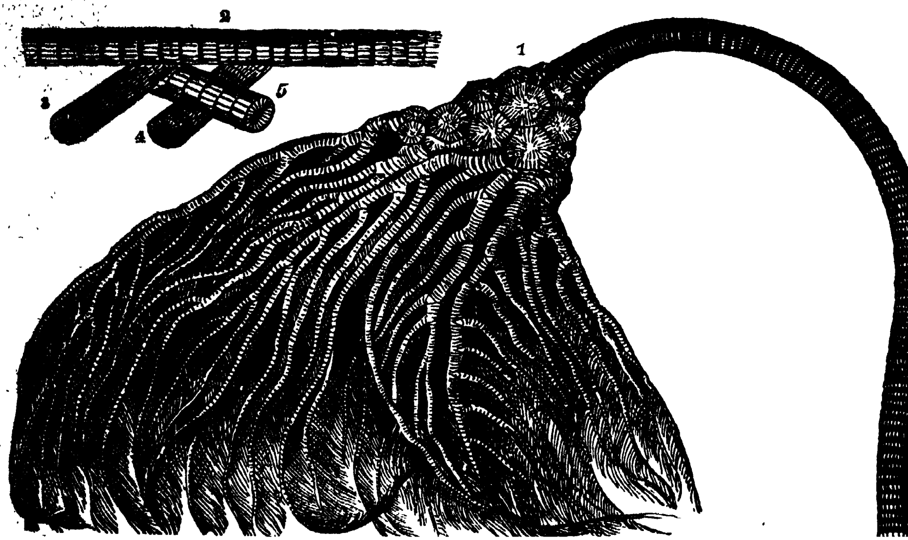
ORGANIC REMAINS OF THE PORTAGE GROUP.

No. 56. — No. 108, page 247.

Fig. 1. *Cyathocrinus ornatissimus*, H.

Figs. 2, 3, 4 and 5. Portions of the column at different distances from the base. Lake Erie shore, Chautauque county.

No. 56.



ORGANIC REMAINS OF THE CHEMUNG GROUP.

No. 57. — No. 116, page 262.

Fig. 1. *Calymene nupera*, H. (Reference *C. lævis*, PHIL. Palæozoic fossils, pl. 55, fig. 250.)

No. 58. — No. 117, page 262.

Figs. 1 and 2. *Avicula pecteniformis*, H. Lower and upper valve. An abundant fossil of the Chemung group.

Fig. 3. *Avicula longispina*, H. Painted-Post.

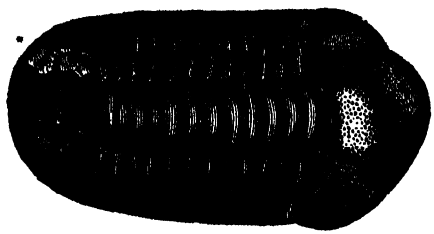
Fig. 4. *Avicula spinigera*, CONRAD (Jour. Acad. Nat. Sci. Vol. 8, p. 237, pl. 12, fig. 3.) Painted-Post.

No. 59. — No. 118, page 263.

Fig. 1 *a* and *b*. *Avicula damnoniensis*, (SOWERBY, in Geol. Trans. 2d series, Vol. 5, pl. 53, fig. 22. PHILLIPS, Palæozoic fossils, pl. 23, figs. 90, 91 and 92.)

ORGANIC REMAINS OF THE CHEMUNG GROUP.

No. 57.



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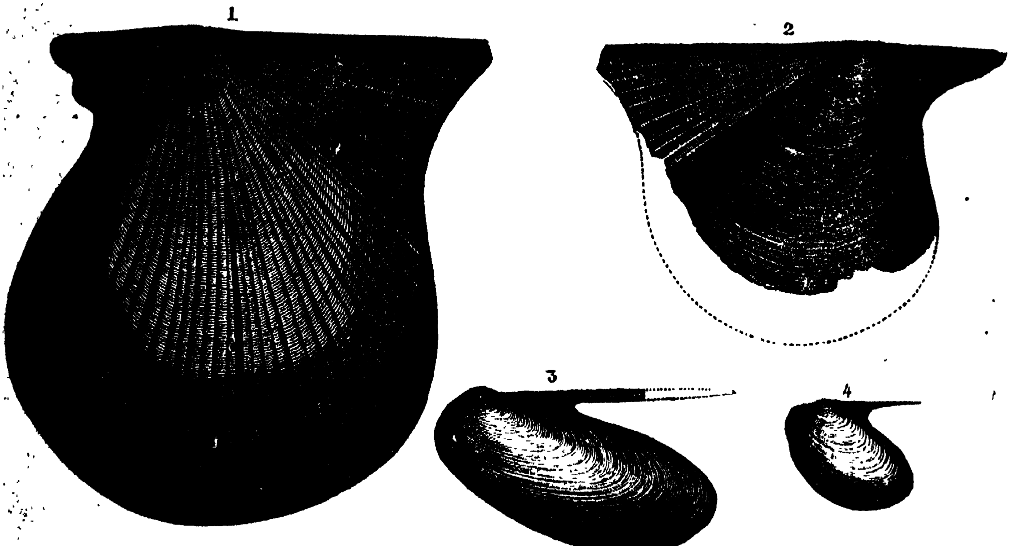

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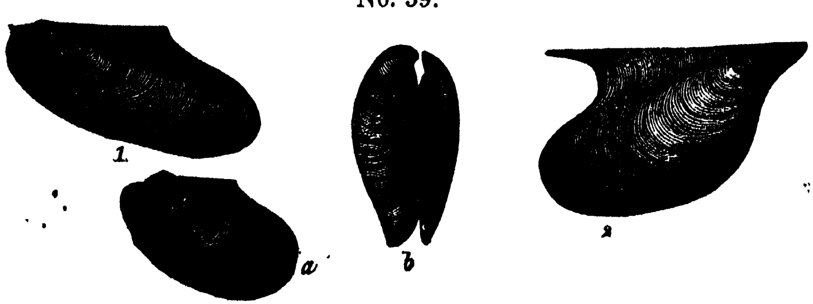


ORGANIC REMAINS OF THE CHEMUNG GROUP.

No. 60.—No. 119, page 264.

Fig. 1. *Pterinea? suborbicularis*, H. Hobbieville, Allegany county.
Fig. 2. *Pecten duplicatus*, H. Phillipsburgh, Allegany county.
Fig. 3. *Lima rugæstriata*, H. Rockville, Allegany county.
Fig. 4. *Pecten cancellatus*, H. Phillipsburgh.
Fig. 5. *Avicula? signata*, H. Rockville.
Fig. 6. *Pecten? convexus*, H. Rockville.
Fig. 7. *Pecten striatus*, H. Painted-Post.
Fig. 8. *Pecten? crenulatus*, H. Rockville.
Fig. 9. *Pecten? dolabriformis*, H. Rockville.
Fig. 10. *Lima glaber*, H. Phillipsburgh.
Fig. 11. *Lima? obsoleta*, H. Phillipsburgh.

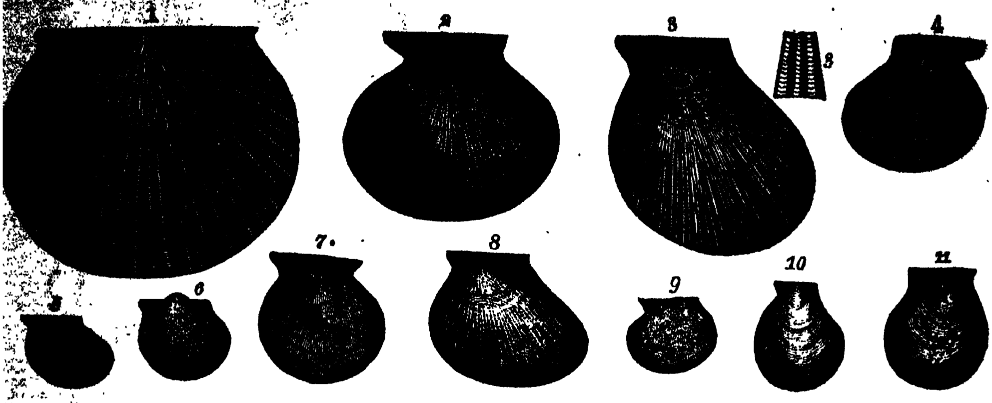
No. 61.—No. 120, page 266.

Fig. 1. *Strophomena nervosa*, H.
Fig. 1 *a*. An enlarged portion of the shell. Campbelltown, Steuben county.
Fig. 2. *Strophomena bifurcata*, H. Napoli, Cattaraugus county.
Fig. 3. *Strophomena arctostriata*, H. Hobbieville, Allegany county.
Fig. 4. *Strophomena pectinacea*. Hobbieville.
Fig. 5 *a*, *b*, *c*. *Strophomena interstrialis*, *Orthis interstrialis* and *Leptæna interstrialis*. (Phillips, Palæozoic fossils, pages 61 and 216, pl. 25, fig. 103.) 5 *a*. Inner side of a flat valve. Chemung. 5 *a*. A magnified portion of the shell. 5 *b*. The two valves somewhat compressed. Ithaca. 5 *c*. The convex valve with the shell partially removed. Elmira.

No. 62.—No. 121, page 267.

Figs. 1 and 1 *a*. *Orthis carinata*, H. Painted-Post.
Fig. 2. *Orthis impressa*, H. Near Elmira.
Figs. 3 and 4. *Orthis interlineata*, (Sowerby in Geol. Trans. 2d series, Vol. 5, pl. 54, fig. 14. Phillips, Palæozoic fossils, p. 63, pl. 26, f. 106.)
Fig. 5. *Orthis unguiculus*, *Atrypa unguiculus*, (Sowerby in Geol. Trans. 2d series, Vol. 5, pl. 54, fig. 8. *Spirifera unguiculus*, Pal. fossils, pl. 26, f. 119.)
Fig. 5 *a*. A cast from Bald Hill, near Ithaca.
Fig. 5 *b*. Lower valve, broad variety. Dexterville, Chautauque county.
Fig. 5 *c*. Upper valve. Painted-Post.
Fig. 5 *d*. Fragment of brownish sandstone, filled with casts of the shell. Jasper, Steuben county.

No. 60.



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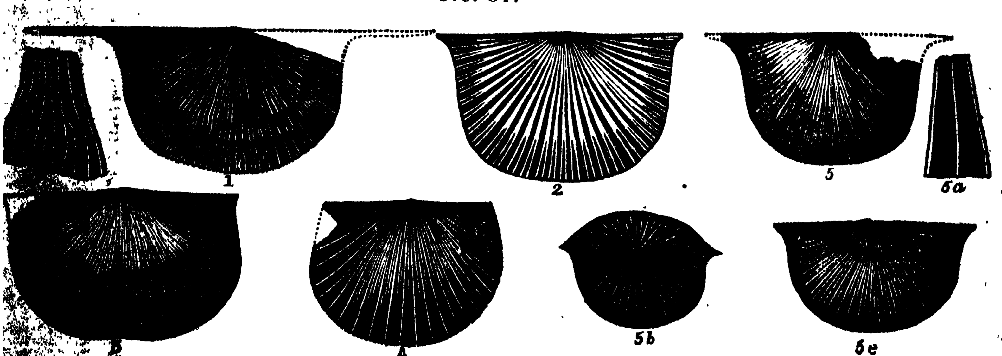

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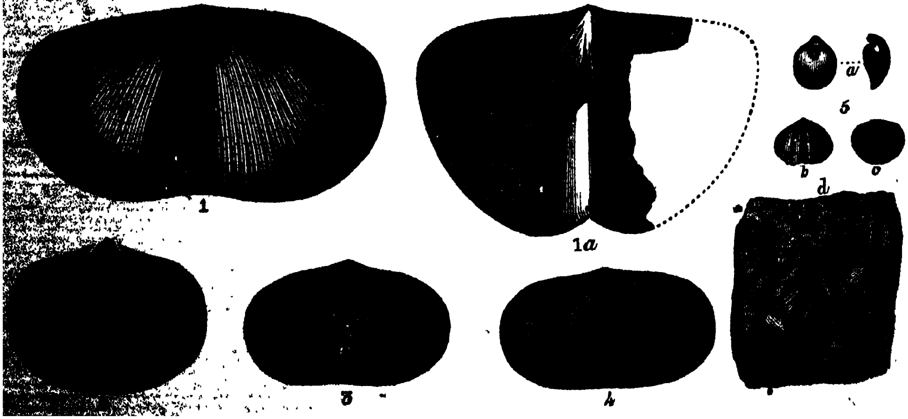


ORGANIC REMAINS OF THE CHEMUNG GROUP.

No. 63. — No. 122, page 269.

Figs. 1 and 1 *a*. *Delthyris mesastrialis*, H. Cayuta creek.

Fig. 2. *Delthyris mesacostalis*, H. Angelica.

Fig. 3. *Delthyris disjuncta?* PHILLIPS (Palæozoic fossils, pl. 29, fig. 128, f. g. h., and 129, pl. 30, fig. 129). Chemung.

No. 64. — No. 123, page 270.

Fig. 1. *Delthyris cuspidata*, H. This fossil resembles some of the varieties of *Spirifera disjuncta*. (SOWERBY, Geol. Trans. 2d series, Vol. 5, pl. 54, figs. 12, 13; pl. 55, fig. 2; also Pal. fossils as quoted above.) Cayuta creek.

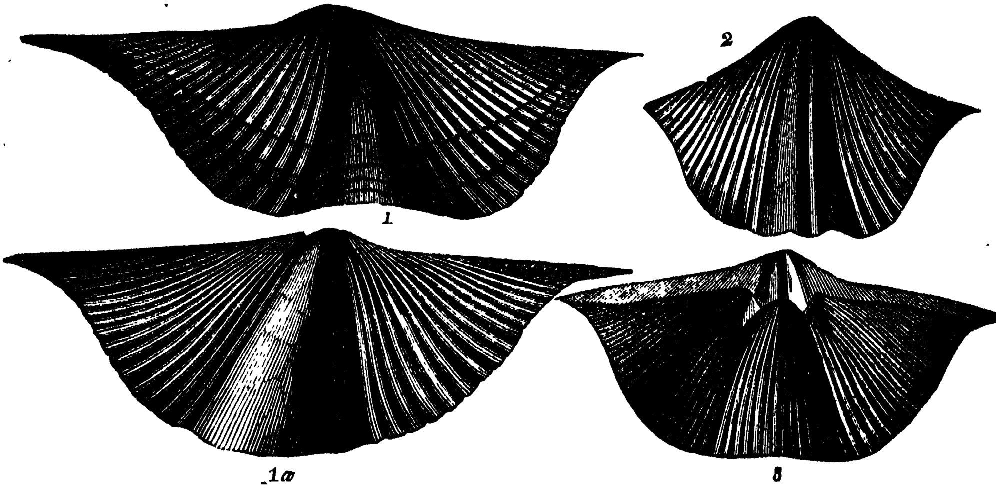
Fig. 2. *Delthyris acanthota*, H. Upper and lower valves. Chemung.

Fig. 3. *Delthyris mucronata?* (See fossils of Hamilton group.) This is the only specimen resembling this fossil seen in the Chemung group.

Figs. 4 and 4 *a*. *Delthyris inermis*, H. Twenty-mile creek, Chautauque county.

Fig. 5. *Delthyris acuminata*, H. 5 and 5 *a*. Internal casts of the shell. 5 *b*. Enlarged portion of a cast of the external surface. Ithaca.

No. 63.



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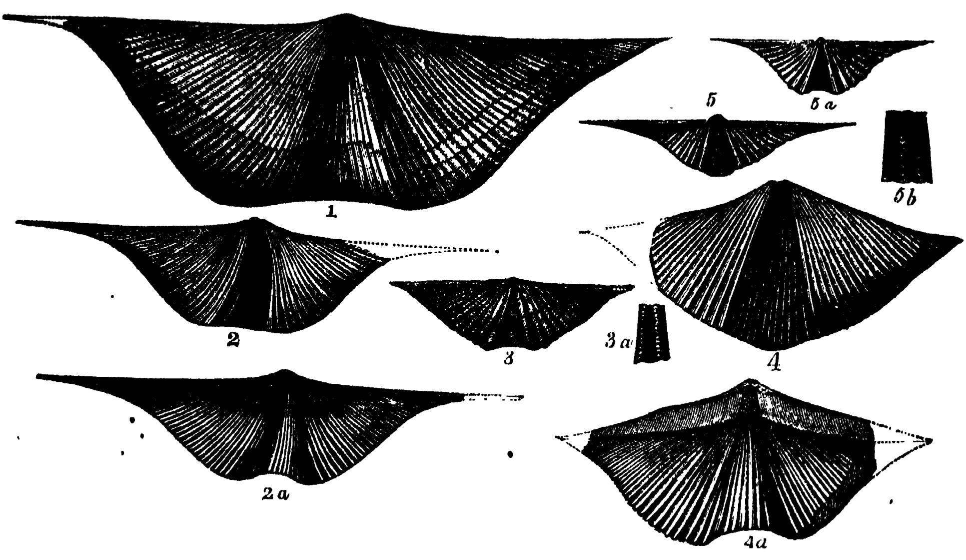


ORGANIC REMAINS OF THE CHEMUNG GROUP.

No. 65. — No. 124, page 271.

Fig. 1 and 1 *a*. *Atrypa dumosa*, H. 1 *b*. Cast of the same. Chemung and Elmira.
Fig. 2. *Atrypa hystrix*, H. Bath, Steuben county.
Fig. 3 and 3 *a*. *Atrypa tribulis*, H. 3 *b*. Cast of the same. Ithaca and Chemung.
Fig. 4. *Atrypa ? tenuilineata*, H. Cattaraugus county.

No. 66.

Fig. 1 *a*, *b*, *c*, *d*. *Atrypa laticostata*, *Terebratula laticostata*. Phillips (Palæozoic fossils, p. 85, pl. 34, fig. 153). These are all apparently varieties of the same shell, and referable to this species.

Fig. 2. *Atrypa laticostata*, var.? This species has six ribs distinctly elevated in front, while the other varieties have usually but three ribs elevated. It is probably a distinct species.

Fig. 3. *Atrypa*. (Species undetermined.) Greenwood, Steuben county.

Fig. 3 *a*. *Atrypa contracta*, H. About three ribs elevated in front. Shell contracted. Greenwood, Steuben county.

Fig. 4, 4 *a* and 4 *b*. *Atrypa eximia*, H. This is an abundant form at Ithaca; often associated in great numbers, but rarely with any other fossil.

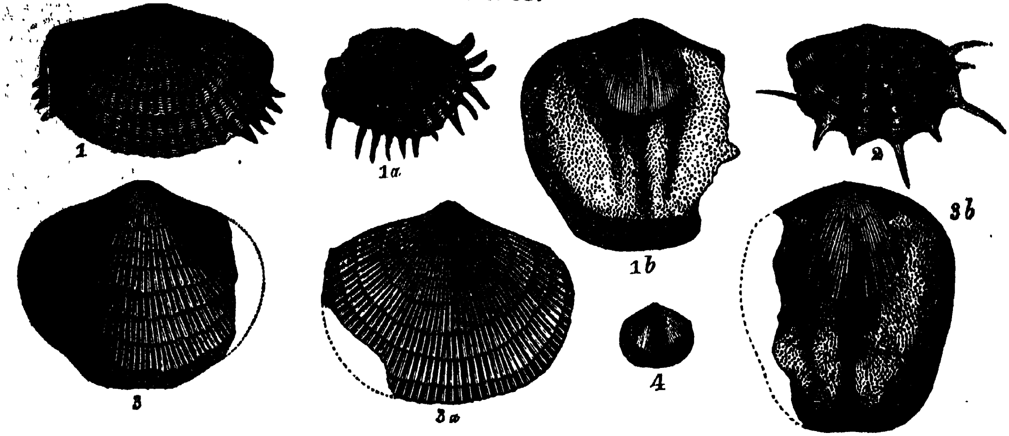
Fig 5. *Atrypa polita*, H. A very neat shell, with the lower valve much elevated in front. Jasper, Steuben county.

No. 67.

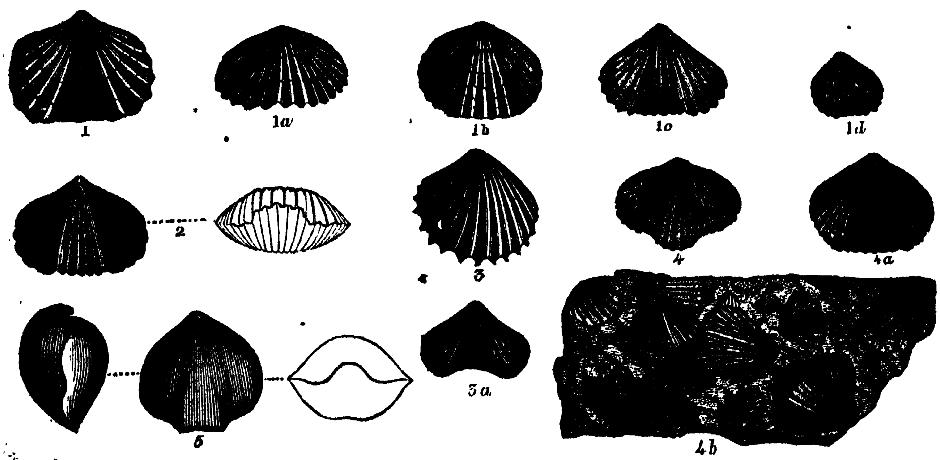
Fig. 1, 1 *a*, and 1 *b*. *Atrypa mesacostalis*, H. Shell with from four to six strong ribs along the mesial elevation and depression of either valve, while they become obsolete toward the margins. The casts are very common everywhere. Ithaca, Chemung, &c.

Fig. 2, 2 *a*, and 2 *b*. *Atrypa duplicata*, H. Shell with two ribs elevated in front, and two on each side the mesial fold. Dexterville, Chautauque county.

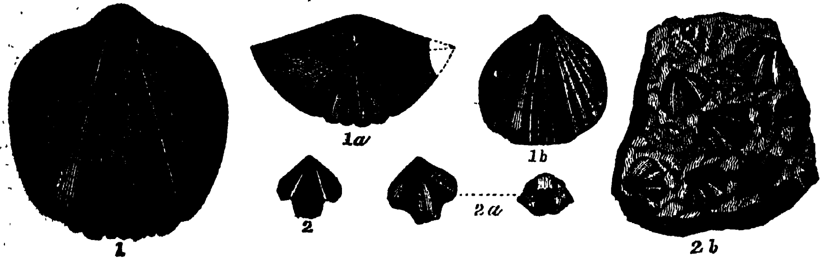
No. 65.



No. 66.



No. 67.

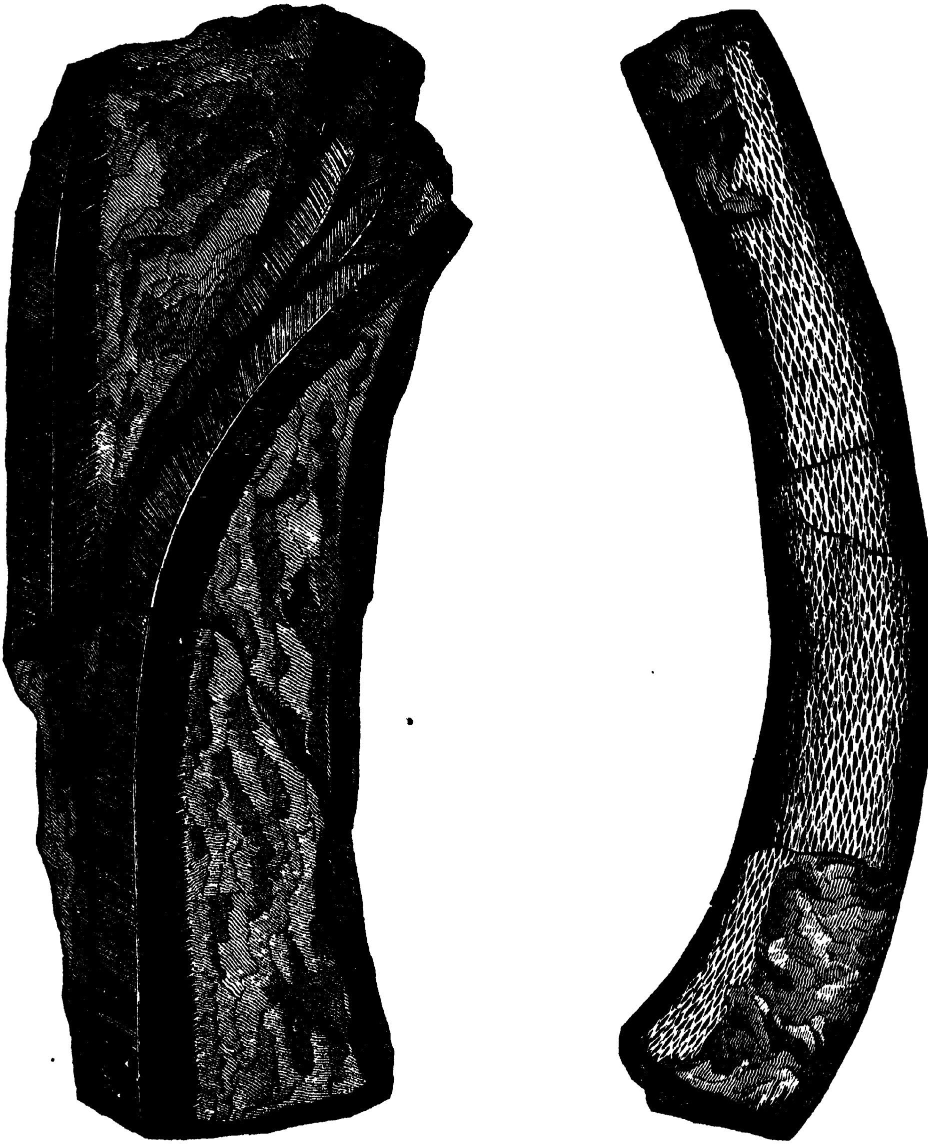


ORGANIC REMAINS OF THE CHEMUNG GROUP.

No 68.—No. 125, and part of 127, pages 273 and 275.

Fig. 1. *Filicites?* An abundant fossil at Ithaca and other places in Tompkins county.
Fig. 2. *Sigillaria Chemungensis*, H. One-half the natural size. Elmira.

No. 68.

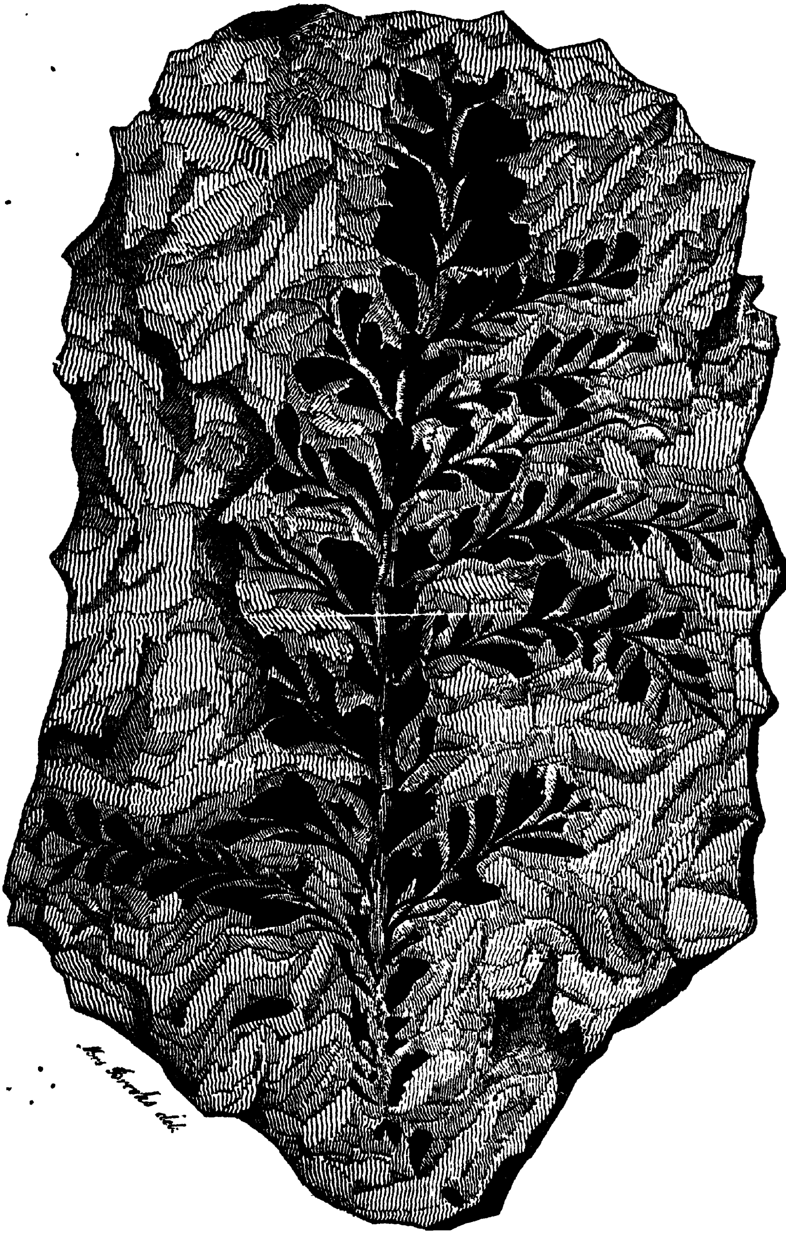


ORGANIC REMAINS OF THE CHEMUNG GROUP.

No 69. — No. 127, page 275.

Fig. 1. *Sphenopteris laxus*, H. Pine valley. This is the only specimen of this fossil yet observed.

No. 69.



ORGANIC REMAINS OF THE OLD REDSANDSTONE.

No. 70. — No. 130, page 281.

Fig. 1. Scale of *Sauripteris Taylori*, H.

Fig. 2. Scale of *Holoptychus nobilissimus*, Agass. (Silurian Researches, plate 2 bis. figs. 1, 2, 3, 4, 8 and 9).

Fig. 3. A smaller scale of *Holoptychus ?*

Fig. 4. A fragment of a tooth waterworn before being imbedded.

No. 71. — No. 131, page 282.

Jaw-bone and teeth of *Holoptychus*.

For further illustration of the fossils of the Old red sandstone, see plate 3 of this report.

No. 72. — Page 186.

Cypricardia ? angustata. Report of Third District.

ORGANIC REMAINS OF THE CONGLOMERATE.

No. 73. — No. 139, page 291.

Fig. 1. *Euomphalus depressus*, H. (Reference *E. serpens*, Phil. Pal. Fossils, pl. 36, fig. 172.)

Figs. 2 and 3. *Cypricardia rshombea*, H.

Fig. 4. *Cypricardia contracta*, H.

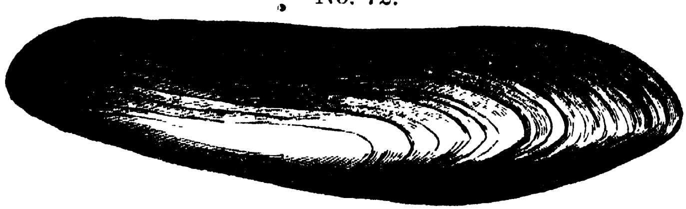
These fossils are all from a single locality in Chautauque county, and the only place where I have seen fossils in the conglomerate.

ORGANIC REMAINS OF THE OLD REDSANDSTONE, etc.

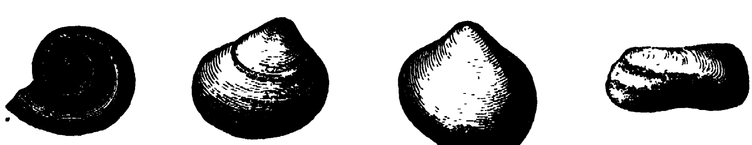
No. 70.

No. 71.

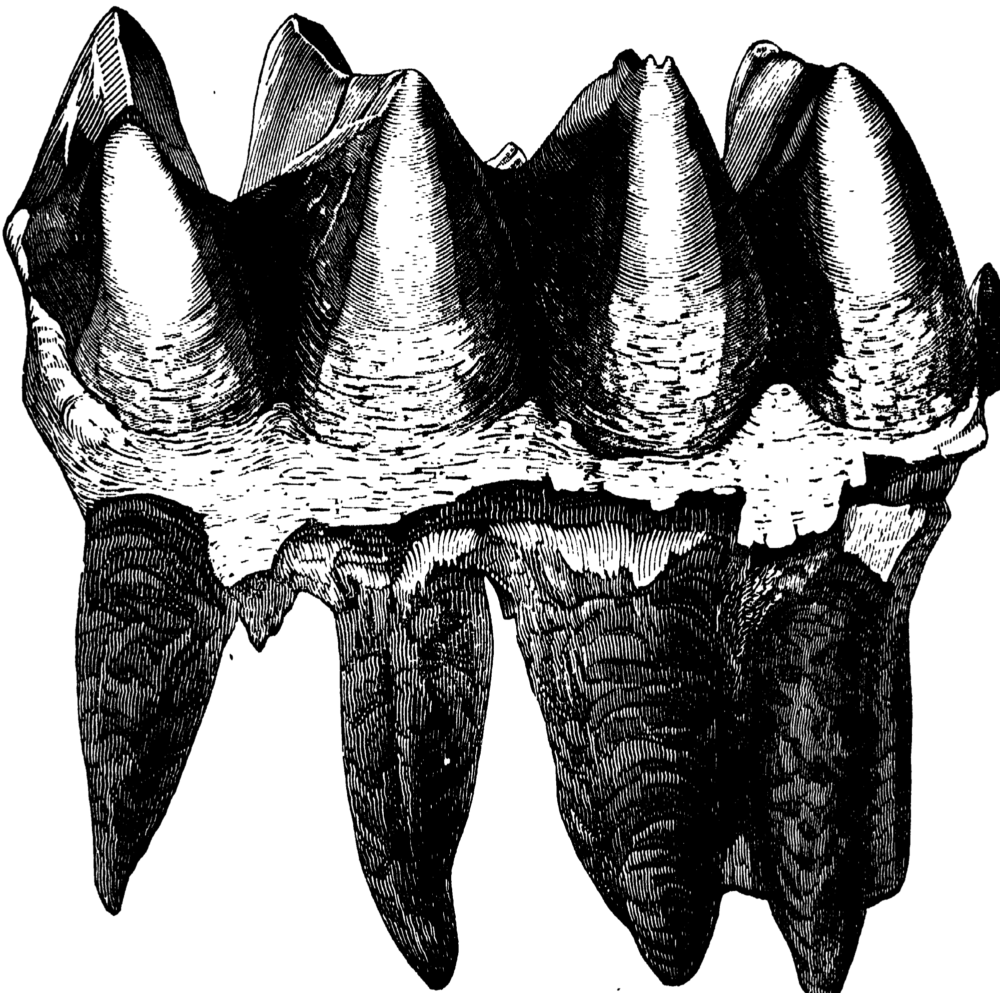
No. 72.



No. 73.



No. 71.



Tooth of *Mastodon maximus* (see page 363)

CLINTON GROUP.

Illustrations No. 7 and 8, transposed

NIAGARA GROUP.

No. 11 is repeated at the head of the page over *Strophomena.* The numbers in this one and the five following ones should be made to correspond with those on the opposite page, viz. 12, 13, 14, 15, 16, 17.

In the names and references for No. 31, *Delthyris anaulus*, with its synonymes, follows in the same line with *Delthyris decemplicata;* this should commence the line below, preceded by fig. 8.

CORNIFEROUS LIMESTONE.

In the illustration No. 38, fig. 8 is accidentally removed from *Strophomena lineata* (See page 175 of the Report)

GENESEE SLATE.

Illustration 51: the numbering of fossils, after 1, should be 5, 6, 7, 8 (See page 225 of Report)

CHEMUNG GROUP.

Illustration 59, fig. 2 *Avicula acanthoptera*, name omitted

APPENDIX.

(A.)

Ridge Road of Lake Ontario.

The elevations given of the Ridge Road bordering Lake Ontario, shows no important variations within the limits of the Fourth District. Since that portion of the Report passed through the press, I have had an opportunity of examining a continuation of the same, or another similar ridge, in the northern part of Oswego and the southern part of Jefferson counties, and about six or eight miles distant from the shore of Lake Ontario. This ridge is about four hundred feet higher than the lake, but having been traced only for a few miles, it is impossible to say whether it continues at a uniform elevation. I am aware that this discrepancy in the elevations between this portion and that in the western part of the State, has been urged as an objection to the supposed mode of its production. I consider, however, that the existence of such a ridge, with all the attendant phenomena before noticed, is paramount to every objection regarding its mode of formation, and different elevations of different portions do not in the least impair the force of the conclusion.

In the example before us, it offers a fact in proof that the lake was not quietly drained by the reduction of the barrier at its outlet, but that the change has taken place by an elevation of the land. The varying elevation of the ridge proves that the amount of upheaval was greatest towards the north-east, in the region of a nucleus of hypogene rocks, and that it gradually subsided towards the south-west, where the strata become undisturbed.

It is not improbable, however, that further investigations will prove the existence of a series of parallel ridges in New-York, showing the effects of successive elevations, aided likewise by a reduction of the outlet.

The different elevations of the well marked Tertiary deposits, upon the valley of Champlain and the St. Lawrence, as well as those upon the New England coast, become interesting in connexion with this subject; and, as before suggested, it is not improbable that future investigations will prove the elevations of these deposits, and the production of the lake ridges, to be synchronous, at least to a certain extent. Still it is very probable that some of the more elevated ridges may have emerged before any of the marine tertiary appeared above the level of the Ocean.

(B.)

Ridge Road of Lake Erie.

I have been furnished, by the Hon. G W. Patterson, of Westfield, Chautauque county, with the following elevations of the Ridge road extending along Lake Erie. The elevation of the Ridge road, where crossed by the New-York and Erie railroad, is one hundred and ninety feet above Lake Erie. At Westfield village, the elevation is one hundred and eighty-seven feet above Lake Erie, showing a difference of three feet between these two points, distant about fifteen miles. Mr. Patterson thinks that one hundred and ninety feet may be considered about the average elevation.

(C.)

Modern action of rivers in deepening their channels.

Under this head, many important facts have been omitted; and from some recent observations, I am satisfied that the operation of the present streams is far more effectual in deepening their channels, than even the most sanguine supporters of the power of existing causes would advocate.

Since this Report has passed through the press, I have had an opportunity of examining the Lebanon reservoir, in Madison county, (constructed for supplying the Chenango canal,) which, during the month of April, 1843, broke through the dam, and passing down a ravine, joined the Chenango valley.

The surface occupied by this reservoir was about ninety acres, with an average depth of about twenty-five feet. The dam at the outlet is of gravel, built very strong, and flagged upon the inner side with stones. During the thawing of the snow, the reservoir became filled; and the wasteweir being defective, it soon commenced undermining it, and the whole was removed in about an hour. The water then excavated a channel to the bottom of the dam, about thirty feet deep, through which it flowed off rapidly into a broad valley below. The force of the water here appears to have been inconsiderable; the materials of the dam lie spread over the bottom of the valley very uniformly, and the trees are still standing as before. About one quarter of a mile below the dam, the valley contracts, and the small stream flows in a gravelly channel with steep sloping banks. It is here that we first perceive the effects of this moving body of water, in uprooting and breaking the largest trees. These falling across the channel, formed with the earth and shrubs, temporary dams, until the accumulating force of the water carried all before it, prostrating hundreds of the largest trees. The gorge gradually narrows, and its bed and banks become rocky. These have been swept clean for many rods, where before they were covered with gravel and clay. For about a quarter of a mile before opening into the valley of the Chenango, the banks are of rock, and from thirty to fifty feet high. Between these banks, in a channel of fifty or sixty feet wide, this body of water bore its accumulated detritus, trees and timber. From the great pressure, owing in part to obstructions by the formation of temporary dams, the channel was both widened and deepened. Persons living in the vicinity, have estimated that the channel for a considerable distance was excavated to the depth of six feet. Two or three small falls along the stream have receded several rods, and huge fragments in immense numbers were torn from the sides of the ravine. The whole of this accumulated mass of earth and stones was forced out from the mouth of this ravine into the level valley of the Chenango; and after the water subsided, an extent of fifteen acres was found completely covered to the depth of from one to five or six feet. The thin-bedded sandstone from the bed and banks of the ravine lies in slabs of two to four feet in length and breadth. Boulders of limestone, sandstone and other northern rocks, are confusedly intermixed with the other materials. One of the boulders of limestone lying near the centre of this area of fifteen acres, I estimated from measurement to weigh about eight tons, and there were numerous smaller ones, and others of the Oriskany sandstone of three or four tons. The uprooted trees, and the timber of two mills which were destroyed in the course of the stream, were scattered over an extent of fifty acres. The passage of this body of water through the ravine occupied four or five hours, and nothing could exceed the grandeur of its resistless force.

What has here resulted from an artificial dam, may easily happen from natural causes. Many of our ravines open into broader valleys above, and a great body of snow melting in this situation and pressing toward the outlet, would carry forward any prostrate trees; these accumulating in some narrow passage would form a temporary dam, which, when broken away by the increasing pressure, would add new materials to form a stronger one at the next narrow pass. In this way the same scenes may be enacted as in the case just described, and the bed of a ravine or stream may be deepened several feet in a few hours.

The process here described, with others before mentioned, operating through ages, is sufficient to produce the deep ravines which we now find, though the quantity of water flowing in them may never have been much greater than at present. The actual amount of excavation produced in this way is immense, and I am perfectly satisfied that the same causes have always operated from the incipient stages of these deep gorges to their present condition. In favorable situations, large and comparatively permanent lakes may have been thus formed, and their subsequent bursting produced the phenomena attributed to lakes originally remaining on the higher ground.

(D.)

Elevation of Lakes.

The following memorandum of the elevation of some of the smaller lakes was mislaid at the time that chapter passed through the press. These elevations were furnished by Mr. Healy, an engineer on the New-York and Erie railroad.

	FEET.		
Bear lake summit	755.4	above Lake Erie.	
Cattaraugus lake summit	725.5	"	"
Mud lake	833.7	"	"
Cassadaga lake	725.0	"	"
Leavenworth summit, between the valley of the Little Connewango, in Randolph, and the Allegany	859	"	"

(E.)

Elevation and depression of water in the Great Lakes.

For numerous interesting facts in relation to this subject, see an article in the 16th volume of Silliman's Journal, by Gen. H. A. S. Dearborn.

See also a pamphlet on the same subject by Edward Giddings, of Lockport.

(F.)

Salines.

In the course of this Report, several unimportant salines were mentioned as occurring in the higher groups of the system. One of these was at Jefferson, and another near Big-stream point. As they appeared to offer no inducements for further exploration, they have merely received the attention which was considered due to them. Since this Report has passed through the press, I have learned that salt in considerable quantity has been made from a similar spring in Dundee, Yates county. Not having visited the place, I am unable to say what probability there is of a supply of brine; and in the absence of any definite information on the subject, this notice is all that can be given.

(G.)

Among the persons who have written upon subjects connected with the Geology of Western New-York, I have been able to name the following. Some of these have not been alluded to in the Report.

DR. BIGSBY on the Geology of Genesee county. *American Journal of Science and Arts*, Vol. 2, p. 250.
SAY on the Fossils of New-York. ID. Vol. 1, p. 384; Vol. 2, p. 31.
EATON on the Geology of the Salt springs. ID. Vol. 6, p. 242.
EATON on the Geology of the District along the Erie canal. ID. Vol. 8, p. 195, and Vol. 13, p. 383.
GEDDES on the Geology of Ontario valley. ID. Vol. 11, p. 213.
EATON on Diluvial deposits. ID. Vol. 12, p. 17.
J. VAN RENSSELAER, Remains of the Mastodon in Ontario county. ID. Vol. 12, p, 381.
DEARBORN on the variations in the level of the lakes. ID. Vol. 16, p. 79.
Carburetted hydrogen at Fredonia. ID. Vol. 17, p. 398.
THOMAS on Diluvial scratches and furrows. ID. Vol. 17, p. 408.
WADSWORTH on the Geology of the Genesee river. ID. Vol. 18, p. 209.
Buffalo Mineral Spring, Analysis of, by C. U. SHEPHERD. ID. Vol. 20, p. 156.
SILLIMAN on an Oil spring in Allegany county. ID. Vol. 23, p. 97.
ROGERS on the Falls of Niagara. ID Vol. 27, p. 326.
HAYES on the Geology and Topography of Western New-York. ID. Vol. 35, No. 1.
SAY on the Crinoidea. *Journal of the Academy of Natural Science of Philadelphia*, Vol. 4, p. 289.
BIGSBY on a Trilobite at Lockport. ID. Vol. 4, p. 765.
CONRAD on the Fossils of New-York. ID. Vol. 8, p. 235.
HAYES on the Inflammable springs in Ontario county. *New-York Medical and Physical Journal*, Vol. 3, p. 49.
HENRY's Topographical Sketch of New-York. *Transactions of the Albany Institute*, Vol. 1, p. 87.
GEDDES, Observations on the Geological features of the south side of the Ontario valley. ID. Vol. 1, p. 55.
HARLAN on the Eurypteris lacustris. *Transactions of the Geological Society of Pennsylvania*, Vol. 1, p. 98.
EATON's Canal Rocks, and his communications to Silliman's Journal.

A chapter upon the Agriculture of the District had been prepared for this work, as mentioned in the text; but since this department was subsequently committed to Dr. Emmons, it has been omitted as unnecessary, a separate report on the subject being in preparation.

INDEX.

D.

E.

H.

I.

DESCRIPTION OF PLATES.

PLATE I.

FOSSILS OF THE MEDINA SANDSTONE.

Fig. 1. Dictuolites Beckii.
— 2. Fucoides auriformis.
— 3. Fucoides heterophyllus.

PLATE II.

Surface of the Medina sandstone, showing the clouded appearance from different kinds of sand, the stranded fragments of rock and shells of Lingula. This is a common appearance upon the surface of the thin strata over many yards in extent, and throughout a thickness of many feet.

PLATE III.

Fin and scales of the Sauripteris Taylori, from the Old Red Sandstone. The fin is a little less than the natural size, and the scales are of the natural size. The sauroid character of this fin is well represented in the arrangement of the bones, as seen in the engraving.

PLATE IV.*

Natural section of the bank of the Niagara river, from the falls to Lewiston. The successive strata and their disappearance beneath the water are explained upon an inspection of the section. The water level is carried on from Lewiston southward, showing a depth of one hundred and four feet at the falls, being the actual descent in the surface between the two points.

* Plates IV, V, VI, VI A, and VI B, represent almost a continuous natural section from Lake Ontario to the Pennsylvania line. The low uninteresting banks occupied by the Onondaga salt group, from near Niagara falls to Black-Rock, and some other portions of little interest, are omitted, as being unimportant.

PLATE V.

Coast section of Lake Erie, from Black-Rock to one mile southwest of Sturgeon point. This section shows the succession of strata from the Corniferous limestone to the Hamilton group, with the lower members of the Portage group.

NOTE.—The figures below the section in this and the following plates indicate the distance, in miles, from Black-Rock or the outlet of Lake Erie.

PLATE VI.

Coast section of Lake Erie, continued from near Sturgeon point to the Lighthouse point at Dunkirk harbor. The rocks exhibited in this section belong entirely to the Portage group.

PLATE VI A.

Coast section of Lake Erie continued, from Van Buren harbor to Chautauque creek.

PLATE VI B.

Coast section of Lake Erie continued, from Chautauque creek to the Pennsylvania line. No rocks appear upon the lake shore higher than the Portage group, but by ascending a few miles from the lake shore the rocks of the Chemung group appear, and to these succeed the conglomerate, as seen in the section across Chautauque county.

PLATE VII.

Section across the formations from Lake Ontario to the northwest extremity of the bituminous coalfield of Pennsylvania, along the line between the third and fourth geological districts. The order of succession of the strata from the Medina sandstone to the coal formation is very clearly exhibited in an almost continuous natural section.

This section was intended for the Report of the Third District, but being engraved too late, was left by Mr. Vanuxem for the present report.

PLATE VIII.

Section of Lake Erie shore one quarter of a mile in length, showing broken strata and intermingled drift. The explanation accompanies the engraving. Numerous examples of this kind along the lake shore show the effects of that tremendous force which has broken up the solid strata and moved them southward. The motion of these fragments, with gravel and sand over surfaces still undisturbed, produce all the phenomena of striæ and grooves which are often attributed to other causes.

PLATE IX.

No. 1. Section across Wayne county.
— 2. Section across Ontario county.
— 3. Section across Ontario and Yates counties.
— 4. Section across Steuben county.

The two figures above at the right hand are of alluvial hills. By uniting the sections 1, 3 and 4, we have a continuous section across all the formations from Lake Ontario to the Pennsylvania line.

The outline of this and the sections of the three following plates are at a uniform elevation above Lake Ontario, and the numbers given indicate the height above that lake, in feet. The base of the sections is sometimes continued only as low as the level of Lake Erie, or even of Crooked lake. These variations are all indicated in the engraving.

PLATE X.

No. 1. Section across Wayne county.
— 2. Section across Seneca county.
— 3. Section across Tompkins county.
— 4. Section across Chemung county.

By uniting these four sections, a continuous one across the district is presented.

Section of the inclined plane at Ithaca. The letters a, b, c, d, &c. indicate the numerous alternations of hard and soft shale and shaly sandstone, with a few courses of compact calcareous sandstone.

PLATE XI.

No. 1. Section across Monroe county.
— 2. Section across Livingston county.
— 3. Section across Allegany county.

These three sections united present a continuous one across the district, along the Genesee river. This section shows the succession of strata from the Medina sandstone to the Old Red sandstone and Conglomerate.

No. 4. Section across Orleans county.
— 5. Section across Genesee county.
— 6. Section across Cattaraugus county.

These three sections present another continuous line of section across the district. The relative elevations of the surface are continued throughout.

PLATE XII.

No. 1. Section across Niagara county.
— 2. Section across Erie county.
— 3. Section across Chautauque county.

The three sections united constitute a continuous section across the western counties of the district.

The two outline sections, extending from Cayuga lake to the Genesee river and from thence to Lake Erie, are constructed from actual surveys, and present the elevations of the principal hills and valleys. The elevations here given are from the tables accompanying a topographical sketch of New-York (Transactions of the Albany Institute, Vol. I.).

PLATE XIII.

Section 1. Natural section along the Genesee river, from Mount-Morris to Portage, showing the Genesee slate succeeded by the rocks of the Portage group.

Section 2. Natural section along the Cattaraugus creek, exhibiting rocks of the Portage group.

Section 3. Section across the formations from Cleveland, on Lake Erie, to the Mississippi river.

This section commences with rocks of the Portage group, and shows the succession of the Chemung group, the Conglomerate and the Coal measures. Descending to the southwest, we pass over the same formations, which are underlaid by a black slate, resting on the Corniferous limestone of New-York. The Corniferous and Onondaga limostones are well represented; and below these we find a drab-colored soft limestone, which is followed by a continuation of the Niagara limestone. Below this we find impure arenaceous limestone, and thin-bedded limestone and shale, which show, by the contained fossils, their equivalency with the Hudson-river group of New-York. Following the section from Cincinnati southwesterly, very nearly the same order among the strata is observed, with the exception that the Chemung group is separated from the Conglomerate by a yellowish grey sandstone, with thin beds of oolitic limestone, and above this by thick-bedded grey limestone, which increasing westward forms the most important limestone formation of the Mississippi valley. This limestone is followed by the Conglomerate and the great Illinois coal-field.

Section 4. Section across the State of New-York from northeast to southwest, showing the natural order of succession among the strata, from the Primary upwards to the Conglomerate of the Carboniferous System. By uniting this section with the one above it, we have an almost continuous section from the northeastern part of New-York to the Mississippi river. In the space between Chautauque county, the termination of this section, and the commencement of the other at Cleveland, there are no rocks seen, except those of the Portage group.

PLATE XIV.

Surface of limestone, exhibiting furrows and striæ. *a*, *c*, *e*, *f*, *g* and *h* are nodules of hornstone. At *a*, *c* and *g*, these have resisted the wearing force, and are elevated above the general surface. At *e*, *f* and *h* the nodules have been broken off, so that their surface is now lower than the surface of the surrounding stone. From *a* to *b*, and from *c* to *d*, there is a little elevated ridge of stone remaining, which has been protected from wearing down by the hornstone before it. It will be perceived that the striæ are often convergent or divergent, and that near the bottom of the plate there are two which are curved and suddenly terminate.

PLATE XV.

View from Bigflats, looking down Chemung river. The hill on the south exhibits numerous gorges, or incipient ravines, which are annually deepened by the action of frost and water.

PLATE XVI.

Ravine at Hammondsport, Steuben county. Rocks of the Portage group. This is a common feature in the scenery of the southern counties.

PLATE XVII.

Hector falls, Tompkins county. This waterfall is almost directly from the top of the cliff into the lake, the gorge being worn back but a very short distance. Rocks of the Portage group.

PLATE XVIII.

Lodi falls, Seneca county.* This fall of water is over the rocks of the lower part of the Portage group, at the head of a gorge three-fourths of a mile from Seneca lake.

PLATE XIX.

Deep gorge of the Genesee below the Middle falls at Portage. The cliffs below the falls are of the rocks of the Portage group, three hundred and fifty feet in perpendicular height.

GEOLOGICAL MAP OF THE MIDDLE AND WESTERN STATES.

In this map are laid down the limits of the principal geological formations occupying the States of New-York, New-Jersey, Pennsylvania, Delaware, Maryland, Virginia, Kentucky, Ohio, Indiana, Michigan, Illinois, and a part of Wiskonsan and Missouri. A portion of Canada, bordering the great lakes, is also added. The accompanying table of colors, and the sections 3 and 4, plate XIII, will give a correct idea of the order of succession among the principal strata.

NOTE. The first intention in constructing this map, was to show the extent of some of the New-York formations beyond the limits of the Fourth District in a westerly direction. As the work progressed, new materials accumulated, and a tour over the western States offered an opportunity of presenting the unbroken continuation of many of the New-York rocks as far as the Mississippi river.

In laying down the formations upon this map, the annual reports of the different States furnished valuable data; and although I had travelled over the country in different directions between the Atlantic and the Mississippi, and was well acquainted with its general features and the outlines of the more important groups, still I should have been unable to give the exact limits of many of these formations but for the kind assistance afforded by many of my fellow laborers; thanks to the enlightened and liberal spirit, which in the free communication and interchange of information has so rapidly advanced our knowledge of American Geology: and it is with pleasure that I acknowledge my obligations to the

* By an error of the engraver, the plate is printed "Lodi falls, Genesee county."

following gentlemen. Dr. David Dale Owen, the State geologist of Indiana, has permitted me to copy his maps of that State and of Illinois, Kentucky and Wiskonsan, including the lead-bearing region of Iowa, into which his researches have extended. Dr. Houghton, the State geologist of Michigan, has obligingly furnished me with a geological map of that State, where my own observations have not extended far beyond the lake shores. In laying down the formations in Ohio, I am indebted both to the reports of Dr. Locke, Mr. Whittlesey, Mr. Briggs and Mr. Foster, and to personal information from these gentlemen. The valuable paper of Dr. Hildreth, in the 29th vol. of Silliman's Journal, has also been of great service to me. In coloring the map of Virginia, Mr. Slade, a member of the geological corps of that State, has pointed out to me the general limits of the formations in the western part. Prof. J. T. Ducatel, the geologist of Maryland, has kindly furnished me with the outlines of the formations in that State; and Prof. J. C. Booth, the geologist of Delaware, has afforded me the same facilities. To Richard C. Taylor, of Philadelphia, I am indebted for a colored map of the eastern part of that State, recording his own observations previous to the year 1834. This map shows very minutely the position and extent of the detached or outlying coal basins on the northeast, and the eastern limits of the great Alleghany coal-field. Mr. Taylor has spent many years in investigating this region, and particularly the position and extent of the coal-fields, and no one is better able to give the geology of this portion of the country.

The numerous and frequently alternating strata along the eastern margin of this great coal-field, as well as of the formations farther east, could not be represented on a map of this scale without going into an extent of detail incompatible with the present object; in many instances where two rocks are colored alike, they are marked by letters which will indicate the formations by referring to the corresponding letters in the index of colors. Bordering the Atlantic south of Delaware, one color only has been used, from the impossibility at present of giving the exact lines of demarkation. The existence of some minor axes within the limits of the great eastern coal-field, and the appearance of lower formations, have not been noticed on the map, as their limits could not be accurately laid down without a more minute survey than I have been able to make.* After leaving the western extremity of Lake Erie, the Niagaria limestone, the Onondaga-salt group, and the Helderberg limestones are so blended that it has been found impossible to define their limits by the same colors as in New-York; the blue, indicating the latter series, is therefore continued as a representative of the whole through Ohio, Indiana and Illinois. The area colored of a deeper blue, with a margin of slate color, of which Cincinnati is near the centre, represents the Birdseye and Trenton limestones of New-York and also the equivalents of the Utica slate and Hudson-river group, the latter having become so calcareous that it is known throughout the west as the Blue limestone.† The purple band, indicating all that remains of the formations between the Corniferous limestone and the Portage group in Ohio and Indiana (the black bituminous shale), represents these as terminating before reaching the Rock river in Illinois. It is possible, however, that this shale may be traced farther westward, although it was not observed in my examinations along the Mississippi.

The difficulties encountered in completing this map for publication have not been few, and I cannot flatter myself that it is free from error; I appeal therefore to my friends and a generous scientific public for their forbearance, hoping that some future opportunity may enable me to offer it to them much improved and corrected; and in the mean time any information or suggestion will be gladly received. A geological map of the remaining portion of the United States is in preparation, and will soon be completed. This map will exhibit the limits of the principal formations east of the Mississippi, and between the Gulf of Mexico and the Great lakes.

In the present map the wide and almost undisturbed range of some of the lower formations is well illustrated, and the immense extent of the two well known American coal-fields seems almost incredible. The great Illinois coal-field occupies a space nearly as large as the whole of Great Britian; and the eastern one, occupying a part of Pennsylvania, Maryland, Virginia, Ohio, Kentucky, Tennessee and Alabama, is even much larger, occupying an area of sixty thousand square miles. These vast formations, with associated iron ores, prove the existence of those sources of wealth, prosperity and civilization, which invite to enterprise and reward with plenty. Although not strictly appertaining to a survey of New-York, she is still not an idle spectator of the vast possessions of the west; she stands upon the vantage ground, and the great mart of the Atlantic is only reached through her lakes, her rivers and canals. The immense territory north of the Ohio river, occu-

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* Since this map was engraved, a geological map of the western States has been published by Mr. Byrem Lawrence. The main features of the two maps are in accordance, but there are some points in which I have felt authorized to differ from Mr. L. in regard to the limits and extent of certain formations.

† See Chapter XXIII.

pied by the same geological formations, possessing an equally or surpassingly fertile soil, is straining every nerve to throw her productions into that ocean thoroughfare, the chain of great lakes; and if New-York now feels the influence of that youthful country, what will it be when the populations and productions have increased to ten, and even twenty times their present amount?

To the geologist here is a vast field laid open for investigation. The unbroken extent of strata offers the means of tracing over wide areas the lithological changes dependant on deeper waters or greater distance from land. The fauna of this ancient ocean presents great and interesting changes, as we progress over these wide districts—its ancient bed. Changes, both in organic remains and the condition of sedimentary deposits, are constantly presenting themselves, and when these shall be more fully investigated, we shall feel at liberty to draw more general conclusions, and to propound more comprehensive theories respecting the primeval condition of our planet.

ERRATA.

Page 19, for "VII," before quaternary system, read "VIII."
Pages 39 and 48, for "*Pleurotomaria*," read "*Euomphalus*."
Page 59, 13th line from top, for "amss," read "mass."
Page 97, 12th line from top, for "Plate 3," read "Plate 4."
Page 107, 1st line, add "*Spirifer sinuatus*," before Silurian Researches.
Page 113, for "41," No. of woodcut, read "41 *bis*."
Page 117, 2d line from bottom, for "one of the most important groups," read "the most important group."
Page 118, 4th line from top, for "Mackinaw," read "Mackinack."
Page 122, in explanation of woodcut, for "*a a*," read "*b*," and for "*b*," read "*a*."
Page 131, 13th line from top, for "place," read "plane."
Page 133, 16th line from bottom, for "geological," read "sedimentary."
Page 158, 18th line from top, for "specimen," read "specimens."
Page 172, 16th line from top. for "2 *a*," read "6 *a*."
Page 175, 9th line from top, for "3," read "4."
Page 189, 9th line from top, and page 190, 8th line from top, for "*Delthyrus mucronatus*," read *Delthyris mucronata*."
Page 195, 8th line from bottom, for "Dimyaira," read "Dimyaria."
Page 200, in explanation of woodcut, for "*Loxonema sinuosa*," read "*Loxonema nexilis*." See description of same, p. 201.
Page 205, in explanation of woodcut, for "*Orthonqta*," read "*Orthonota*."
Page 206, 10th line from bottom, for "pressed," read "perfect."
Page 212, illustration 190, the strata beneath the Tully limestone are incorrectly represented as horizontal, whereas they should follow the curve of the stratum above.
Page 219, 13th line from bottom, for "Seneca county," read "Seneca lake."
Page 224, reference to sections for "Pl. VII," read "Pl. VI."
Page 257, 15th line, for "plain," read "plane."
Page 280, 2d line from bottom in note, for "right hand." read "left hand."
Page 285, 10th line from bottom, for "rock itself," read "rock *in situ*."
Page 315, Catalogue of Mineral Springs, 4th column, 8th line, for "Cal. Mag.," read "Sul. Mag."
Page 327, 14th line, for "the accompanying plate," read "Plate XIV."
Page 340, 13th line from bottom, after the word "thrown," add "down."
Page 352, 10th line, after "opposite," add the word "side."
Page 406, 13th line from bottom, for "northward," read "southward."
Page 481, 8th line; for "birdseye maple," read "birdseye marble."
Page 503, 7th line, for "the same as fossils at," read "the same fossils as at."
Page 509, 17th line, for "were," read "are."
Page 509, in note, for Tenestella, read "Fenestella."