Compliments of

JOHN M. CLARKE

Director State Museum and
State Geologist

EDUCATION BUILDING, ALBANY, N. Y.

New York State Museum Bulletin

Entered as second-class matter November 27, 1915, at the Post Office at Albany, N. Y., under the act of August 24, 1912

Published monthly by The University of the State of New York

No. 196 ALBANY, N. Y. APRIL 1, 1917

The University of the State of New York

New York State Museum

JOHN M. CLARKE, Director

THIRTEENTH REPORT OF THE DIRECTOR OF THE STATE MUSEUM AND SCIENCE DEPARTMENT

INCLUDING THE SEVENTIETH REPORT OF THE STATE MUSEUM, THE THIRTY-SIXTH REPORT OF THE STATE GEOLOGIST AND THE REPORT OF THE STATE PALEONTOLOGIST FOR 1916

The University of the State of New York

Department of Science, April 11, 1917

Dr John H. Finley
President of the University

SIR: I beg to transmit to you herewith for publication as a bulletin of the State Museum, the report of the Director of the Museum for the last fiscal years.

Very respectfully yours

JOHN M. CLARKE
Director

THE UNIVERSITY OF THE STATE OF NEW YORK
OFFICE OF THE PRESIDENT

Approved for publication this 18th day of April, 1917

President of the University

New York State Museum Bulletin

Entered as second-class matter November 27, 1915, at the Post-Office at Albany, N. Y., under the Act of August 24, 1912

Published monthly by The University of the State of New York

No. 196 | ALBANY, N. Y. | APRIL 1, 1917

The University of the State of New York

New York State Museum

JOHN M. CLARKE, Director

THIRTEENTH REPORT OF THE DIRECTOR OF THE STATE MUSEUM AND SCIENCE DEPARTMENT

INCLUDING THE SEVENTIETH REPORT OF THE STATE MUSEUM, THE THIRTY-SIXTH REPORT OF THE STATE GEOLOGIST AND THE REPORT OF THE STATE PALEONTOLOGIST FOR 1916

INTRODUCTION

This report covers all divisions of the scientific operations and museum work under the supervision of The University of the State of New York and has reference to the progress made therein during the fiscal year 1915–16. It constitutes the 70th consecutive annual report of the State Museum, the 36th annual report of the State Geologist (consecutive since 1881) and the report of the State Paleontologist for 1916. It is introductory to all memoirs and bulletins issued by this Department during the year named.

The subjects presented in this report are considered under the following captions:

I Legal Status and Scope of the State Museum
II Present Condition of the Museum
III Condition of the Scientific Reservations Belonging to the Museum
IV Department Publications
V Considerations for Future Growth of the Museum
VI Report of the Geological Survey

VII Report of the State Botanist
VIII Report of the State Entomologist
IX Report of the Division of Zoology
X Report of the Division of Archeology and Ethnology
XI Staff of the Department
XII Accessions to the Collections
XIII Scientific Papers
XIV Appendixes (to be continued in subsequent volumes)

I

LEGAL STATUS AND SCOPE OF THE STATE MUSEUM

The broad scope of the State Museum was clearly and succinctly defined in the Education Law (as amended in 1910) under article 3, which relates to the objects and functions of the University. Section 54 of that law reads as follows: "All scientific specimens and collections, *works of art, objects of historic interest* and similar property appropriate to a general museum, if owned by the State and not placed in other custody by a specific law, *shall constitute the State Museum.* . . The State Museum shall include the work of the State Geologist and Paleontologist, the State Botanist and the State Entomologist, who, with their assistants, shall be included in the scientific staff of the State Museum."

This definition of scope is broad and clear. It is the specific expression of the intent of the people of the State to constitute and maintain not alone a state museum of science, but a state museum of art, a state museum of history and a state museum which may depict any other field of civic and educational concern which in the judgment of the Regents of the University, would be justified by public interest. The spirit of the law where its sentences bear upon the creation of a museum of art and a museum of history is so obvious as to be constructively a command. The wish of the people and the desire of the Board in regard to this expansion of the actual museum nearer to the ideal of the museum expressed in the law have become a matter of record. It is then to be understood that the existing science museum of the State represents the development of only one phase of what should be, and what within the implied intention of the law is to be, the State Museum.

II

PRESENT CONDITION OF THE MUSEUM

During the year the erection of additional exhibit cases with their displays has reached close to the walls of the Museum halls, and has practically preempted all the available floor space of the Museum. Further exhibitions must be carefully planned with reference to the amount of floor space to be occupied, lest too serious encroachment be made on the aisle space necessary for a dignified presentation of the displays. These physical limitations of the Museum necessitate the constant renovation of the exhibits, the substitution of specimens by materials of a better quality; and while these physical boundaries of the Museum are to be regretted because of the constraints which they compel, yet they afford an opportunity of beautification which might not otherwise be practicable. There is an undoubted and obvious advantage in the restriction of a museum to a reasonable area. A museum in which the floor space is without restraining limitations and is distributed over several floors, often becomes a receptacle of materials which are put on display solely for the purpose of filling space, and are quite likely to detract from the impressiveness and quality of the museum as well as to add to the fatigue and labor of the visitor. The thought is kept in mind that a public museum of this kind will be the resort of the people rather more than of the special student, and while the demands of a scientific and orderly classification, the requirements of scientific students, are not lost sight of, the arrangement generally and the mode of display must be of a sort to elicit the interest of the average visitor.

The largest addition of moment to the collections has been that returned to the Museum from the Panama–Pacific Exposition. The exhibit made in San Francisco was entirely given over to an illustration of the mineral industry of New York, and the materials sent there were in a large measure brought together for that specific end. With their return they constitute a very important addition to the Museum displays in practical and applied geology. With them came fifteen cases which had been built to accord with the case patterns adopted in the Museum, and though these were of somewhat inferior quality of material, they have been adapted to the geology exhibits, and the geology hall is now fairly well crowded. This condition made necessary the diminution of some of the aisle space, and it is not likely that the geology collections can now be much expanded without the most economic form of distribution of the material. It should be recorded that these new accessions were the property of the New York Commission of the Panama–Pacific Exposition, and should be regarded as a donation from them. To provide room for these accessions, and the necessary rearrangement of the cases, the work was in progress for a considerable portion of the year. While the exhibit as it now stands is fairly representative of the economic resources of this State in the present stage of knowledge and utilization, there is still a very large opportunity for further expansion in order to illustrate the varied industrial applications of the products of mine and quarry and to portray by models the technic and methods employed in their extraction and elaboration. The use of models has an undoubted educational value, as is evinced by the degree of attention which they attract from visitors.

In the paleontology hall some important additions have also been made. Two new cases were added in the hall of fossil plants, one in the hall of vertebrates, and four in the hall of invertebrates. Some of the cases have been rearranged and the result of this work has been the creation of two very attractive exhibits, one of the starfishes and crinoids, and one of the Pleistocene fossils deposited by the marine waters of the Lake Champlain basin. All these cases were arranged by Miss Goldring, and the material for the latter collected at her own expense in New York, Vermont and the provinces of Quebec and Ontario. These recently extinct Pleistocene fossils from the salt-water deposits bounding the ancient Hochelagan sea which preceded Lake Champlain, are displayed in such a manner as to bring out not only the perfection of the material, but to indicate that these marine shells decreased in size, thickness and number as one goes southward from the St Lawrence region where the waters of the sea were deepest and of maximum salinity. Where the fresh waters flowed freely into this ancient sea at the south, the species decreased in size and number, so that the marine life seems practically to have become extinct at the latitude of Crown Point, while the waters of this narrow sea extended still farther south, though too diluted in their salinity to support the existence of these animals.

Some additions have been made of restorations in the paleontology exhibits. The Museum has received by gift a restoration of one of the largest of the fossil fishes, Dinichthys, made by Dr L. Hussakof and presented by the courtesy of the American Museum of Natural History. Mr Marchand has created some additional models of graptolites, and Mr Hartnagel has now finished the special exhibit of fossil corals.

In the zoology hall some noteworthy additions have been made to the exhibits, among which may be mentioned the installation of the New York fishes received from the Conservation Commission; an exhibit of the tree toad, designed to show protective coloration; new groups representing a family of woodchucks; and a section of a sand bank with nesting bank swallows. The collection of domestic pigeons has been enlarged, and an effort has been made to present a representative collection of the mollusks of New York. The Museum owns a very large series of the New York mollusca, but the limitations of the Museum hall have thus far permitted the display of but a small portion of this collection. The corals and other low invertebrates have been installed so far as the available space permits, and a series of cases has been devoted to the display of the birds' eggs and nests, the collection which has been considerably augmented by the acquisition of the series brought together by the late Martin J. Conway of Troy.

A special illustration has been made of the sea fowl nesting in the greatest of the remaining colonies of these birds, Bonaventure island in the Gulf of St Lawrence. These are all representatives of New York species. Quite recently a very important addition has been made to the Museum by the gift from Benjamin Walworth Arnold of Albany, of his entire collection of eggs and nests of birds, upon the assembling of which he has been engaged for the last forty years. Mr Arnold's collection is very large, and represents about 1000 species of birds from North America, and several hundred additional species from South America, the Falkland and other South Atlantic islands, Africa, Australia and Europe. This Arnold collection is one of the very largest in the possession of any public museum in this country, and its acquisition therefore makes of necessity this Museum a headquarters for students of ornithology. It is planned to instal this collection in part along the west corridor into the zoology hall where it will not be exposed to the direct sunlight, and so in a large measure be protected from fading.

The zoological division is insufficiently manned. So many special lines of interest are represented here that it is difficult for one man, however expert, to handle them all. The present zoologist is active and efficient, but he is without adequate assistance, and the growing importance of his work makes it imperative that he should have more help. In its present equipment the zoology division does not balance with the other divisions of the Museum, and with the burden of work which the division presents, practically no time is permitted to the zoologist for scientific investigations.

The collection of reproductions of edible and poisonous fungi, contemplated in the last report of the Director, has now been completed to its present possible limits. Fifty-nine reproductions in specially prepared composition, have been made by Mr Marchand and are temporarily installed in the end room of the east mezzanine. They will eventually be displayed more centrally in the rotunda, between the corridors, where their extraordinary workmanship will be more effectively presented. Doubtless this collection should be increased in size, although it now includes the most obvious edible species and a few of the noxious forms. It is hoped that the presentation of this illustration of fungi may encourage a closer familiarity with this important source of nitrogenous food. But very few species growing in this State are poisonous. The great majority are edible, at least by most people. It happens, however, that the most poisonous species are often the most striking and attractive, and it is quite essential that gatherers and eaters of mushrooms should recognize these noxious species first of all.

It has not thus far been possible to make an effective installation of the botanical collections. Botanical material seldom lends itself to public display, and though the herbarium of the Museum is of a very large size, it must of necessity be kept in the background. There is very little room in the Museum at present that can be utilized for such botanical exhibit. The woods of New York have been arranged in the botanical room in the east mezzanine, and it is planned to introduce there or elsewhere in the Museum a display of reproductions of the pharmaceutical plants of New York. This display, if effectively rendered, should be of distinct educational value.

The west mezzanine room, which is continuous with the Iroquois floor, has hitherto been used for lecture purposes and temporary exhibits. As the Museum needs a place for lectures, not far away from immediate association with the exhibit halls, it has been found convenient to utilize this for such purpose, even though its seating capacity is small. The room is still reserved for this use, but its walls have been utilized for the purpose of displaying a series of the geological maps of the State and parts thereof, and also for showing the various certificates, diplomas and medals of award that have been received by the Museum at the various national and international expositions.

During the past year the heroic statue of Professor Joseph Henry, which had been for some years standing in the rotunda of the Capitol, and which was modeled by the sculptor John Flanagan for use at the St Louis Exposition, has been removed to the Museum halls, its broken condition repaired, the surface suitably bronzed, and the statue placed in a commanding position in the rotunda. Alongside of it is attached a frame carrying parts of simple electrical instruments devised and used by Professor Henry for his fundamental experiments on electrical transmission and induction, made while he was a teacher of mathematics in the Albany Academy in the years 1827–32.

With the present tremendous development of electrical science and its application to a great diversity of human comforts, Professor Henry's fundamental work is just coming into the fulness of its recognition. As he was a native of the Albany district, a resident of this city for most of his younger years, and a teacher in one of the Albany schools, it has seemed very proper that measures be taken for a memorial here to the service he rendered to humanity. A campaign has therefore been undertaken for the purpose of raising funds to put this fine model of Henry into bronze. This canvass has been reasonably successful and the amount raised, it is believed, will be, with the cooperation that has been promised, sufficient to erect this memorial, which is to be placed in the city park well in front of the venerable Albany Academy building, permission for this having already been granted by the city council.

In Lincoln Park, one of the municipal parks of Albany, stands a low, red brick building which was built by James Hall, the late State Geologist and Paleontologist, about the year 1856, and which from that time until his death in 1898, served as the laboratory where his geological investigations were carried on, and where were kept the great collections of geological material belonging to himself and to the State. At the time it was built, Professor Hall had no other official headquarters. He had chosen a place well outside of the settled part of the city, and lived in comparative isolation, surrounded by his scientific materials and his scientific assistants. From 1856 to 1886 all the work of the Geological

Survey was done in this building, and from this laboratory were graduated many geologists who afterwards attained distinction in the science, among whom may be mentioned Ferdinand V. Hayden, director of the United States Geological Survey; William M. Gabb, state geologist of California; Fielding V. Meek, United States geologist; Robert P. Whitfield, paleontologist; Charles D. Walcott, director of the United States Geological Survey and present secretary of the Smithsonian Institution; Charles E. Beecher, professor of paleontology, Yale University; Charles Schuchert, professor of historical geology and paleontology, Yale University. In the building were written not only the volumes of the Paleontology of New York, various geological reports of New York issued during those years, but also reports on the geology of the states of Wisconsin, Iowa and Ohio, and various government scientific expeditions; the Mexican boundary survey, the Pacific Railway survey, the Stansbury expedition, etc. For a generation the influences which emanated from this building were the most potent factor in the development of American geology, and in recognition of this fact, now that the building has become the property of the city and is used for purposes connected with the maintenance of the Lincoln Park, it has been decided by the Association of American State Geologists to perpetuate its associations by placing thereupon a commemorative bronze tablet. The money has been provided for this purpose and the tablet will be presently erected. We have received from the commissioner of public works of the city of Albany the assurance that the building will be maintained intact in perpetuity.

The field meeting of the Association of American State Geologists. By the desire of the officers of the association, the annual field meeting of the official geologists of the States was held under the auspices of the Museum in September. The association was represented by a party of about thirty-five, which included several representatives of the United States Geological Survey. In spite of rather forbidding weather the field meetings were instructive and satisfactory. The first day was given to a trip by automobile into the classical Paleozoic sections of the Helderberg mountains, the Indian ladder, with its succession of formations, and from there upward the geological series was followed along the outcrops through Thompson's lake and on by Warner lake, into Knox; thence, on returning, the geologists were entertained at Altamont at the home of Mrs John Boyd Thacher, the donor of the Helderberg escarpment to the State (John Boyd Thacher Park). On the following day the party went to Saratoga Springs to examine the mineral springs and their relation to the Saratoga fault. From the state reservation there a visit was made to the Cryptozoon ledge, or Lester Park, returning in time to arrive at Port Henry that evening. The following day a visit of inspection was made to the iron mines at Mineville, and by courtesy of the Witherbee Sherman Company the visitors were given every opportunity to descend into the mines and see the underground as well as the surface workings in every detail. The afternoon of the same day a walking trip was made from Port Henry northward along the shore of the lake where brilliant and instructive exposures were shown of the Grenville limestone with its contorted inclusions. Leaving that evening for Port Kent, the early part of the following day was spent in the Ausable chasm at the mouth of which automobiles met the party and took its members to the Champlain Club of the Catholic Summer School at Cliff Haven, the road thus passed running over the dissected deltas of the Ausable and Little Ausable rivers. At Cliff Haven the geologists were the guests of the school by invitation of the Rt. Rev. Mgr. John P. Chidwick, and here they were most agreeably entertained. After examination of the very interesting geological phenomena upon and about the grounds of Cliff Haven, the party was met by Prof. George H. Hudson, who carried them by boat to Valcour island. Under Professor Hudson's guidance the interesting geological structures of Valcour island were exploited and the evening of the day was most agreeably spent at Professor Hudson's camp on the island. Late at night the visitors returned by boat to Plattsburg and left thence in the early morning for Burlington, Vermont, where, under the guidance of Prof. George H. Perkins, opportunity was given to visit striking geological developments in the vicinity. There the party disbanded.

Meeting at Albany. By invitation of the president of the University, the Geological Society of America, the Paleontological Society, and the Association of American State Geologists held their annual meetings in Albany during the week beginning December 25, 1916. These meetings brought together a large number of geologists, perhaps the largest ever gathered here, and they continued through the week. The comfort of the visitors was studied in every regard and an effort made to give the sessions the assurance of success. At these sessions the Director of the Museum acted as president of the Geological Society of America, and Dr Rudolf Ruedemann as president of the Paleontological Society.

The New York State Archeological Association. The activity of the Archeologist of the Museum has resulted in the organization of a state society devoting itself to the scientific collection of aboriginal relics and the protection of aboriginal monuments. Its fundamental purpose is to prevent, so far as possible, the destruction and scattering of these records as well as the desultory and indifferent preservation of them. Several field meetings of the association have already been held, and one vigorous chapter organized in the city of Rochester. It is planned that other local chapters will be formed as the local interest in archeological studies develops. The relation of the Museum to this association is that of parent organization, and under the present form of organization the State Museum is the authorized headquarters. Doubtless the influence and the benefit of the Museum and the local societies will be mutual and efficient.

Museum lecture course. The course of free public lectures was instituted during the winter of last year, all of which were on topics closely related to the activities of the Museum, and all were presented by members of the Museum staff. As an illustration of the character of this course, the following list of the topics presented is here given:

1 The State Museum — How to Use It
2 Diamonds
3 The Forests of New York State
4 Lake Albany, Our Present Abode
5 Man and Insects
6 How Minerals Are Formed
7 Mastodons and Elephants of New York
8 The Empire State of Indian Days
9 Harmonics and Cross Purposes in the Insect World
10 Earthquakes of New York
11 Nature Monuments
12 Life of the Ancient Seas

These lectures were well attended, usually to and sometimes beyond the capacity of the Museum lecture room. The public interest in them justifies the continuation of this undertaking.

Dedication of the New York State Museum. Although the New York State Museum at Albany has been open to the public for some months past, it seemed wise to the Regents of the University to bring the public into closer touch with the new Museum by formal dedicatory exercises. These took place in the Chancellors Hall of the Education Building at Albany on the afternoon and evening of Friday, December 29, 1916. The afternoon exercises consisted of a series of addresses from eminent speakers, each representing a special phase of community interest in the Museum. The Hon. Charles B. Alexander, chairman of the Regents committee on the State Museum, presided, and the speakers were President John H. Finley on behalf of the University and the educational system of the State, Senator Henry M. Sage on behalf of the state government. Dr Francis Lynde Stetson on behalf of the people, the Hon. Charles D. Walcott, speaking as a representative of science in its broadest sense, and Director John M. Clarke on behalf of the Museum. In the evening the principal address was by Colonel Theodore Roosevelt, who spoke under the title "Productive Scientific Scholarship," and gave an extraordinary and illuminating speech to a colossal audience. Colonel Roosevelt was introduced by Governor Charles S. Whitman, who very happily set forth the value of the research work of the scientific corps attached to the Museum. The evening exercises were felicitous and successful throughout, and were followed by a reception in the halls of the Museum. Colonel Roosevelt's address on this occasion, or the part of it that related especially to his scientific theme, has been already printed in "Science," and all the addresses of the occasion have been published together as a bulletin of the University.

III

CONDITION OF THE SCIENTIFIC RESERVATIONS BELONGING TO THE MUSEUM

Since the publication of the last report of the Director, the Museum has acquired by the gift of Mr Emerson McMillin, of New York, the property known as the *Northumberland volcano*, or *Stark's knob*, situated 2 miles north of Schuylerville. An account of this interesting geological spot has been given in previous reports of the Director, and its structure fully illustrated up to the present state of our knowledge. This gift rescues from certain oblivion what is to New York, and perhaps in a broader sense to geological science, a unique phenomenon. The place is easily accessible to travelers on the road leading from Schuylerville north along the Hudson river, and as the volcanic core is now cut in half by quarry operations, which the gift has happily forestalled, its intimate structure is instructively revealed. This knoll of volcanic rocks has a historic interest because of its association with the Battle of Saratoga and the erection thereupon of the battery by General John Stark.

Of the three properties now under the control of the State Museum — the Clark Reservation near Jamesville, the Lester Park west of Saratoga Springs, and the Stark's Knob Reservation, only the Lester Park is well protected and satisfactorily monumented. In the case of the Clark Reservation, the donor has been pleased to construct an elaborate and attractive entrance, built of blocks of local limestone, which in the piers of the gateway are of very large dimensions. Otherwise this reservation is without protection. Its line fences are in large measure down, and some of its boundaries, being new lines, have never been fenced at all. As public property the place is rather more exposed now to the stealing of timber and the vandalism of collectors of rare ferns than it ever was before, and while, through the kindness of the benefactor, we have rescued the place from commercial invasion so far as its effective landscape scenery is concerned, we are failing to defend it against the attacks of marauders. It is further to be said that no provision has been made for the accommodation of visitors by the laying out of paths or building stairways, one of which, down the face of the cliff to the waters of the lake, is quite imperative for safety's sake. The condition of the place is such that it has been necessary to post notices to the effect that visitors are in the reservation at their own risk, and this has been done in order to defend the State against any liability. It is foreign to the purpose of these reservations to turn them into public parks. They have been set aside in order that they may be preserved, but it is obvious that we are failing of our duty in respect to the proper treatment of the Clark Reservation.

This is also true of the more recently acquired Stark's knob. No boundary fences have been set up about this property and its original condition as transferred to us has not been modified.

For successive years requests have been made for modest appropriations to cover these justifiable expenses, but up to this time nothing has been allowed.

In view of the fact that the State has in many instances accepted private properties of real estate for public park uses, as in the case of the gifts by Mrs John Boyd Thacher of the Thacher Park in the Helderberg mountains, of the late William Prior Letchworth of Letchworth Park on the Genesee river, and Mrs E. H. Harriman of her large properties, and has in recognition thereof made annual or regular contributions for their upkeep and maintenance, it seems an untoward attitude to deny the modest provision necessary to keep these Museum properties in proper condition on the basis of the somewhat ungenerous argument that whoever is to give such private properties to the State must also provide for their care and maintenance.

IV

DEPARTMENT PUBLICATIONS

During the year the bulletins of the Museum have been issued as rapidly as circumstances permitted. They have the following numbers and titles:

181 The Quarry Materials of New York. By D. H. Newland
182 The Geology of the Lake Pleasant Quadrangle. By William J. Miller
183 Glacial Geology of the Saratoga Quadrangle. By James H. Stoller
184 The Constitution of the Five Nations. By A. C. Parker
185 The Precambrian Rocks of the Canton Quadrangle. By James C. Martin
186 31st Report of the State Entomologist 1915. By E. P. Felt
187 Director's Report for 1915
188 Report of the State Botanist for 1915. By H. D. House
189 Paleontologic Contributions from the New York State Museum. By Rudolf Ruedemann

The State Museum Bulletin is now issued as a regular monthly periodical. This arrangement holds back in some degree the number of reports which can be issued in any one year, as it seems impracticable with the present service to issue more than one a month, while it might be possible for the staff to prepare more than twelve a year.

The Wild Flowers of New York. Under provision of the Legislature the preparation of this monograph has gone forward with entire success, and the detailed account of its present condition will be found in the report of the State Botanist. It is believed now that all the necessary color plates for illustration have been taken and the preparation of the text for these volumes is advancing favorably, so that publication may perhaps be expected within another year.

Birds of New York. The demand for this work still continues. The supply of the quarto Memoir volumes is very greatly reduced, and these books can not be much longer supplied. The first edition of the portfolio of colored plates, 16,759 copies, has been exhausted, and by agreement with the Comptroller a second edition has been printed to the number of 10,000 copies, each copy of these being held for sale under this agreement at the price of $1, transportation paid.

V

CONSIDERATIONS FOR FUTURE GROWTH OF THE MUSEUM

The Director in previous reports and on many occasions has set forth the conception of the central State Museum as pictured by the statute, and has failed of no opportunity to present the claim of the statute to the attention and consideration of the people and their representatives. Constant dropping will wear away the hardest stone; constant reiteration may eventually effect the purposes of the law. It has been a source of gratification to find the expressed purpose of the statute as so often and so urgently presented, indorsed by the speakers who participated in the dedicatory exercises at the formal opening of the Museum.

Senator Henry M. Sage said:

It is hoped that its [Museum's] growth will finally include collections of every kind which have an educational value to the people of this State. The "chariot is hitched to a star," and yet no great thing has ever been accomplished without ambition seemingly impossible of fulfilment.

Dr Francis Lynde Stetson said:

So for our own people, this generation as well as its successors, wise prevision is needed and also wise provision, and the people of the State of New York need, even though they may not know it, the creation and nourishment of public museums of art and of science and in particular their own museum, in this capital city.

Mr Theodore Roosevelt said:

I warmly sympathize with the ambition expressed in your annual report to have this Museum more than a mere scientific museum. It should be a museum of arts and letters as well as a museum of science.

The science museum in its present development constitutes a unit in the museum scheme. The development of the additional units must be a matter of slow growth, but it is not necessary to wait for the development of these additional units in the central State Museum in order to validate the provisions of the statute which give to the central Museum control, the same advisory and inspection functions as are given to the State Library in its attitude toward local libraries. The State Museum stands in the law with this positive and well-defined function; supervisory affiliation with local museums supplemented by power to grant public moneys for the encouragement and maintenance of such local museums. It may be said that the effectiveness of this provision is fully contingent upon the willingness of the Legislature to make money grants for the specified purpose. This, however, is a secondary reason. The primary reason lies in initiative in approaching the Legislature for this purpose in order to carry out the expressions of the statute.

VI

REPORT ON THE GEOLOGICAL SURVEY

In the last season the Director was obliged to take a large personal risk in order to continue field operations of an important character, because of the failure of adequate provision for this purpose. Only the well-worn appeal to the loyalty of some of the more patient members of the geological staff and the generous disposition of others in deferring immediate compensation for their work has made this active field service possible.

AREAL GEOLOGY

In the work directed toward the completion of the great geological map of the State on a scale basis of one mile to the inch, considerable progress was made in the Adirondack region by Prof. H. P. Cushing, Prof. W. J. Miller and Prof. C. H. Smyth, jr, who was associated in the field operations with Dr A. F. Buddington.

The geology of the Gouverneur quadrangle was in part reported upon last year. Professor Cushing's report on his later operations follow:

The Gouverneur quadrangle. With the exception of scattered patches of Potsdam sandstone, most of them very small, the entire area of the quadrangle is occupied by Precambrian rocks. Early Paleozoic sediments seem to have once covered the entire quadrangle and to have been entirely removed by erosion except for these Potsdam remnants. This sandstone was deposited on the worn and irregular surface of the crystalline rocks and the patches which remain are those portions of the sand which were deposited in the deeper depressions of the old surface. Such depressions were substantially in all places where limestone was the surface rock, and all the patches which remain rest upon limestone. In many of them a small thickness of conglomerate is found at the base of the sandstone, the angular pebbles having been derived from the thin bands of quartzite in the limestone. The sandstone is either red or gray in color and for the most part very thoroughly indurated. It was deposited on sloping surfaces, for the most part, and its dips rudely conform to these slopes. Locally the limestone surfaces were intersected by joint cracks which had become widened by solution, these became filled with sand, and such sand-filled cracks still remain in places where the remainder of the sandstone has been entirely worn away, and appear like dikes cutting the limestone. A notable instance of the sort occurs at Halls Corners (Rock Island School).

As is the rule in northern New York, the Precambrian rocks comprise the sedimentary Grenville series and various later intrusives. Though the igneous rocks occupy somewhat more than 50 per cent of the area of the quadrangle, it is nevertheless probably true that the Grenville rocks have greater areal extent here than in any other quadrangle in northern New York. Particularly impressive is the great belt of Grenville limestone which stretches all the way across the quadrangle from northeast to southwest, much of it very pure limestone. Toward the northeast it becomes impure and belts of other Grenville rocks wedge into it; but along the west margin of the quadrangle it has a breadth of some 8 miles, 5 miles of which is pure limestone. As Smyth long ago pointed out, it is the longest and broadest belt of Grenville limestone in New York. A large quarry industry has long been based upon it.

The larger part of the impure limestone of the quadrangle consists of alternating beds of limestone and quartzite. Where the quartzite bands are few and thin the stresses to which the rocks have been subjected have resulted in the fracturing of the brittle quartzite bands and the indiscriminate mingling of the fragments with the general mass of the limestone, giving a rude resemblance to a conglomerate. Such pseudo-conglomerate alternates with thicker bands of quartzite. One very prominent band of alternating limestone and quartzite enters the quadrangle from the south at Sylvia lake and runs east-north-east to Edwards. It is of especial importance because of the talc deposits that occur within it, and a line of openings for this mineral marks the course of the belt across the quadrangle. Because of this it has been given a separate coloration upon the map; at the same time it must be understood that there is always some quartzitic material in the belts which are mapped as limestone.

Aside from the limestone and the quartzite the Grenville rocks comprise a great variety of schists, hornblende schists, mica schists, red to green calcareous pyroxenic schists, garnetiferous gneisses and pyritous gneisses, together with many other less common varieties. For the most part these varieties of gneiss and schist are sufficiently distinct and of easy enough identification to warrant their separate mapping were it not for the fact that they commonly occur interbanded with one another in such thin beds as wholly to preclude their mapping, except upon a very large scale.

In general also thin bands of limestone and of quartzite are interbedded with them. It therefore becomes necessary to map the whole complex as Grenville schist in the majority of cases. It is only in exceptional instances that any one of these rocks occurs in sufficient bulk and sufficiently free from admixture with the other varieties to warrant separate mapping. Within the Gouverneur quadrangle are two belts of hard, mica gneiss, usually garnetiferous, which have received separate mapping. One of these belts enters the quadrangle near its southwest corner, and has been traced for 12 miles when it is apparently cut out by granite. Another and still broader belt occurs in the southeast part of the quadrangle, and only a small part of its mass lies within the quadrangle's limits.

There is considerable of the rusty, pyritous gneiss, which is such a characteristic Grenville rock, within the quadrangle but in such thin beds that separate mapping is not practicable. One such belt wedges up within the limestone just west of Gouverneur and thence runs continuously clear across the quadrangle and beyond. A number of openings for pyrite have been made along it and the Stella mine at Hermon, just without the quadrangle's limits, is still active. But the rusty gneiss is simply a thin, uppermost bed to a belt of hard, fine-grained gneiss and coarser mica gneiss interbedded in the limestone, too thin to separate from them in mapping. Another thin band of the rusty gneiss overlies the limestone belt which comes into the quadrangle on the west side of Sylvia lake, lying between the limestone and the gabbro which borders it on the west and north.

The Grenville rocks across the quadrangle have a general northeast strike and northwest dip. The mapping clearly brings out the fact, however, that the structure is not that of a simple monocline but consists of a series of closely compressed and overturned folds; in other words, that it is isoclinal. Southeast dips occur here and there, but only locally. The dips are in places very flat, elsewhere so steep that they are nearly or quite vertical. At one stage in the work it was hoped that one limb of a fold would prove to have a steeper dip than the other limb, and that this might give aid in working out the structure; but no such relation could be demonstrated. Many of the folds, probably all of them, have a decided pitch, but in the vast majority of cases it can not be determined whether the pitch is to the northeast or the southwest; in other words, whether the structure is anticlinal or synclinal.

Locally many variations in direction of strike occur, and there is especially manifest a tendency on the part of the sediments to wrap around the ends of the sills of igneous rocks.

The igneous rocks of the quadrangle consist of gabbro and of two different granites. The gabbro is much older than one of the granites and is probably older than either, though its time relation to the older of the granites can not be definitely ascertained. It is everywhere highly metamorphosed and converted into the hornblende-feldspar rock called amphibolite for convenience. In its marginal phases it is always a thoroughly foliated hornblende gneiss or schist and can not be distinguished from similar gneisses which are interbanded with the Grenville sediments and form a characteristic constituent of that series. But in the larger masses more solid, less metamorphosed cores are always present whose igneous origin is clearly apparent. In the southeast half of the quadrangle there was originally a large mass of this gabbro but it has been badly cut up and cut out by the later of the two granites, and now occurs in a number of disconnected masses.

Of all the rocks of the quadrangle this gabbro was the most susceptible to attack by the granite. Its marginal portions are always full of masses of pegmatite and of quartz either as dikes or as lenticles; and in addition there has also been much minute penetration and soaking of the gabbro by the granite. Wherever the two rocks adjoin there is apt to be a gradual passage from the one rock into the other, no sharp boundary separating them can be drawn, and to discriminate between granite-cut gabbro and granite with plentiful gabbro inclusions is no easy matter. More rarely, however, the boundary is quite sharp.

The gabbro occurs in part in more or less oval masses which plainly either wedge aside or else cut out the sediments and whose intrusive nature is therefore clear; and in part in long, narrow bands which probably represent sills and whose intrusive nature is much more difficult to demonstrate. The long, narrow belt of gabbro which lies just east of Moss ridge and whose prolongation is associated with the rusty gneiss of the Stella pyrite mine at Hermon, is mostly thoroughly gneissoid and the proof of its igneous nature is very difficult to obtain, though rather massive rock may be obtained from within it at various places. Smyth shows a disposition to regard it as an igneous rock at the Stella mine occurrence, and my study of the whole belt leads me to the same conclusion, though with the candid admission that certainty is unattainable in the matter.

The only representative within the quadrangle of the old granite gneiss which I correlate with the Laurentian granite of Canada is the oval mass or stock, comprising some 7 square miles in areal extent, which lies directly north of the village of Gouverneur. In its thorough conversion to orthogneiss with evenly granular texture and its abundant inclusions which are invariably of amphibolite, it conforms wholly to the type of this earliest granite and is quite distinct from the remainder of the granite of the quadrangle. Though the mass is small it lies only a short distance from, and is really the northeast prolongation of, a large mass of this granite which the railroad cuts across all the way from Keene to Philadelphia and which forms what I have called the Antwerp batholith in reporting upon the Theresa quadrangle. This stock at Gouverneur is entirely surrounded by limestone, into which it sends dikes; hence it is impossible to determine its time relations with the gabbro and the other granite.

The younger granite of the quadrangle is a porphyritic granite which is precisely like the porphyritic granite which in many localities in northern New York occurs as a border phase of the augite syenite of the region, so that I have no hesitation in correlating it with that rock. It shows many phases, sometimes being very coarsely porphyritic, sometimes being fine grained and with little trace of porphyritic texture. The smaller bodies of the rock are most apt to be fine grained, and the larger masses are often of similar grain marginally; but there is much variation in the different masses, and from place to place in the same mass. Where the granite cuts gabbros broad zones of mixed rock are often produced, in the manner just described, injection gneisses, soaked zones, and a host of pegmatite and quartz veins. Where Grenville rocks are cut the granite sends occasional dikes into them and holds occasional inclusions of them, but the Grenville rocks are little affected by the intrusion except locally. Some very large Grenville inclusions are found in these granites, often large enough to be mapped, and several of these are of limestone. In this respect this granite contrasts strongly with the older granite in which the inclusions are always of amphibolite.

The most unusual feature attaching to the porphyritic granite is its manner of occurrence, in a series of subparallel, long, narrow tongues, which conform to the bedding of the adjacent sediments and which seem to be sills. This type of occurrence is unusual in northern New York, in which the igneous rocks occur usually in batholiths, stocks and dikes, and I have met with it only in this immediate region. When the mapping shall have been extended over the southeast part of the quadrangle it may prove that these sills are merely outlying members of a batholite of granite or syenite which occurs there. If not that then, in all probability, they indicate the presence of a batholite at no great depth below the present surface. Evidence has been forthcoming in the Thousand Islands region, in the case of the Picton granite, that the present surface exposures of the batholite are of its very roof. The occurrence of these granite sills on the Gouverneur quadrangle, and on the Ogdensburg and Lake Bonaparte quadrangles just north and south also, sills which have with little doubt been given off from a larger mass of probable batholic nature, is additional evidence that in this northwestern region erosion has not cut deeply into the Precambrian rocks; and the large amount of the Grenville series which still remains, in contrast to the region farther east, is indicative of the same thing. It is becoming quite clear that there is a sharp contrast between this region and the general Adirondack region in this respect; that the general altitude of the former has been less than that of the latter, as it is today; that it has been less subject to considerable uplift; and that as a result erosion has bitten far less deeply into the Precambrian rocks of the Gouverneur region than into those which lie more to the east.

Lake Placid quadrangle. Professor Miller, who is completing the survey of this region for a joint report thereon by Professor Ruedemann and himself, makes the following statement:

A prominent belt of coarse, often porphyritic, granite extends across the northern portion, and extensive areas of the Whiteface type of anorthosite lie just south of the granite. Two considerable areas of Grenville gneisses with some limestone occur, one near Franklin falls and the other between Catamount and Wilmington mountains.

Between 1 and 2 miles west of East Kilns a large mass of rock was discovered which quite certainly has resulted from the assimilation of anorthosite by syenite (and possibly granite) magma, the evidence for this mode of origin being well shown in good outcrops.

A feature of particular importance is the occurrence of parallel, narrow dikes of basic rock cutting the coarse granite on Catamount mountain and on the small mountain between 1 and 2 miles north of East Kilns. These dikes are holo-crystalline and mostly badly weathered. They are quite different from any dike rocks hitherto observed by the writer in the Adirondacks.

Catamount mountain exhibits a remarkable variety of rocks. Within a single square mile from the base of the mountain to the summit, the following rock types are well exhibited: Grenville gneisses and limestone, Whiteface anorthosite, coarse granite, syenite, granitic syenite, aplite dikes, gabbro stock, basic (norite?) dikes, pegmatite dikes, diabase dikes and quartz veins.

Schroon Lake quadrangle. For this quadrangle Professor Miller reports that the Precambric rocks comprise anorthosite, Whiteface anorthosite, syenite, granite syenite, granite, gabbro, pegmatite and diabase.

A feature of particular importance is the outlier of Paleozoic strata in the vicinity of Schroon Lake village. Several large outcrops of Little Falls (?) dolomite occur in and near the village. A small area of Potsdam sandstone was discovered one and one-half miles southwest of the village, but most of the Paleozoic strata are concealed under Pleistocene deposits.

In the central portion of the quadrangle, a zone several miles wide, between the great body of anorthosite on the north and the syenite-granite series on the south, exhibits a very mixed lot of rocks, one type which frequently appears being almost certainly an assimilation product between anorthosite and syenite-granite magma.

Lake Bonaparte quadrangle. The field work on this area has been carried on by Doctor Buddington under the direct supervision of Prof. C. H. Smyth jr. They report as follows:

The results of the survey in 1916 are, in all essentials, confirmatory of the conclusions regarding this district based upon brief reconnaissances made by the senior author in 1894 and 1897. A detailed report on the region is now in course of preparation, although not yet far enough advanced to warrant more than a slightly modified restatement of the previous conclusions. The dominant trend of the formations is from northeast to southwest throughout the quadrangle. The prevailing strike of the gneissic and cleavage structures is likewise northeast with a variable steep dip to the northwest. The region may be considered in a broad way as comprising three bands of different geological characteristics. The entire southeastern half of the district is formed by a great mass of banded differentiated syenitic rocks, varying in a very broad way, from a normal augite syenite with more basic bands, through a more siliceous red hornblende grano-syenite (interrupted by bands of a more basic or more siliceous character) to a hornblende biotite granite which sends off numerous dikes. Occasional dikes of hyperite with an ophitic texture cut the syenites.

The central band, about 4 miles wide, comprises a belt of Grenville gneisses and marble intruded by sheets and bosses (for the most part parallel to the cleavage or bedding) of gabbro, syenite and granite, the latter usually a coarse porphyritic type. The gneisses are the usual biotite, pyroxene, garnet, sillimanite and rusty gneisses characteristic of this formation. South of Lake Bonaparte the Grenville gneisses are intruded by an elliptical shaped mass of fine-grained red granite.

The northwestern band is a rock complex consisting of (1) an elongated intruded mass of fine-grained granite partially overlain and completely surrounded by a narrow belt of garnet gneiss with thin beds of intercalated marble; (2) two masses of gray quartz biotite gneiss intruded by sheets of porphyritic granite and more or less abundant pegmatite veins parallel to the cleavage, one mass wrapping around the granite-garnet gneiss belt on the southeast and northeast, the other intruded by a small mass of porphyritic granite and forming the whole northwest corner of the district; (3) a narrow tongue of marble and white quartzite beds overlapping on this quadrangle from the Gouverneur district. The garnet gneiss is a mixed rock formed by intimate injection of Grenville gneiss by pegmatite veins. On the northwest side of the granite mass it possesses a low undulatory dip in general about 30° northwest, while on the southeast side of the granite it dips vertical to steep northwest indicating the possibility of an asymmetrical fold slightly overturned toward the southeast. The quartz biotite gneiss is presumably igneous, but of doubtful origin. It contains inclusions or residuals of gabbro but is granitic in composition. Like the garnet gneiss, the northwest area dips low northwest while that on the southeast side of the granite-garnet gneiss belt dips steep northwest beneath the garnet gneiss.

Indications are that the mode of intrusion of the porphyritic granite has been dominantly by pushing in along cleavage or bedding planes, and to a minor extent by brecciation. In one case, the gabbro similarly forms an almost continuous belt about 14 miles long and not over one-half of a mile wide and must be sill-like in nature. The northwestern mass of fine-grained granite is now being exposed by erosion of a domed series of overlying beds of Grenville gneiss, while the strikes of the beds around a similar mass of fine-grained granite south of Lake Bonaparte are parallel to its border.

The syenite bears intrusive relations to the gabbro, while the syenite itself is intruded by granite dikes offshooting, presumably from the porphyritic granite, from the fine-grained granite, and from its own granitic differentiate as the case may be.

Four small patches of Potsdam sandstone remain as outlying remnants within the central belt of the Grenville series, resting unconformably on the lower eroded levels of the marble beds.

Thoroughgoing cataclastic metamorphism of a portion of the syenite mass, as well as of dikes of hyperite and granite cutting this mass whose cleavage is parallel to that of the inclosing rock, together with the regional trend of the formations, shows unmistakably the evidence of intense, long-continued orogenic forces previously acting in this region. The minor evidence of cataclastic structures in the Grenville gneisses may be partially explained by subsequent igneous metamorphism. A possible variation in the effect of these forces distributed according to the geographical location and character and age of the rock is being investigated. Other important data with respect to the gneissic structures will be given later.

SURFICIAL GEOLOGY

The glacial phenomena of the Catskill mountains. The investigation of the glacial geology of the Catskills was begun during the past summer by Dr John L. Rich, and included a reconnaissance of the region as a whole and a semidetailed mapping of its glacial features directed toward the outlining of the major events of its glacial history and a determination of the problems for whose solution more detailed examinations might be required.

All the higher mountain region, except a small section south and southwest of Arkville, was studied, and, in addition, reconnaissance surveys were carried down the west branch of the Delaware river to Delhi, thence up the little Delaware to Lake Delaware, and also south of the mountains into the upper branches of Neversink and Rondout creeks. The area examined included the whole of the Phoenician and the mountainous parts of the

Kaaterskill and Durham quadrangles besides parts of the Gilboa, Hobart, Delhi, Margaretville, Neversink, Slide Mountain and Rosendale quadrangles.

Within this area, all the principal valleys and those of all but a few of the smaller tributaries were examined. Almost all the surface was seen from a greater or less distance.

Types of glacial deposits. On account of the prevailing rugged relief of the region, the glacial deposits, with the exception of the ground moraine or till, are rather strictly limited to the valley bottoms and lower slopes and are absent, or very weakly developed, on the steeper slopes. To trace moraines from one valley across the intervening ridges to another is, therefore, commonly difficult or impossible, hence the correlation of moraines in adjacent valleys can not always be made with certainty by this means.

The types of glacial drift distinguished on the map include till, thick nonmorainic drift, drumlins, kames, eskers, and glacial lake and outwash deposits. Smooth-topped deposits of thick nonmorainic drift proved to be widespread. They differ from moraines in that the characteristic irregular topography and looped form are lacking. In many places they seem to have been formed by the accumulation of débris beneath the ice, and there are all gradations to typical drumlins. Elsewhere they prove to be glacial deposits of various kinds which have been overridden and smoothed by advancing ice. In the upper Schoharie and the Esopus valleys many such smooth-topped deposits were found to be stratified lake clays, sands and gravels covered with a veneer of till.

The drift filling in the valleys is surprisingly deep. Borings by the New York City board of water supply have established the fact that the rock beds of Schoharie creek and its tributaries in the vicinity of Prattsville lie, roughly, 200 feet below the present beds of the streams. Much of the filling in that vicinity consists of stratified glacial lake clays, but in most places there is a veneer of till on the surface.

Glacial movements. At the time of its maximum extension, the ice of the continental glacier appears to have completely buried the Catskills, with the possible exception of a few of the highest peaks. The highest definite striae were found on the west spur of Slide mountain at an elevation of 3580 feet, but compact, stony soil, indistinguishable from glacial till, was found at 4030 feet on Slide mountain and at 3900 feet on Hunter mountain. No conclusive evidences either for or against glaciation were found at higher elevations on these or other mountains. In general, it is very difficult to find evidences of glaciation at elevations above 3000 feet, partly because erratic boulders of rocks foreign to the region are very rare except opposite the passes on the north and east borders of the mountains.

The striae at the higher elevations all indicate a general southwestward movement of the ice across the region. The direction of movement ranged, in different places, from south to S. 45° W. About S. 20° W. is the dominant direction. At lower elevations, the striae indicate much greater diversity of movement.

During the retreat of the ice front across the mountains, the series of events was complicated by the fact that the movements of the marginal portion of the ice were strongly influenced by the broader features of the topography, and, further, by the development of local valley glaciers whose deposits are not everywhere easily distinguished from those of the continental glacier. The possibility that important readvances of the ice may have affected the northern and eastern parts of the region must also be borne in mind.

Possible early drift. The earliest stages of the ice retreat across the area under examination are recorded in the valley of the Little Delaware, where the ice moved southwestward and westward down the valley, and along the upper courses of Neversink and Rondout creeks, where, also, the movement was southwestward down the valleys.

In each of these regions the glacial deposits seem to be notably older than those observed elsewhere. Flood plains are wider; extensive alluvial fans have developed; the forms of the drift seem more subdued; and drift terraces appear to be much more dissected by streams than elsewhere.

These features suggest the possibility that the ice of the latest glacial advance did not reach these localities, sheltered, as they are, in the lea of the higher Catskills.

Ice movements in Esopus and Delaware watersheds. The major valleys on the north side of the Slide mountain range — Big Indian hollow and Woodland valley — appear to have been last occupied by local glaciers moving northward.

The valleys leading southward and southwestward from the central escarpment of the Catskills, which extends northwestward from Plattekill and Overlook mountains to and beyond Stamford, were all important channels of ice movement, and those which head in gaps in that escarpment all carry heavy deposits of moraine whose southern limits are marked, in a general way, by the Esopus valley and by the valley of Bush kill between Grand Hotel and Arkville. From Stony Clove, Forest Valley and Bushnellsville creek, the ice entered Esopus valley, spreading, in bulb form, both up and down the valley.

Of the valleys at the head of the east branch of the Delaware river, those heading against the central escarpment, namely, those of east branch, Batavia kill, and Vly creek have massive moraines ending respectively at Margaretville (?), Kelly Corners and Griffin Corners, whereas those which do not extend back to the escarpment, notably Red kill, have very little morainic material in them.

There are strong moraines near Stamford and between Stamford and Hobart, opposite the gaps in the escarpment east of Stamford, and there is an almost unbroken series of morainic loops along the valley of the west branch of the Delaware river from South Kortright, 4 miles below Hobart, to Delhi and beyond. These moraines are most strongly developed along the south side of the valley.

At about the time that ice lobes were descending from the Bushnellsville and other valleys into Esopus valley, the great tongue of ice on the Hudson river lowland lay across the mouth of Esopus creek. From it, lobes of ice pushed westward and northwestward into the valleys of Beaver kill and Little Beaver kill, and pushed up the Esopus nearly to Phoenicia, impounding a lake in Esopus valley. Meanwhile the ice lay banked against the eastern spur of the Catskills at High Point, south of the Esopus. At this period, which must have been a long one, the marginal drainage of the ice, together with all the drainage of the Esopus watershed, discharged into Rondout creek through the "Gulf" past Peekamoose lodge, and cut a magnificent gorge. Later, as the level of the ice banked against the eastern spur of High Point was lowered to that of the bottom of the "Gulf" (1677 feet), the latter was abandoned and a sharp notch, "Wagon Wheel gap," noted by Darton[1] was cut in the mountain spur. Further lowering of the ice caused this channel to be abandoned. The lower slopes of the spur have not been examined.

[1] Darton, N. H., Preliminary Report on the Geology of Ulster County, N. Y. State Museum Rep't 47. 1894.

Ice movements in Schoharie valley. North of the central escarpment the ice movements, dominated by the major features of the topography, were very complex. The principal valleys tributary to the upper Schoharie trend approximately across the general direction of the ice movement at the flood stage, and the valleys of the two upper branches of Schoharie creek are entirely open to the east where they have been beheaded by the retreat of the Catskill front.

In the lower Schoharie valley, nearly as far up as Prattsville, the ice movement at all stages appears to have been southward, up the valley. In the valley of the Batavia kill tributary above Red falls, and of Schoharie creek above the mouth of Little West kill, the general ice movement at an early stage of the retreat was westward, down the valleys, as is indicated by moraines and abundant striae in the valley of Batavia kill and by moraines along the north side of the valley of Schoharie creek. This current met the opposing current, moving up Schoharie valley, in the general neighborhood of the junction of Batavia kill with the Schoharie where, by alternating advances of the opposing currents, a complex series of moraines was formed. Between the opposing ice tongues small lakes were impounded, as is shown by a series of hanging deltas.

At a later stage in the retreat, ice from the lobe in the Hudson valley pushed into the open eastern ends of the Schoharie valley past Kaaterskill and Plaat clove to the vicinity of the junction of the two valleys between Tannersville and Hunter, while ice from the north lay banked against the East Jewett range, pushing a tongue into the pass south of East Jewett, another through the gap south of Beaches Corner, and a third and larger one round the western end of the range at Jewett Center. The latter spread out as a bulb in the alley of Schoharie creek and seems to have blocked the valley, impounding a lake in which deltas were built at various levels by the streams carrying outwash from the tongues of ice which pushed through the gaps in the range farther east.

The ice stood in this general position long enough to build conspicuous moraines. Meanwhile, the great, fluted, drumlinlike deposits of thick drift which lie across the valley of East kill, especially between Beaches Corner and the pass south of Hensonville, were probably accumulated beneath the ice.

Small deltas in the valley of East kill, between East Jewett and Beaches Corner, indicate that the ice melted out of this part of the valley while the lower end was still blocked.

At the next later stage of the retreating ice front to be marked by conspicuous moraines, the ice was pushing through the gaps in the northeastern border range between Mount Pisgah and Windham High peak and building massive moraines in the valleys tributary to Batavia kill at and above Windham. The ice from the gap at East Windham bulged eastward into the upper Batavia Kill valley above Hensonville and impounded a lake in which deltas at two levels, approximately those of the cols south of Big Hollow and Hensonville, respectively, were built. At Windham and below, the ice at this stage discharged into the waters of the glacial lake whose outlet was through the central escarpment at Grand gorge.

East and northeast of Windham are about a dozen perfectly formed drumlins whose origin is probably connected with the spreading of the ice after its passage through the narrow gaps in the northeastern border range.

Local glaciation. Special attention was given to the problem of local glaciation, evidences of which had previously been discovered at a few points.

On the north-facing slope of the central escarpment, no less than ten valleys were found in which distinct morainic loops, convex down-valley, testify to the former existence of independent local glaciers moving northward and northeastward in a direction directly opposed to that of the movement of the continental glacier. Many other valleys, similarly situated, contain deposits which, considered individually, do not constitute convincing evidence of local glaciation, but which, taken as a whole in the light of more definite evidence in neighboring valleys, seem to be most reasonably interpreted as the products of local glaciers.

A characteristic type of deposit, found in most of the valleys on the north face of the central escarpment, and elsewhere in similar situations, is a mass of smooth, thick drift which makes a distinct step in the valley bottom with a steep slope up to the top of the step and a more gentle slope above. Such deposits commonly present a convex front down the valley and many of them are higher in the middle of the valley than at the sides. In many instances it is clear that they were fashioned by local glaciers moving down the valleys. Field study led to the hypothesis that they were built, in a manner analogous to the formation of drumlins, by deposition of till beneath the ice where its transporting ability was decreased, either on account of its thinness near the end or on account of its spreading in the form of piedmont bulbs on being released from the confines of the narrow mountain valleys. Some of the deposits may be moraines of local glaciers overridden by later advances.

In addition to the indications of local glaciation furnished by the short, steep valleys on the north slope of the central escarpment, there is evidence which suggested and gives strong support to the theory that the valleys of Little West kill and West kill, respectively 4½ and 11 miles long, were for a time occupied for their full length by independent local glaciers. Unfortunately the evidence on which the above theory is based can not be adequately presented in the space available for this abstract.

South of Esopus creek, in the valleys on the north side of the Slide mountain group, there were also local glaciers, some of them of large size. Big Indian hollow, at least above Oliverea, and possibly for its whole length, was occupied by a local glacier. A smaller one descended the north slope of Balsam mountain, southwest of Big Indian and reached levels at least as low as 1400 feet. Woodland valley, which heads on the north side of Slide mountain, was occupied by a local glacier which left distinct moraines at Woodland and less distinct ones a mile below. Whether the great morainic embankments in Esopus valley at Phoenicia were built by a bulb of a local glacier from Woodlawn valley is a problem whose solution requires further field study.

There is evidence that, for a time at least, local glaciers occupied the Stony Clove valley and its higher tributaries, but whether the great moraines in the lower part of the valley at Chichester belong to the morainic system of a local glacier could not be definitely determined by reconnaissance.

The critical elevation necessary for the formation of local glaciers was found to be about 3400 feet, and the glaciers in the smaller valleys descended to various levels down to 1400 feet. In the larger valleys, heading in the highest mountains, what are believed to have been local glaciers reached levels between 1300 and 1400 feet above the sea at the mouth of West kill and, possibly, of 800 feet at Phoenicia.

A noteworthy feature of the local glaciation of the Catskills is the weak development of land forms produced by glacial sculpture, namely, cirques and trough valleys. The heads of the valleys tributary to the upper West kill and those heading on Hunter and Plateau mountains present evidences of weak cirque action, but typical, strongly sculptured cirques were nowhere recognized.

This condition harmonizes with the evidence of very slight glacial erosion in the bottoms of all but a few of the valleys occupied by glaciers, and with the fact that the moraines of the local glaciers are built largely of drift previously deposited by the continental glacier.

All these features indicate that the local glaciation of the Catskills, though extensive, could not have been of long duration.

The moraines of the local glaciers are remarkably fresh and distinct and are undoubtedly among the most recent glacial deposits of the region. The evidences upon which a statement of the exact date of local glaciation might be based have been partly worked out, but not in sufficient detail to warrant review here.

Broader problems. The work of the past summer, in addition to its contribution to the knowledge of the local details of the glacial history of the Catskills, brought forward two major problems of more than local interest.

The first is based on the seeming greater age of the glacial deposits in the lea of the Catskills than elsewhere, and may be stated as follows: Did the ice of the last glacial epoch (possibly corresponding to the Late Wisconsin of the Middle West), though it pushed into the northern and eastern Catskills, fail to override the southern ranges?

The second is based on the somewhat anomalous phenomenon of extensive, though seemingly short-lived, local glaciation in a region far to the south of such mountain groups as the White mountains, Green mountains and Adirondacks where the evidence hitherto presented indicates a very limited development of local glaciers at the close of the last glacial epoch. The problem may be stated thus: Is the local glaciation of the Catskills a border phenomenon of an ice sheet which ended in the Catskills, or is it merely a phenomenon of the retreat of the continental glacier from its maximum limits in New Jersey and Pennsylvania?

The solution of these two closely related problems should be made the first object of future studies.

INDUSTRIAL GEOLOGY

Mr David H. Newland reports as follows:

Mining summary. The usual summary of the mining developments, with statistics of production, was presented in the form of an annual bulletin for the information and guidance of those interested in the local resources. The year's contribution of crude ores and of mineral products in first marketable forms was valued at $35,988,407, a total equal to that of the preceding year, but rather below the normal output. It was an exceptional season, marked by great prosperity in certain branches of industry and by equally great depression in others, such contrasting conditions as have scarcely been witnessed in any previous period. There was a notable revival of activity among the iron ore properties which will probably lead to a new record in the output for the current year, and some expansion in other lines; but the market for building materials (stone, clay and cement) was poor and led to decreases in these important items of local productions.

A new industry came into existence in 1915 with the inauguration of zinc mining in the Edwards district of St Lawrence county. The first ore shipments (several thousand tons for the year) are an earnest of a substantial increment in the State's developed resources. The district has long been known for its valuable talc deposits, but the value of the metallic minerals, which include both pyrite and zinc, has only recently gained recognition.

Quarry materials. An appraisal of the quarry resources that are contained in the crystalline formations, mainly Precambric, was published during the year as Bulletin 181 of the State Museum. The various kinds of products derived from these formations are granite, gneiss, marble, trap and pegmatite, all of which have considerable commercial importance. Their distribution and local development are presented comprehensively; and some of the more attractive building or monumental stones are reproduced, as faithfully as may be, in color. The description of the local features is preceded by a general discussion of the fundamental geological structures of the State as a key to the distribution of the resources; and by chapters on the qualities, physical and chemical, which determine the value of stone for different uses, and the methods available for their discrimination in the field and laboratory.

Zinc ore investigations. Steps have been taken to meet the call for information, which has come to the department from all directions, in regard to the general features of the zinc ore occurrences in the Edwards district and their probable economic importance. In addition to the areal mapping of the region now in progress, it is purposed to carry out a special investigation of the more limited area in which the ores occur. The necessary field work for this investigation, in fact, has already been practically completed. Short summaries of the developments and geological conditions in the district have been prepared for the technical and scientific press, preliminary to the complete report which it is hoped will soon be ready for publication.

The Edwards zinc district stands quite apart from the other productive areas of the country, for the deposits are found in Precambric (Grenville) limestones, about the lowest and oldest of the geological formations that can be definitely recognized with a place in the stratigraphic sequence. So far as known there are no other active mines based on sulphide ores in this association, although occurrences of similar type have been discovered from time to time in the Canadian Grenville areas. The problems connected with the derivation of the ores and the time of their introduction necessarily are complicated by the vicissitudes of age. The wall rocks have been subjected to intrusion repeatedly, have been broken up, strongly compressed and metamorphosed, so that their structure and original characters are most obscure, only to be cleared up by careful study and weighing of the evidences.

Miscellaneous. The demands upon the office for information and guidance in matters pertaining to mining and mineral resources have been particularly large in the last year or two, partly as a result, no doubt, of the unusual commercial and industrial situation generally. Requests of this character are always given consideration, and so far as compatible with the practice of the office the desired information is promptly supplied. In many instances this can be done by the mailing of a published bulletin, for which only a nominal charge is made. It should be noted, however, that the office does not undertake to supply analyses or ores and minerals in competition with public laboratories, although there seems to be a very general impression to the contrary. Samples, however, may be submitted for identification and an opinion as to their value, which can be given in most cases with a close approximation to the truth upon the basis of experience and tests that are readily applied. To carry out an exact analysis is the work of one or more days and can not be undertaken except under special circumstances where the matter is of unusual interest.

PALEONTOLOGY

The Museum. The work of installation in the division of paleontology was actively continued during the year. There were added two cases in the hall of fossil plants, one large wall case in the hall of vertebrates, and three cases in the hall of invertebrates. Of the two new cases of fossil plants, one contains Devonian plants from western New York and the Catskill region, the other Upper Devonian plants from Scaumenac bay, P. Q., Canada. The new case in the hall of vertebrates is a large wall case devoted to the remarkable Devonian lung fishes and ganoids from Scaumenac bay. A recent Australian lung fish and a recent ganoid from the Nile have been installed for comparison with the fossil forms. The new cases in the invertebrate hall comprise two AA cases of crinoids in the general collection, and an upright case of starfishes and echinoids. The two AA cases of starfishes have been rearranged and much new material, lately described, has been added.

The special exhibit of corals, filling eight AA cases altogether, has been finished.

Mr Henri Marchand has added four more wax models of graptolites to the series in process of construction. This series will illustrate not only the remarkable variety of forms attained by graptolites in the Paleozoic seas of New York, but also the distinct genetic series which they form, from irregular sessile bushes to highly symmetric floating and swimming forms.

An exhibit of the Pleistocene fossils from the marine invasion of the Champlain basin at the end of the last glacial period has been installed in special cases. In obtaining this fine and comprehensive collection the important observation was made that the marine shells decrease in size and thickness as one goes southward from the St Lawrence region, and that at the same time one species after another drops out, until at the southernmost locality of marine Pleistocene shells at Crown Point, N. Y., and Chimney Point, Vt., only small representatives of Macoma groenlandica Beck and Yoldia arctica Grey are left. From the changes brought about in marine forms where a gradual freshening of the water takes place, as in the Baltic Sea, it is inferred that these facts indicate a gradual decrease in the salinity of the Hochelagan sea southward, until at Crown Point the water had become so fresh that it no longer could support marine forms. The continuation of the Champlain clays proves that the sea itself extended much farther south.

Guidebook. A Guide to the Paleontologic Collections (35 pages) which purports to give a popular account of the fossils shown and of their biological and geologic relationships has been prepared for free distribution to visitors who are sufficiently interested in the collections to inquire for it.

Field work. The field work consisted of the two months' collecting trip in the Pleistocene and about six weeks' investigation of the Utica, Frankfort and Lorraine formations in central and northwestern New York, the funds not allowing a longer stay in the field.

Researches. The field work of the year here recorded, together with a few weeks of research in the field, in the preceding year, have furnished sufficient data to continue the laboratory investigation of the Upper Ordovician shale and sandstone terranes of the Mohawk and Black River valleys; the first instalment of which was published in Museum Bulletin 162, entitled "The Lower Siluric Shales of the Mohawk Valley." In this publication the Trenton age of the black shale (formerly Utica) and sandstones (formerly Frankfort and Lorraine) of the Lower Mohawk valley was demonstrated.

In the westward continuation of this work in the last two years, the Utica, Frankfort and Lorraine beds of the Upper Mohawk and Black River valley were investigated. It was found that the true Utica shale in the Utica basin contains at least three major graptolite zones, to which a fourth or younger zone is added in the Black River valley. This rests on Trenton limestone younger than the Trenton of Trenton Falls. The black shale hence shows a continuous and progressive rise in the time scale from the Hudson river westward and northward to the St Lawrence river, from lowest Trenton to post-Utica age. A distinct graptolite zone develops also in the Black River valley in beds corresponding in stratigraphic position and lithology to the Frankfort shale of the Utica region. Collections of Lorraine fossils from the Lorraine gulf and the deep ravines interesecting the Lorraine plateau toward the Black river at the Whetstone gulf, with careful notation of their horizons, have been made and it is expected that their study will also permit the subdivision of the Lorraine formation on the basis of its faunas and a subsequent correlation with the horizons distinguished in the Ohio basin and in Canada. It is by this careful analysis of the faunas of sections that the facts of the shiftings of the ancient epicontinental seas are established and the basis for paleogeographic maps of the different periods furnished. The work on the Lorraine formation could not be fully completed owing to the lack of funds.

Occurrences of Mastodon and Mammoth

In my report for 1903 a summary was given of the recorded occurrences of the mastodon in this State, and this summary has been supplemented in succeeding reports as new discoveries were announced both of the mastodon and the mammoth (Elephas).

Additional lists have been published in the reports for 1906, 1907 and 1909.

Further discoveries and items not before recorded are here given, including several localities where mammoth remains have been found.

Onondaga county

Near Salina. Two specimens of mammoth teeth in possession of the Museum bear the label "Near Salina, N. Y." One specimen is a single nearly complete tooth; its small size and immature appearance stamp it as one of the milk teeth. The second specimen is a fragment of a small tooth.

Near Minoa. Specimens from a mammoth obtained from the east side of Limestone creek near Minoa have been described by Dr Burnett Smith.[1] The remains were unearthed during the construction of the West Shore Railroad about 1883, and consist of one tooth and parts of a tusk or tusks. The best preserved part of the tusk and the molar are in the museum of Syracuse University.

Wayne county

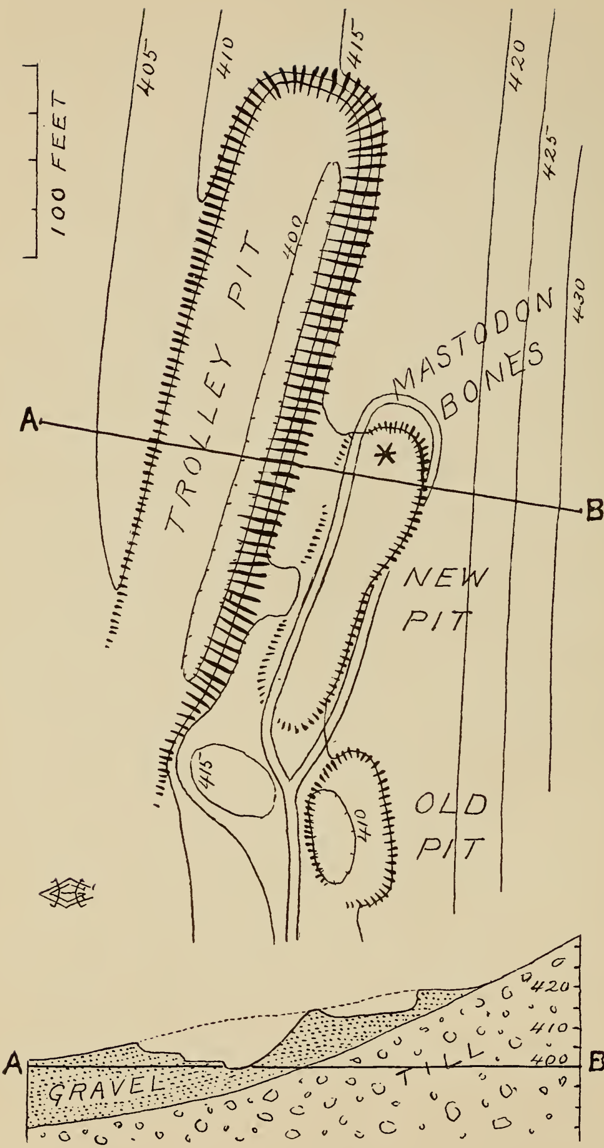
Near Clyde. In November 1910 a mammoth tooth was received from Mr William B. Landreth, deputy state engineer. A letter from Mr B. E. Failing, resident engineer of Lyons, N. Y., gives these details: "The mammoth tooth was found while excavating for lock 26, Barge canal, 2½ miles east of Clyde, N. Y. It was found about 100 feet from the Clyde river and 22 feet underground in a layer of sand and clay, on top of gravel which appears to have been the old river bottom."

Near Savannah. In October 1916 there were dug up in a gravel pit near Savannah, two excellently preserved mammoth teeth consisting of the back upper left and right molars. They were about 8 feet underground and 4 feet apart. These teeth have been purchased by the Museum.

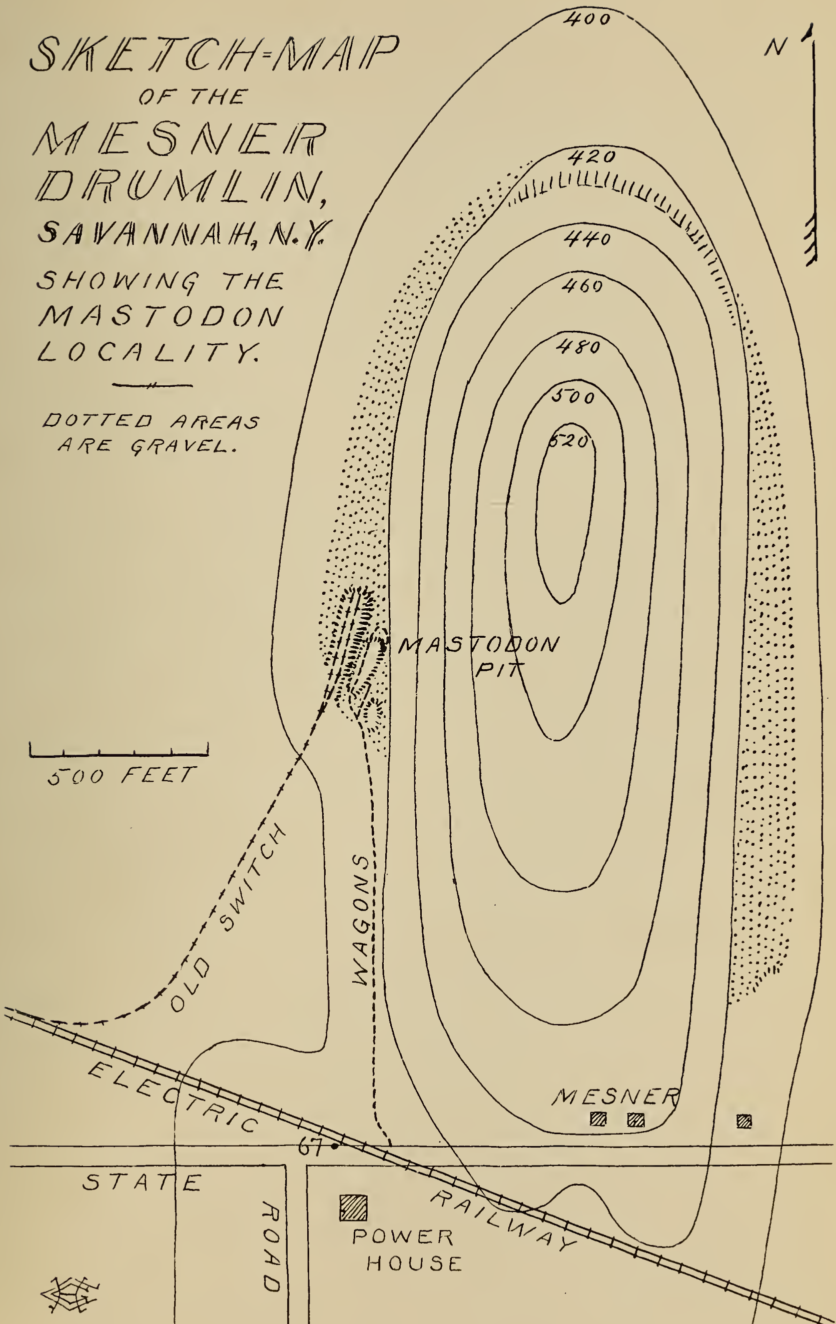
In September of this year an additional find, consisting of the right shoulder blade, was reported. The bone has been presented to the Museum by Mr Gipson Mead of Savannah, N. Y. Recently Prof. G. H. Chadwick has visited the gravel pit and his report is here incorporated.

The Savannah Mammoth. The gravel pit at Savannah from which the two mammoth teeth and the shoulder blade were previously secured was visited on October 27th, at which time exca-

[1] New York State Mus. Bul. 171, p. 68 (1914).



DETAIL MAP AND SECTION
OF THE MESNER GRAVEL PIT


SKETCH-MAP
OF THE
MESNER
DRUMLIN,
SAVANNAH, N.Y.
SHOWING THE
MASTODON
LOCALITY.
DOTTED AREAS
ARE GRAVEL.
500 FEET
N
400
420
440
460
480
500
520
MASTODON
PIT
OLD SWITCH
WAGONS
ELECTRIC
RAILWAY
MESNER
67
STATE
ROAD
POWER
HOUSE

vation had ceased for the winter. A systematic search resulted in the finding of two more pieces, belonging to the leg and foot, which are transmitted with this report. A sketch map with cross-section of the area is also submitted.

The chief interest of this find is the character of the occurrence. The locality is a gravel pit on the west side of a high drumlin hill one mile due northwest of Savannah, N. Y., at the northwest corner of what Fairchild has aptly called the "*heart* of the drumlin area." The isolated nature of this drumlin mass, surrounded by wide marshes as is strikingly shown by his plate 12 of Bulletin 111 of the Museum, is due to the fact that it was an island or rather an archipelago in the waters of glacial Lake Iroquois. The gravel pit itself, which is about 1400 feet due north of the power house (stop number 67) on the Rochester, Syracuse & Eastern electric railway, is dug in one of the beach spits built by the waves of the lake, and its summit level of about 420 feet above the sea therefore marks the position of the ancient water surface. This level is over 30 feet above the surrounding marshes, indicating clearly that at no point between this mass and the mainland or the neighboring islands could the icy waters of Lake Iroquois have been less than 30 feet deep. Nor was it anywhere less than one-fourth of a mile across to the nearest other land, which was, like itself, an island.

There is every reason to believe, nevertheless, that the bones were buried in these beach gravels by the waves themselves, and at the time when Lake Iroquois was at its full height. In no other way could they have become so interstratified with the beach shingle. Three pits have been opened here: a large one (90 by 325 feet) on the west slope of the spit by the trolley company during the construction of their line, and two smaller ones (respectively 50 by 170 and 40 by 80 feet) on the crest of the beach for road metal. These upper pits are shallow, not over 6 feet deep, in the finer surface gravels, stopping when they reach the underlying coarse gravels that appear in the railway pit just below them. It is the larger and fresher of these shallow upper pits that has furnished the remains so far found. Besides the portions that have been saved, a crumbling tusk appears to have been shovelled in with the gravel, and there is no knowing how many other small bones or fragments have been distributed upon the roads of the town. The two pieces just collected lay unrecognized among the rejected larger cobbles.

The separation of the parts, especially the isolation of the teeth, and the fact that the pieces found have belonged to various portions of the animal, harmonize with the belief that they were the play of the waves, yet not carried far. Lying high in the gravel ridge, yet mostly beneath the reach of plant roots, they have escaped rotting, suffering chiefly from pick and shovel. The problem that engages us is, How did the mammoth reach the island?

Without attempting to defend any theory, the following possibilities are suggested: that he swam there; that he crossed on the ice in winter; that mammoths may have roamed on the surface of the glacier itself and been drifted to this shore by icebergs; that the bloated carcass was floated to the island; that a mammoth colony may have been marooned on the Savannah island by the slowly rising waters of Iroquois, since that lake is now known to have been flooded back upon the south shore by slow uplift of its outlet region. These are some of the possibilities that present themselves; it is not imperative that their pros and cons should be argued until more is known about the pit and its fossil contents. The outstanding fact that seems unlikely to be modified by further evidence is that this occurrence fixes the existence of living mammoths in western New York during the closing phase of full-height Iroquois, a lake that coincided with the period of final recession of the second Wisconsin glacier from the Ontario basin and upper St Lawrence valley.

Madison county

Near Canastota. In August of this year Dr. Burnett Smith reported the discovery of mastodon or mammoth bones. The occurrence is 4 miles north of Canastota and 2 miles distant from the south shore of Oneida lake. The bones were found while excavating for a drainage canal in the extensive swampy region lying to the south of Oneida lake. At the present writing, one each of the following bones have been uncovered: femur, ulna, radius, rib, patella.

Chittenango. Among the collections are several ribs bearing the label "Chittenango, N. Y., E. Emmons 1873." From the same collection are two tusks, with the ivory in an excellent state of preservation. They bear the label "Chittenango, N. Y." From the character of the tusks, these remains are referred to the mammoth. (See Tenth Ann. Rep't State Cab. Nat. Hist. 1857. p. 188.)

Orange county

Near Harriman. In October 1913 there was acquired by the gift of Mr W. J. Post of Harriman, N. Y., a finely preserved tusk of the mastodon. The specimen was found about 2 miles south of

Harriman station (Erie Railroad). It was covered by about 6 feet of muck at the bottom of a pond which had become dry at this season.

Near Vails Gate Junction. During the summer of 1917, remains of a mastodon were found on the muck land of Antonio Fisher, one-half of a mile west of Temple Hill monument and 1 mile north of Vails Gate Junction. The find consists of a few scattering bones together with a well-preserved lower jaw containing the four teeth. These remains were found in a shallow excavation 2 feet below the surface. In size the jaw is slightly larger than that of the Cohoes mastodon.

Near Milton. About 1890 a very small tooth of a mastodon was found near Milton by Charles Kniffen, on the farm now owned (1917) by J. R. Bray. The tooth at the present writing is in the possession of the finder.

Schenectady county

South Schenectady. In 1914 a fairly well-preserved tooth of medium size of the mastodon was obtained from the gravels at South Schenectady by Richard Ribley, who still has possession of it.

Cortland county

Near Homer. Among the collections are two mammoth teeth carrying the label " from near Homer, N. Y." One is a complete large specimen, the other has one end broken away. The part remaining represents two-thirds of the specimen.

Niagara county

Lewiston. In 1912 the remains of mammoths were found in a gravel pit of the Iroquois beach, not more than 40 rods from the railroad station at Lewiston. The parts recovered include two atlases, one complete molar, parts of two other molars, the pelvis, a few ribs, and one vertebra. The layers of sand and gravel dip at nearly 45° east or southeast, and the bones were found in several layers aggregating 6 to 10 feet and 20 to 40 feet below the flat top of the terrace.

Warren county

Near Queensbury. Among the collection of local objects from the vicinity of Glens Falls presented to the Museum by James A. Holden is a large tooth of a mammoth. The specimen was found on the farm of John Harris in upper Queensbury.

MINERALOGY

Exchanges. Pursuing the policy that the large stock of duplicates both in the general mineral collection and in the New York State collection should be utilized as a means of acquiring by exchange desirable new material for both collections, a circular letter was issued to a group of private collectors soliciting exchange and stating the needs and standards of both collections. This policy, which will be adhered to in the future developing of this section of the Museum, has already enriched the collections in both exhibited and study specimens. The high standard already set by the exhibited specimens in both collections makes it increasingly difficult to add new material, which, at least in the case of an addition to the general collection, must be subjected to a rigorous comparison with the displayed suite, and which must prove its right to a place in the exhibited series by displacing a corresponding specimen.

Guide. The visitors' guide to the mineral collection which was issued in October 1916, and distributed to the public in response to a request, has met a demand amounting to about 100 copies a month. It fills a gap in the educational scheme of this section of the Museum in that it supplies to the visitor whose interest has been aroused, popular information of a more detailed character than can be gained from the necessarily brief group labels, and it also opens the way for a more comprehensive study of the collections, using Bulletin 58 as a textbook. In line with this idea, a reference table has been placed in the center of the collections, equipped with several of the mineralogic publications of the Museum, descriptive of the collections.

Lectures. The extension work of the section of mineralogy has grown in the past year. In addition to the two lectures delivered in the State Museum course, the curator of mineralogy has been called on to deliver the following lectures and addresses:

"Lettered Signs" before the State Library School.

"The New State Museum and the Peoples University" before the Peoples Forum of Binghamton, N. Y.

"Diamonds" before the Chemical Society of the State College for Teachers, Albany.

"Gems and Gem Minerals" before the Woman's Club of Hudson.

"Gem Symbolism in Legend and Folklore" before the Albany Philosophical Society.

"The Installation and Development of the Mineral Collections of the New York State Museum" before the New York Mineral Club, New York City.

"Methods of Museum Installation as Illustrated in the New York State Museum" before the State Library School.

Research. Crystallographic research has been confined to the study of several occurrences of barite, the material for which was furnished by the general collection, and an occurrence of wernerite, the material for which was drawn from the New York State collection. Both studies have resulted in the establishment of new crystal forms.

VII

REPORT OF THE STATE BOTANIST

Noteworthy contributions. The most important additions to the state herbarium during the past year are contributions of specimens from Prof. J. J. Davis, of Madison, Wis., the New York Botanical Garden and Dr J. R. Weir of Missoula, Mont., in addition to the collections made by members of the staff.

Wild Flowers of New York. The season of 1916 was largely spent in continuation of the field work necessary for the completion of the proposed memoir on the Wild Flowers of New York State. This work was started early in August 1915 and with the appearance of the earliest spring flowers in April 1916, the work was carried forward and completed late in September of the past year. During the two months of 1915 and the six months from April 15 to September 15, 1916, there were photographed in the field 364 species of plants which, because of their conspicuous flowers or attractive appearance, might be classed under the rather indefinite term of "wild flowers."

The 364 illustrations will be in colors and grouped on about 264 plates, of which 161 plates will have each a single illustration and the 103 remaining plates will contain two illustrations each. The text will consist of a brief description of each species together with its range and such other remarks concerning its habitat as seem proper.

By means of a specially constructed apparatus as shown in the accompanying illustration each flower was photographed in position as it grew, without any interference from wind or excessive sunlight. For each subject there were taken one or two (usually two) dry plate photographs and one lumiere (autochrome) photograph. These were usually developed within a few hours so that any serious faults might be corrected by taking another exposure of the subject.

It is proper to remark here that the success of these photographs is largely due to the skill, patience and enthusiasm, often under disagreeable physical circumstances, shown by the two photographers employed: Mr Walter B. Starr of the Matthews–Northrup Company, Buffalo, and Mr Harold H. Snyder of the Zeese–Wilkinson Company, New York.

View of cage used to protect wild flowers from wind while photographing

Each subject photographed was given a number in order to facilitate its designation in subsequent correspondence, engraving and arrangement in final order. Photographic proofs of the dry plates were marked with directions for size of completed illustration and such other alterations as seemed desirable and duplicate copies of such proofs were kept on file in the Botanist's office. From retouched photographs approved by the Botanist, the engraving companies made their plates for engraving and these were etched down with the autochrome positive as a color guide until each of the four copper plates gave the proper register of color when used upon the press in combination with one another, that is to say, blue, yellow, red and black.

Scientific investigations. A rather limited amount of time was devoted to the completion of a reconnaissance of the vegetation and its ecological relations about the eastern end of Oneida lake, a region of extensive sandy barrens, swamps and bogs in addition to the broad, sandy beach of the lake and the numerous shallow waters of the lake shore and the streams flowing into the lake, the home of numerous water-loving plants. Because of soil conditions and a climate, influenced to some extent by the Great Lakes, the region is characterized by a large number of plants common to the northern coastal plain. The results of this investigation appear in the Botanist's report.

Exchanges. Duplicate specimens of fungi, ferns and flowering plants have been exchanged for desirable material with the New York Botanical Garden, the National Herbarium at Washington, Prof. J. Dearness of London, Canada; Dr J. R. Weir of Missoula, Mont., and other institutions and individuals.

Additions to the herbarium. The number of specimens of New York State species which have been added to the herbarium from current collections of the staff during the past year is 528, from contributions 375, a total of 903 specimens. Of the total number of specimens received, 131 were new to the herbarium and 25 species are described as new to science.

In addition, about 900 specimens of species extralimital to New York, from the Sheldon herbarium, presented in 1914, representing characteristic species of the eastern and southern flora, have been remounted and incorporated into the herbarium. It is not the aim of the state herbarium to represent to any great extent the flora of regions beyond the State's border. The Sheldon herbarium. however, contains over 13,000 specimens, representing nearly

8000 species, most of them extralimital to New York, and it seems advisable gradually to incorporate the best of them into the herbarium for purposes of comparison with our native species and as an aid in the identification of material collected outside the State by persons who bring or send them here for determination.

Twenty persons have contributed specimens to the herbarium, and the number of species represented by their contributions is 375. This includes specimens sent or brought for identification which were desirable additions to the herbarium.

Collections have been made by the staff in the following counties: Albany, Bronx, Cayuga, Columbia, Genesee, Herkimer, Madison, Monroe, Nassau, Oneida, Onondaga, Ontario, Oswego, Queens, Rensselaer, Suffolk and Wayne.

Identifications. The number of identifications made of specimens sent or brought to the office by 95 inquirers is 465.

Mushroom models. The Peck testimonial collection of models cast in wax of edible and poisonous mushrooms now includes 56 groups of which 8 represent poisonous species. This constitutes a most interesting exhibit and one of high educational value. It is planned to arrange these in an attractive manner in wall cases.

Many of these groups have been the subject of special study and illustration by Doctor Peck. The following list of the groups is collated with reference to illustrations of them which have appeared in publications of the State Museum.

1 Craterellus clavatus (*Pers.*) *Fr.*
Memoir 4, pl. 56, fig. 17–21; 49th Rep't, pl. 44, fig. 1–5 (as Craterellus cantharellus)

2 Mitrula irregularis *Peck* (M. vitellina *Sacc.* var. irregularis *Peck*)
48th Rep't, pl. 5, fig. 8–14

3 Russula cyanoxantha (*Schaeff.*) *Fr.*

4 Lepiota naucina *Fr.* (Lepiota naucinioides *Peck*)
48th Rep't, pl. 19

5 Agaricus arvensis *Schaeff.*
48th Rep't, pl. 8

6 Leottia lubrica (*Scop.*) *Fr.*

7 Peziza badia *Fr.*

8 Pleurotus sapidus *Kalchbr.*

9 Tricholoma personatum *Fr.*
48th Rep't, pl. 20

10 Clavaria pistilaris umbonata *Peck*
Memoir 4, pl. 66, fig. 15–17

11 Russula roseipes (*Secr.*) *Bres.*
51st Rep't, pl. 53, fig. 1–7; Memoir 4, pl. 54, fig. 1–7
12 Russula emetica *Fr.*
13 Lycoperdon pyriforme *Schaeff.*
14 Peziza aurantia *Pers.*
15 Tremellodon gelatinosum (*Scop.*) *Pres.*
16 Clavaria cristata *Pres.*
48th Rep't, pl. 39, fig. 8–12
17 Cantharellus cibarius *Fr.*
18 Lepiota procera (*Scop.*) *S. F. Gray*
48th Rep't, pl. 18
19 Hypholoma perplexum *Peck*
48th Rep't, pl. 47, fig. 11–18; Memoir 4, pl. 60, fig. 10–17
20 Armillaria mellea (Vahl) Quel.
48th Rep't, pl. 20
21 Scleroderma vulgare *Hornem.*
22 Boletus cyanescens *Bull.*
23 Tricholoma sejunctum (*Sow.*) *Quel.*
24 Craterellus cantharellus (*Schw.*) *Fr.*
25 Russula albidula *Peck*
26 Pleurotus serotinus (*Schrad.*) *Fr.*
27 Fistulina hepatica *Fr.*
48th Rep't, pl. 37, fig. 8–12
28 Geoglossum ophioglossoides (*L.*) *Sacc.*
29 Hypomyces lactifluorum (*Schw.*) *Fr.*
Mus. Bul. 105, pl. 103
30 Hydnum albidum *Peck*
Memoir 4, pl. 67, fig. 1–6; 51st Rep't, pl. 56, fig. 1–7
31 Hygrophorus eburneus (*Bull.*) *Fr.*
32 Collybia radicata *Relh.*
33 Chanterel floccosus *Schw.*
Memoir 4, pl. 55, fig. 9–13; 52d Rep't, pl. 60, fig. 10–14
34 Coprinus comatus *Fr.*
48th Rep't, pl. 10
35 Boletus alboater *Schw.* (B. nigrellus *Peck*)
36 Clavaria ligula *Fr.*
37 Russula virescens *Fr.*
48th Rep't, pl. 31
38 Calvatia elata *Massee*
39 Gyromitra brevipes *Fr.* (G. esculenta very similar to this is illustrated in 48th Rep't, pl. 5, fig. 1–3)
40 Gyromitra brunnea *Underw.*
41 Sparassis crispa (*Wulf.*) *Fr.*

42 Morchella deliciosa *Fr.*
48th Rep't, pl. 3, fig. 4-7
43 Strobilomyces strobilaceus (*Scop.*) *Berk.*
Mus. Bul. 94, pl. 92
44 Craterellus cornucopioides (*L.*) *Pers.*
48th Rep't, pl. 24, fig. 7-10
45 Polyporus sulphureus *Fr.*
48th Rep't, pl. 37, fig. 1-4
46 Polyporus caudicinus (*Scop.*) *Murr.* (P. squamosus *Huds.*)
47 Agaricus campestris (*L.*) *Fr.*
48th Rep't, pl. 6, fig. 1-10
48 Amanita caesarea (*Scop.*) *Pers.*
48th Rep't, pl. 10
49 Tremella lutescens *Pers.*
50 Clitocybe illudens (*Schw.*) *Fr.*
Memoir 4, pl. 68
51 Hypomyces hyalinus (*Schw.*) *Tul.*
52 Amanita phalloides *Fr.*
(Four models showing variations in color and form)

VIII

REPORT OF THE STATE ENTOMOLOGIST

The Entomologist reports that the frequent and rather heavy rains of the spring and early summer offset, in large measure, depredations by various leaf feeders by producing an unusual growth of vegetation. Apple tent caterpillars were numerous in many localities and yet the damage was relatively small. There were no complaints of injuries by the forest tent caterpillar and very little serious damage by the elm leaf beetle, a pest which, in earlier years, defoliated thousands of trees, and one which has killed many magnificent elms in the Hudson valley.

The subjects briefly outlined in this report are more fully discussed in the annual report of the Entomologist.

Fruit tree insects. Practical work with the *codling moth* was continued the past season in cooperation with the bureau of horticulture of the State Department of Agriculture, and the Monroe County Farm Bureau. These studies were conducted in four commercial orchards in western New York through the hearty cooperation of their respective owners and an effort made to determine the relative value, as in former years, of the first, second and third sprays for the control of this pest. In connection with these investigations, observations were also made upon the development and biology of the codling moth. The data secured show, as do those of earlier years, the very great benefits which may be derived from the first or so-called calyx spray, and indicate most strongly the necessity of thoroughness if satisfactory results are to be obtained. This alone is of great value to the commercial fruit grower, since it indicates the most promising method of controlling a destructive insect. The work in the orchard of Mr H. E. Wellman, Kendall, when compared with that of the preceding year, shows a very gratifying reduction in infestation. The same plots were used and the wormy apples of the past season were from one-third to two-thirds less than those of 1915.

A careful study of the different types of codling moth injury has enabled the Entomologist to verify his earlier opinions as to the relation existing between them and the habits of the insect, and also to outline rules for determining the period during which different types of injury may be inflicted. The latter is of considerable importance in connection with the enforcement of the apple grading and packing law. He has also, through the cooperation of several local observers, secured detailed records of evening temperatures and other meteorological data under actual orchard conditions. Unfortunately the egg laying of the moth was so distributed the past season that it was impossible to demonstrate a well-marked relation between variations in evening temperatures and the deposition of eggs, though it is very probable that such exists. The meteorological data recorded constitute a substantial basis for subsequent investigations. Spraying for the control of the codling moth was followed by serious and somewhat general injury to Baldwin foliage, in particular, due probably to the application of a rather strong fungicide immediately after a series of rains which produced an unusually tender growth.

Continued injuries by the *apple maggot* resulted in beginning an investigation of the pest, with especial reference to practical control measures. This was started through the cooperation of Mr Edward Van Alstyne of Kinderhook, and Mr George T. Powell of Ghent. The results of a series of tests with sweetened poisons for the destruction of the flies were so equivocal that this office is unable to recommend this spray and for the present is content with advising the early destruction of infested fruit, supplemented by good orchard practice. The investigations of the past season demonstrated such variations in the habits of the flies in nearby orchards that a continuance of the study is planned for another year.

Incidental to work with the codling moth noticed above, investigations showed that the *leaf roller,* a serious pest of the fruit grower in the western part of the State, was much less abundant than was the case in 1915. This condition is probably due to one of the natural and frequently unexplainable oscillations in insect life.

Studies of *red bugs* the past year indicate that the two species generally grouped under this common name, are becoming well established in the fruit-growing sections of the State and here and there are causing serious injury. The practical work of the past two years has demonstrated nothing to be more effective than the use of a tobacco extract, 40 per cent nicotine, just before the blossoms open. This may be applied in water to which any cheap soap has been added to aid in spreading the insecticide, or incorporated in the delayed dormant spray. In the case of bad infestations this last treatment should be supplemented by the use of tobacco in the usual calyx spray for the codling moth and the compound applied as soon as possible after the dropping of the blossoms.

The *San José scale*, greatly feared in earlier years, has caused comparatively little injury in the Hudson valley, and in some sections has been remarkable for its scarcity. This reduction in abundance is probably attributable in large measure to the activities of various small parasites, though climatic conditions may have considerable influence. Unsprayed orchards, even though they have been infested with the scale for a series of years, are in somewhat better condition, generally speaking, than they were eight or ten years ago and a few fruit growers have been encouraged by this comparative scarcity of the pest, to omit the early spring application for the control of the scale. No serious consequences have followed this procedure to our knowledge, though it is a practice which can not be recommended at the present time.

The minute and destructive *pear thrips* have been abundant here and there in the Hudson valley and has caused serious injury in a few localities. Through a combination of fortunate conditions the Entomologist was able to secure a somewhat satisfactory test of the value of a thick lime-sulphur wash as a means of controlling the thrips, the application being made before the buds crack. The results are most encouraging though owing to the erratic habits of the insect, there can be only a qualified recommendation.

Injuries by the *pear psylla* have not been serious, as a rule, in Hudson valley orchards and in many, comparatively few eggs were deposited in early spring. The late application of the winter lime-sulphur wash for the destruction of the eggs continues to be one of the most satisfactory methods of controlling this pest though occasionally the treatment must be supplemented by midsummer spraying with a contact insecticide.

Gipsy moth. The area infested by the gipsy moth at Mount Kisco was examined, and though the scouting of the winter of 1915 and 1916 revealed an extension of the infested area there was no marked change in the situation. The infested woodland had been well cleaned during the winter and early spring, was thoroughly sprayed in early summer, and in August no living insects were to be found. There is no reason why this local infestation should not be eradicated if the work is prosecuted with desirable thoroughness and those most conversant with the situation can not gainsay the wisdom of such procedure.

Grass and grain pests. The grasshopper devastations of the last two years on the borders of the Adirondacks were much reduced during the past season, though many young insects hatched in early spring, as shown by observations in Lewis, Saratoga and Albany counties. There were two causes for this change. The frequent and copious rains of the spring and summer produced an abundant forage capable of supporting many grasshoppers without marked injury. The rains doubtless killed many of the young insects by producing conditions unfavorable for their development and, in addition, the systematic poisoning of earlier years over large areas resulted in a great decrease in the pests. The experience of the last three years has amply demonstrated, generally speaking, the practicability of local control through the distribution of poisoned baits.

The *white grub* outbreak of 1915 was followed, as was to be expected, by numerous full-grown grubs in many fields last spring and as a consequence many farmers were afraid to plant susceptible crops on such land. Moderately late planting of these areas was advised and the outcome in the field fully justified the recommendation. General notices were also issued calling attention to the more salient features in the life history of these destructive insects and pointing out the most practical means of avoiding injury. Studies were continued of the white grub robber fly, a species which has proved an important natural enemy of white grubs.

Incidental observations during recent years, upon several minor *clover insects,* have been brought together and placed on record in the Entomologist's report. It will be seen by referring to these two accounts that two European weevils in addition to the much better known and earlier introduced, punctured clover leaf weevil, have become established in recent years in the Hudson valley and in certain localities, at least, are causing an appreciable amount of injury.

Shade tree insects. There has been comparatively little damage to the shade trees of the State, owing in part to the climatic conditions being unusually favorable for the growth of vegetation.

An interesting injury, that of the maple leaf stem borer, has been studied. This insect is a comparatively unknown one in New

York State and occasionally, as shown by observations in other portions of the country, becomes somewhat abundant and injurious.

There is annually more or less bleeding from wounded trees. The past season was characterized by an unusual prevalence of this trouble. While there may be other causes for this phenomenon, observations of the last few years have enabled us to associate much of this damage with slender, white maggots, the young of a small and hitherto almost unknown fly.

Forest tree pests. Injuries by the hickory bark beetle, as shown by observations, have continued though the damage the past season appears to be materially less and, in certain cases at least, seems to be favored by a weakened condition following the severe drought of earlier years. Studies of this species have resulted in securing valuable information respecting the biology and habits of several associated species.

Greenhouse pests. A number of greenhouse insects were brought to the notice of the office during the past year and investigated so far as opportunities permitted. The Florida fern caterpillar, a well-known southern insect, was found well established in a fern house at Lockport.

The rose bud midge, a dangerous enemy of indoor roses, has again appeared in greenhouses in the lower Hudson valley, while reports from different localities indicate a wide dissemination for the recently introduced chrysanthemum gall midge, a species liable to appear in numbers and cause serious injury in almost any chrysanthemum house of the State.

Periodical Cicada. A brood of this remarkable insect appeared in the western part of the State, and detailed records concerning its distribution and abundance, together with observations upon its habits, have been collated and are given in the Entomologist's report.

Flies. There is continued interest in the control of the house fly and a number of requests for information in regard to this insect have been complied with. Mobilization of troops the past summer made it necessary to control flies under camp conditions and at the request of Dr H. L. Van Winkle, the Entomologist made a personal examination of Camp Whitman, Greenhaven, and submitted a series of recommendations for the control of the house fly.

Infantile paralysis. A serious outbreak of this disease made it very desirable to investigate thoroughly the possibilities of flies or other insects acting as carriers of this infection, and at the invitation of Dr Haven Emerson, commissioner of health, New York City, the Entomologist attended a conference for the purpose of outlining a fly survey. This work was placed in charge of an entomologist employed by the department of health of the city of New York, and the details of the investigation will be made public later.

Gall midges. An unusual number of economic and comparatively unknown species belonging to this group have been brought to our attention during the past year, and the probabilities are that there will be more rather than less injury of this character in the future. The studies of these interesting forms have been continued and a number of new species, mostly reared, and several new genera described.

Key to insect galls. The studies of gall midges have resulted in many insect galls being submitted for identification and, as a matter of convenience, an illustrated key of these deformations has been prepared. This tabulates about 1400 galls in relation to their food plants, gives the principal characters of each deformity and a reference to the best or more accessible description. The key has greatly facilitated the naming of galls and it is believed that its publication will materially increase the interest in this branch of natural history.

Lectures. The Entomologist has delivered a number of lectures on insects, mostly economic species, before various agricultural and horticultural gatherings, some of them being in cooperation with the Bureau of Farmers' Institutes or the county farm bureau agents. Several lectures have also been given under the auspices of local welfare associations.

Publications. A number of brief, popular accounts regarding such common pests as the apple tent caterpillar, pear thrips, white grubs and grasshoppers have been prepared and widely circulated through the press. The Entomologist's report contains a list of his more important publications during the year.

The increased interest in agriculture and nature study resulted in a large demand from school teachers for information relating to insects, and as a consequence the editions of certain more popular bulletins and reprints, some dating back a number of years, were exhausted the past summer. These publications could hardly have been placed to better advantage.

Faunal studies. Investigations along these lines have been continued and a manuscript list of the insects of the Adirondack region, based mostly upon material in the state collection, is nearly ready for publication. This list is a growing one, additions being constantly made thereto in connection with other work carried on within the limits of our faunal area, such as the study of grasshoppers the last two or three years.

Another valuable addition to the natural history of the State is practically ready for the printer, namely "A Monographic Account of the Caddis Flies or Trichoptera," by Dr Cornelius Betten. This work had its inception in the studies of aquatic insects begun at the entomological field station, Saranac Inn, in 1901, many of the results of which appear in Museum Bulletins 47, 68, 86 and 124. The Trichoptera are an important group economically, since there are numerous species occurring in all kinds of fresh waters throughout the State, some of them being exceedingly abundant and consequently of great value as food for fish and other aquatic life.

Substantial progress on the "Monograph of the Stone Flies or Plecoptera" has been made by Prof. James G. Needham. This is another study begun at the entomological field station mentioned above and will make an extensive and valuable addition to our knowledge of an important and comparatively unknown group of aquatic insects. These studies and those already published on aquatic forms, comprise by far the most important additions to our knowledge of American aquatic insects.

The contributions to the natural history of the State from the office of the State Entomologist are worthy of mention in this connection. The scope of these studies, as indicated by the titles cited and the amount of work involved, is suggested by the approximately 3500 pages of text with numerous illustrations devoted to the discussion of the various groups. The more important titles, aside from the long series of reports and bulletins, treating of especially destructive forms, are listed below.

Entomological Contributions 1–4, by J. A. Lintner, appearing in the 23d, 24th, 26th and 30th Museum Reports, respectively, contain many and valuable additions to the knowledge of our local fauna.

Scale Insects of Importance and List of the Species in New York State, by the Entomologist, Museum Bulletin 46. The more destructive species are faithfully illustrated in color, discussed in some detail and a list given of all the species then known to occur in the State.

Aquatic Insects in the Adirondacks, by J. G. Needham and Cornelius Betten, Museum Bulletin 47. Contains comprehensive accounts of many aquatic forms and is illustrated by a number of admirably executed colored plates.

Monograph on the Genus Saperda, by the Entomologist and L. H. Joutel, Museum Bulletin 74. An extended economic and systematic discussion of these important beetles illustrated by an unequaled series of colored plates.

Mosquitoes or Culicidae of New York State, by the Entomologist, Museum Bulletin 79. The first comprehensive account of New York forms, based upon an exact study of both adult and immature stages, illustrated by a large series of original plates.

Aquatic Insects in New York State, by J. G. Needham, A. D. MacGillivray, O. A. Johannsen and K. C. Davis, Museum Bulletin 68. Contains accounts of numerous aquatic forms with monographic discussions of several groups.

May Flies and Midges of New York State, by J. G. Needham, J. K. Morton and O. A. Johannsen, Museum Bulletin 86. The greater part of this work deals with the Ephemeridae and Chironomidae and there is, in addition, a valuable paper on the Hydroptilidae.

Studies in Culicidae; Jassidae of New York; List of Hemiptera Taken in the Adirondack Mountains, by the Entomologist, Herbert Osborn and E. P. Van Duzee, respectively, Museum Bulletin 79. The three papers specifically mentioned comprise valuable additions to our knowledge, the first being mostly morphological and taxonomic and the others faunal and biological.

Catalogue of the "Phytoptid" Galls of North America; Report of the Entomological Field Station, Old Forge, 1905; New North American Chironomidae; Studies in Cecidomyiidae II, by G. H. Chadwick, J. G. Needham, O. A. Johannsen and the Entomologist, respectively, Museum Bulletin 124. This comprises a series of extensive and important additions to our knowledge of the natural history of the State.

Catalogue of the Described Scolytidae of America North of Mexico, by J. M. Swaine, Museum Bulletin 134. The only comprehensive bibliographic catalog of this group which has appeared.

A Study of Gall Midges, Parts 1–4, by the Entomologist, in

Museum Bulletins 165, 175, 180 and 186. Portions of a monographic account of a large and important family, the American forms of which, prior to these studies, were practically unknown.

Insects Affecting Park and Woodland Trees, by the Entomologist, Museum Memoir 8. Contains many New York records relating to forest and shade tree insects and is the only comprehensive and moderately recent work dealing with this very important group.

Collections. The insect collections of the State Museum, more than those of any other institution of the State of New York, should contain an adequate representation of our rich and economically important fauna. There are probably 20,000 different species of insects in the State, each represented by at least four stages and these, with varieties, specimens of their work and other desirable illustrative material, would mean a collection of some 100,000 different specimens in order to represent properly this great and fascinating complex. The development of this one feature is an enormous undertaking and one utterly beyond the limited time which can be devoted to such work under present conditions.

The assembling and preparation of the enlarged exhibit of insects extended well into 1916 and, owing to the great amount of time required, necessarily prevented very desirable work in the arrangement and classification of the reference collections. Additions to these are constantly being made, especially of specimens representing the early stages and work of various injurious forms, since biological material of this character greatly facilitates identification of the different insects and is indispensable in a well-prepared exhibit illustrating the life histories of different species. Several special collecting trips in connection with grasshopper or other investigations were made by Mr D. B. Young and resulted in securing a considerable number of very desirable specimens. The identification of this material, especially of the crane flies or Tipulidae, has been taken advantage of to rearrange this interesting and hitherto largely neglected family. The state collections now contain a large amount of material which is invaluable because of the associated data. Numerous microscopic preparations of smaller insects have been made and incorporated in the collections as in earlier years.

A number of very desirable additions have been made by exchange, notably those from Mr Paul B. Sears, Columbus, Ohio, Mr W. J. Chamberlin, Corvallis, Ore., and Mr J. R. Malloch, Urbana, Ill. The species acquired are listed with the other accessions.

The wooden boxes containing the insect collections should be replaced by steel cabinets, as soon as practicable and more provided to accommodate the extra boxes and trays required by the normal increase in the collection. No adequate provision has as yet been made for the constantly increasing biological material and the large number of microscopic slides, many of which contain types of species and genera and are therefore unique. A metal filing case for the collection of negatives and photographs illustrating insects or other work is also greatly needed.

Nursery inspection. Nursery inspection work of the State Department of Agriculture has resulted in a number of specimens representing various stages of insect development, some in very poor condition, being submitted for identification. As such material may originate in a foreign country, determinations of this character are laborious and require for their successful prosecution a large collection and an excellent library of both domestic and foreign works. The correct identification of such material is important, since the disposal of an entire shipment of nursery stock must depend in considerable measure upon the character of the infestation.

General. The work of the entomological division has been materially aided, as in past years, by the identification of a number of species through the courtesy of Dr L. O. Howard, chief of the bureau of entomology, United States Department of Agriculture, and his associates. There has been, as already stated, very effective cooperation with the State Department of Agriculture, several county farm bureaus and other public welfare agencies in the State. A number of correspondents have donated valuable specimens and many have rendered efficient service by transmitting local data respecting various insects. There has been, as in the past, a most helpful cooperation on the part of all interested in the entomological work of the Museum.

IX

REPORT OF THE ZOOLOGIST

In February of the past year, the Zoologist, Dr. Willard G. Van Name, tendered his resignation and left the service of the department. Just preceding his departure, Doctor Van Name was engaged in arranging for exhibit the collections of bivalve mollusks and birds' eggs and relabeling in part the bird collection.

During the period following Doctor Van Name's resignation and the appointment of a new zoologist, a considerable amount of material was worked over and prepared for display by Mr N. T. Clarke and the taxidermist. At this time the collection of corals was unpacked, cleaned and installed in zoology hall; the birds' eggs rearranged and augmented by additional specimens from the recently acquired Conway collection and a series of skeletons of birds, fishes and mammals installed in cases reserved for them. An interesting tree-toad exhibit designed to show protective coloration was placed in zoology hall for the first time and additional specimens of mounted fishes added to those already displayed.

The preparation of groups has proceeded as far as available material would permit. New groups recently installed are a family of woodchucks and a section of a sand bank with nesting bank swallows. The Museum's collection of univalve mollusks, native to New York State, are now on exhibit but many species are needed to complete the series. The accessions to the department during the fiscal year include the collection of birds' eggs and nests of the late Martin J. Conway of Troy and represent about three hundred species. Fourteen pairs of domestic pigeons of as many varieties were secured from Mr B. M. Hartly of West Haven, Conn., and these with the specimens already in the possession of the Museum represent most of the common varieties.

By exchange with the Victoria Memorial Museum of Ottawa, Canada, a number of sea fowl were secured typical of the great nesting community of Bonaventure island.

But little time was available for field work, nevertheless in the few days' collecting a rather extensive series of spiders was taken, including many species new to the State and several new to science.

The visible evidences of the activities of the department represent but a fraction of the work accomplished during the year. A considerable amount of cataloging and labeling of specimens, with complete sorting and arrangement of the collections of birds' skins and eggs, has been finished.

That there is a growing interest in general natural history and zoology is daily evidenced by the increasing number of inquiries relative to these subjects and the number of visitors to the office of the Zoologist.

X

REPORT OF THE ARCHEOLOGIST

The activities of the Archeologist of the State Museum are divided in the field of research into two distinct groups, each of which requires different methods of approach and study. The field of archeology requires a knowledge of the prehistoric and more recent aboriginal occupation of the State, a knowledge of the various culture areas and the ability to seek out the important centers and excavate them. The field of ethnology requires the study of the folk ways, social organization rituals, folk lore, technology and material culture of the Indians who still survive and who are able to give information concerning their ancestors. It will be seen that the special training needful for equipment in each of these lines of research differs, and that while the two fields are correlated, any attempt to follow both thoroughly requires constant application.

Supplementing the research activities are those of the curator. The archeological and ethnological collections in our custody are extensive and very valuable. To arrange, catalog, label and instal the specimens properly is a work of years and will require careful study. The value of our collections to students of ethnology is such that every effort is being put forth to bring out fully the facts represented by them.

Condition of the collections. The collections placed in the care of this section of the Museum are installed in the mezzanine halls of the top floor and extend from one end of the building to the other. The ethnological collection occupies the most space. Owing to the rarity of the specimens and the relatively small number to be obtained it is not likely that our cases will soon be overtaxed. The installation is in tall cases, centrally placed, and in wall cases having desk extensions. The wampum belts of the Iroquois Confederacy, placed permanently in our custody, are displayed in the ethnological hall.

Care is taken to poison properly all specimens that might become infected with moths or other vermin but we have not yet been able to destroy all vestiges of such life in some of the more recently acquired specimens of food plants. Constant inspection during the year has contributed to the safety of the valuable specimens and we are now reasonably sure that none of the fabrics are infested with destructive insects. We are still troubled by the entrance of dust into the cases caused by the minute particles of cement dislodged from the floor. There can be no adequate remedy until means are at hand to coat the cement properly with a preparation that will prevent the formation of dust through abrasion.

The Iroquois habitat and culture-history groups in the Governor Myron H. Clark Hall of Iroquois Ethnology are constantly receiving attention and care. This is necessary not only on account of the value of the groups, but owing to the necessity of inspecting the electric wiring, protecting the contents from destruction by moths and keeping the acessories in a state of good preservation. During the year all six have been poisoned with a cyanide gas and all fur garments sprayed with mercury bichloride.

The physical condition of the groups is good and no signs of deterioration have become visible since their installation. An effort is made to preserve the proper humidity and to keep the temperature at the uniform degree of 72. Screened ventilators permit the exit of air heated by the electric lamps to a point above normal. There is thus a constantly automatic breathing by the cases.

The detached rooms on each end of this mezzanine are at present serving for other purposes than ethnological exhibits, but only temporarily so. The westmost room, near Swan street, is employed as a convenient lecture hall for museum lectures. The room at the opposite end, at the center of the building, is designed to contain a bark lodge, to be furnished completely with Iroquois utensils. At present the room contains an exhibit of plows, illustrating the evolution of the plow and the plowshare in America.

The hall of archeology is in the eastmost mezzanine. The cases are crowded and there appears to be no room for expansion. The most recent section of the Museum has completely outgrown the quarters assigned to it, and this within the period during which the collections have been installed in the Education Building. Only by carefully selecting the specimens and by restricting the exhibits is it possible to display what we have. There remains but little room for the exhibition of the many relief maps, models and restorations that were originally contemplated. The only relief will be to disjoint and disassociate the collections and remove a section to the west end of the building and eliminate the lecture room.

The archeological collections on exhibition are receiving con-

A COMPARISON OF THE IROQUOIAN AND ALGONKIAN POTTERY VESSELS

This is one of the comparative exhibits outlining the differences between the several cultural types

THE OWASCO LAKE POT

An Algonkian pot discovered in fragments in an Algonkian site at Lakeside park, near Auburn

stant curatoral oversight, each specimen having been selected by the Archeologist and given its place in the exhibition series. The painstaking labors of Mr Howard A. Lansing in cataloging and preparing labels have contributed much to the preservation of the facts associated with the specimens, but the work yet to be done remains enormous.

Our complete plan calls for a typewritten or printed guide book on each case, whereby the student may have a proper understanding of the meaning of each exhibit.

Office work. The work in the office, besides the labor of preparing the catalog and making the proper entries on the records, consists of answering numerous requests for information, for names of Indian localities, and for publications. It is the study and classification of specimens, however, that consumes the greater portion of the time. About ten thousand objects have been placed on exhibition but nearly ninety thousand are stored in drawers for study purposes. These have received attention during the year. Our researches have covered the subjects of industry, experiments in primitive methods of manufacture and experiments to determine the uses of certain forms of "problematical" objects. These latter include banner stones, boat stones, gorgets and bird stones. On these specimens we have made extended notes.

Public interest. The interest of the public, and particularly of the special student, grows from year to year, as is evidenced by the number of letters received, by the personal visits of collectors, historians, museum curators from other states and from foreign lands, and especially by the visits of teachers and pupils in the public schools. Our section is becoming known, as it should be, as a repository of Indian lore of widely varied subjects. Our facilities make possible the answering of appeals for service from the several state departments and in several instances from the federal government. The interest and cooperation of the surviving Iroquois Indians must also be mentioned, and our records are frequently used as a source of information by them. An unusual example is the appeal of the "last remnants of the Mohicans" for assistance in locating Indians in New York State related by blood to them. This was in order to distribute certain funds that the tribe, now living in Wisconsin, had recovered.

Utility of the archeology section. Beyond the scientific and historical value of this section and its value in the study and preservation of New York's prehistory, it has a distinctly utilitarian value which is appreciated by certain specialists. Our collections are visual illustrations of primitive technology and illustrate the beginnings of industry. We are able to show how early man responded to his environment and what he devised to overcome its obstacles. There is a pointed lesson here that the student of the simpler life appreciates, for we are able to teach by means of the collections, how to employ the simplest things at hand for useful purposes. Modern man is forgetting this and relying on complex devices that he is unable easily to produce without machinery. By means of our exhibits of primitive industries, primitive amusements, primitive agriculture and primitive ceremonials, we respond to vital human interests. We believe that this is a correct museum theory and that one of our highest functions is to meet human needs, physical as well as intellectual.

By this effort to interpret human cultural development we have attracted students of history, artists, writers and advocates of outdoor life. Our exhibitions thus become a source of material of no uncertain value to the public.

Publications. During the year the Museum has published a bulletin on the *Constitution of the Five Nations,* or the Great Binding Law of the Iroquois. This work has been widely sought by ethnologists and by students of primitive civics and law. Copies have been requested by persons in many parts of the civilized world. The edition has all but become exhausted.

Another manuscript is in the course of preparation and deals with the "Archeological History of New York." Additions to the manuscript have constantly been made during the year and it is hoped that it may go to press during 1917. The range of topics considered by this work is a discussion and description of the various culture areas, a list of sites, a series of detailed maps and a description of the earth works, mounds and other evidences of aboriginal work, together with descriptions of implements and ornaments used by the aborigines of the State and the territory adjacent to it.

The New York State Archeological Association. During the year a new statewide organization has been formed by collectors and students of New York anthropology. This is the New York State Archeological Association. We have been developing the plan for several years and during the month of March instituted the first local branch in the city of Rochester, under the name of Lewis H. Morgan chapter. The plan of organization contemplates

TYPES OF ALGONKIAN PIPES FROM NEW YORK

1 and 2 are from a single grave in Madison county
3 and 4 are typical Cayuga county Algonkian forms

the adherence to scientific methods by collectors, a uniform catalog system, the registration of collectors and an insistance upon the taking of adequate data by every individual member. By means of a state society we are able to unite the interests of those concerned in archeological research and to obtain the results of their field studies. This contributes to the advancement of knowledge.

The association has held several field meetings during the year and has planned a lecture course during the autumn and winter of 1916. It has already taken steps to work in cooperation with the state archeological societies of Wisconsin and Ohio. The present officers are Alvin H. Dewey, president; E. Gordon Lee, secretary, 66 Richland street, Rochester; Edward D. Putnam, treasurer; and John G. D'Olier, vice president. The headquarters of the association are in the State Museum, the Archeologist at present acting as director. This organized effort on the part of citizens to contribute to the extension of the influence of the State Museum and to conserve properly the field of investigation is worthy of attention and some analysis. It marks the beginning of a more efficient, not to say more patriotic, cooperation of the citizen with the institutions that he has created for the benefit of society. By means of the work of the association local museums of archeology will become better supported and their collections fostered with greater care, archeological monuments will not be so ruthlessly destroyed nor will vandals destroy and scatter archeological evidences as heretofore.

Field meetings of the association have been held at the estate of Admiral Hanford, Scottsville, and on the John Dann farm, Honeoye Falls. Under the auspices of Lewis H. Morgan chapter the Archeologist of the State Museum this year delivered the annual address before the federated scientific and historical societies of Rochester at Rochester University. During the year the chapter, which has a membership of about 100, began its plans and collected funds for a memorial arch to Lewis H. Morgan to be erected in Rochester and also requested permission to place a memorial tablet to Morgan in the hall of ethnology in the State Museum.

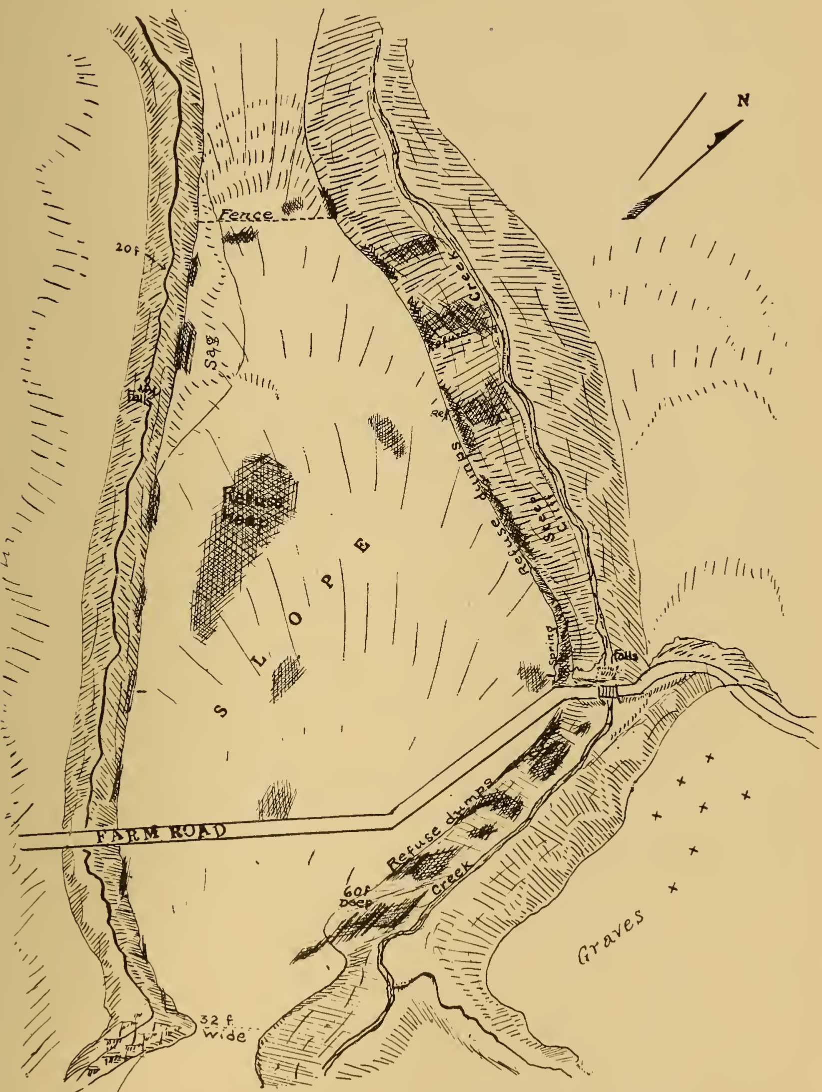
Needs and recommendations. The work of the archeology section is seriously handicapped by the lack of adequate clerical assistance. We are in need of a stenographer and transcript clerk. With this assistance the efficiency of our office work would be more than doubled. At present the congestion of work renders any progress in the preparation of manuscripts, the prompt reply to correspondence or the preparation of descriptive booklets for the cases, cumbersome and difficult. Our work is extensive and urgent but without equipment we can not do what should be done. Thus hampered, we are nevertheless doing all that should be expected.

The efficiency of our field investigations would be largely increased if the Archeologist or a representative could be stationed in the field when the weather opens up every spring. Proper field work requires actual presence on the field and an uninterrupted and unhampered research. To bring this about there must be an adequate research fund. With this support we should not only be able to obtain an efficient grasp on our field but also make it productive of far greater results. This is true in both the fields of archeology and ethnology. If the State Museum will not and can not undertake to exploit its field, a field to which it is restricted, other institutions must and will take up the work. During the year field explorations in New York were made by the Museum of the American Indian and by the Andover Academy Expedition, as well as by private collectors.

Observations. In conducting this section there should be no undue concern about obtaining specimens, the primary aim being to advance the knowledge of our subject, and the secondary purpose being to bring back illustrative material. We point out, as an example of this method, the explorations by the Peabody Museum of Harvard, in New York during 1903–6.

Prehistoric Seneca site. A very important Seneca site, from the standpoint of chronology, examined during the year is that situated on the George Reed farm on the terrace above the Hemlock lake outlet, near Richmond Mills, New York. During the past seventy-five years this site has been gone over by collectors who have carried off an incredible amount of material. During the past twenty years excavators have been particularly active and so far no object of European origin has been discovered in any pit or refuse heap.

The Reed Fort site is a sandy arm of the terrace projecting nearly westward into the Hemlock valley. It covers a sloping sandy hill lying between two brooks that have cut deep ravines. The place is a natural fortification since the brooks at the southwest end come within 30 feet of each other, measured from the rims of their banks. The effect is a natural inclosure easily protected from human and beast enemies. From this upper neck the area gradually expands to a point directly above a fine spring



Map of the Red Fort site, Richmond Mills, Ontario

that flows into a large brook on the north bank. From this point the site gradually tapers down the slope until it reaches a steep knoll the base of which rests in a more level space between the brooks, which again approach within 40 to 50 feet of it. The brook on the northwest side is shallower at the upper end but quickly eats its way into the shale and plunges over a series of falls until at the lower end of the fortification the banks are 30 to 40 feet in height. The brook on the opposite side is deeper and throughout the length of the hill its depth is 40 to 50 feet with high shaly embankments impossible to climb in places. Along these embankments, particularly at the upper end, the refuse heaps are found scattered over the end of the bank and down the talus slope almost to the bed of the brook; in fact the entire outline of the fortification is nearly bounded by refuse heaps.

The site covers an area of about 5 acres, which was ample space for a considerable Indian village. When the site was cleared about 1850, it was covered with a dense growth of large oak trees, with pines at the lower slope.

The Seneca Indians who frequently passed over this site at the time it was cleared and who frequently hunted, fished and worked in the neighborhood, told the original settlers they had no idea who had lived on the site and the pipes, flints and fragments of pottery were of as much interest to them as to the settlers who opened up the tract.

From this time on antiquarian and amateur archeologists commenced their search for relics and the first spring plowings were always a signal for relic hunters to pick over the surface for finely shaped flints, pipes and shell and bone trinkets. During recent years the most successful collectors so far as we know have been Mr Alva Reed, Mr Joseph Mattern of West Rush; Mr Alvin H. Dewey, Mr H. C. Follett and Mr George Mills of Rochester; and Mr Frederick Houghton of Buffalo. A large share of the material found by individual collectors is in the New York State Museum collection. No burials were found until 1912, when Mr Frederick Houghton, excavating for the Buffalo Society of Natural Sciences, found a burial site on the projecting nose across the ravine east of the spring and nearly opposite the falls. Our examination of this site made in 1905, 1910, 1911 and 1916, resulted in the series of notes here given.

It was found that the soil in nearly every portion of the site was deeply stained and that there were natural depressions irregular in shape that seem to have been used as refuse dumps. Even after much cultivation for farming purposes, the soil still shows blackened areas that outline the village dumps. Some of these pits and deposits are 6 or more feet in depth and filled with broken stone, ashes, animal bones and broken implements with an occasional fine specimen in good condition. As we have previously stated, the larger deposits were along the northeast bank, sloping toward the falls. In many of these sidehill dumps the ashes are several feet in thickness and have led some excavators to think that the site was occupied for a prolonged period. Our opinion is, however, that a village of one hundred to one hundred fifty people occupying this site for ten years would produce the amount of ash found in the dumps, especially if refuse as well as fuel had been consumed.

The present appearance of the site is that of a sloping sandy hill edged by ravines and fringed with trees. The brooks flow the year around and the larger one has a considerable fall over which the farm owners have built a bridge. Above the falls it is possible to walk along the edge of the brook and up the ravine for a considerable distance. The ravine is wide and has a flat bottom which gives ample space for the meandering of the stream. Near the upper end of the fort from the base a natural trail runs up the embankment along the projecting nose, but access is not easy from any other point. Along this embankment from the falls southward and up the ravine the débris may be seen mixed with the talus. An excavation reveals quantities of animal bones, broken pottery and fragments of implements.

From the lower end of the fortification the trail runs down to a sloping flat that gradually leads to the valley level. From this point it is about one-fourth of a mile to the Hemlock outlet.

The character of the implements found on the site are without question prehistoric Iroquoian and presumably Senecan. Sites to the northeast on the Alva Reed farm are non-Iroquoian, as are most of the contiguous sites where relics are found in any quantity.

XI

STAFF OF THE DEPARTMENT OF SCIENCE

The members of the staff, permanent and temporary, of the Department of Science as at present constituted are:

ADMINISTRATION

John M. Clarke, Director
Jacob Van Deloo, Director's Clerk
Edwin J. Stein, Stenographer

GEOLOGY AND PALEONTOLOGY

John M. Clarke, State Geologist and Paleontologist
David H. Newland, Assistant State Geologist, *Curator of Geology*
Rudolf Ruedemann, Assistant State Paleontologist, *Curator of Paleontology*
William L. Bryant, Honorary Custodian of Fossil Fishes
C. A. Hartnagel, Assistant in Geology, *Curator of Stratigraphy*
Robert W. Jones, Assistant in Economic Geology, *Assistant Curator of Industrial Geology*
Herbert P. Whitlock, Mineralogist, *Curator of Mineralogy*
George S. Barkentin, Draftsman
Noah T. Clarke, Technical Assistant
Winifred Goldring, Assistant in Paleontology
H. C. Wardell, Preparator, *Assistant Curator of Paleontology*
Theodore J. Lipsky, Stenographer
Charles P. Heidenrich, Mechanical Assistant
Joseph J. Bylancik, Clerk
John L. Casey, Custodian
William Rausch, Cabinet Maker
Jerry Hayes, Laborer

Temporary experts

Areal geology

Prof. H. P. Cushing, Adelbert College
Prof. W. J. Miller, Smith College
Prof. G. H. Hudson, Plattsburg State Normal School
Dr W. O. Crosby, Massachusetts Institute of Technology
Prof. George H. Chadwick, St Lawrence University
Prof. John L. Rich, University of Illinois
Dr A. F. Buddington, Princeton University

Geographic geology

Prof. Herman L. Fairchild, University of Rochester
Prof. James H. Stoller, Union College

BOTANY

Homer D. House, State Botanist
Joseph Rubinger, Assistant, *Curator of Botany*

ENTOMOLOGY

Ephraim P. Felt, State Entomologist
D. B. Young, Assistant State Entomologist, *Curator of Entomology*
Fanny T. Hartman, Assistant, *Assistant Curator of Entomology*
Anna M. Tolhurst, Stenographer
William A. J. Tracy, Page

ZOOLOGY

Sherman C. Bishop, Zoologist, *Curator of Zoology*
Benjamin Walworth Arnold, Honorary Curator of Ornithology
Arthur Paladin, Taxidermist

Temporary expert

Dr H. A. Pilsbry, Philadelphia

ARCHEOLOGY

Arthur C. Parker, Archeologist, *Curator of Archeology and Ethnology*

Temporary assistant

Howard A. Lansing, Albany

XII

ACCESSIONS TO THE COLLECTIONS

ECONOMIC GEOLOGY

Collection

Hartnagel, C. A., Albany

Zinc ore from Canajoharie	1

Newland, D. H., Albany

Rutile ores from Roseland, Va	5
Ilmenite from near Galax, Va	10
Pyrrhotite from near Galax, Va	1
Graphite and wall rocks, Adirondacks	17
Magnetite and country rocks from Sterlington, N. Y	15
Zinc ores and country rocks from Edwards, N. Y	40

Donation

Robert Geer & Son, Albany

Large block of crystallized solar salt	1

New York State Highway Department

Samples illustrating physical testing of cement	16

Binn, Prof. Charles S., Alfred

Burned clay samples showing shrinkage	12
	118

MINERALOGY

Donation

Emerson, Prof. B. K., Amherst, Mass.

Fluorite, Westmoreland, N. H	3
Molybdenite, Westmoreland, N. H	1
Wulfenite, Lendville, Mass	1
Anhydrite, Hadley, Mass	1
Crocidolite, Bondville, Mass	1
Datolite, Westfield, Mass	1
Corundum, Pelham, Mass	1
Amphibole (asbestos), Pelham, Mass	1
Vermiculite, Pelham, Mass	1
Rutile, Graves Mt., Ga	3
Rutile (large), Graves Mt., Ga	1
Psilomelane, Cary Empire Mine, Ga	2
Cinnabar in opal, Almadencito, Mexico	3
Lazulite, Graves Mt., Ga	1
Staurolite, Farrington, Ga	11
Zoisite, Poultney, Vt	1
Diaspore, Chester, Mass	1
Columbite, Portland, Conn	1

Titanite, Renfrew, Canada	1
Serpentine, Washington, Ga	1
Opal (tripolite), Dacres, South Africa	1
Serpentine, Havana, Cuba	1
Vauquelinite (elroquite), Elroque, West Indies	2
Apatite (rock phosphate), Charleston, S. C	1
Apatite (rock phosphate), Mona, West Indies	3
Apatite (rock phosphate), Dunellen, Fla	1
Serpentine (menelite), Beaufort, S. C	1
Wait, Charles, Crown Point	
Fluorite in microcline, Crown Point, N. Y	3
Newland, D. H., Albany	
Ilmenite, Galax, Va	1
Mathis, William, Feura Bush	
Quartz (crystal), Feura Bush, N. Y	1

Exchange

Utman, J. C., Ashland, Wis.	
Hematite, Ironwood, Mich	12
Psilomelane, Ironwood, Mich	6
Limonite, Ironwood, Mich	3
Psilomelane, Hurley, Wis	1
Hematite after goethite, Ironwood, Mich	1
Pyrolusite on psilomelane, Hurley, Wis	1
Manganite, Ironwood, Mich	1
Xanthosiderite, Ironwood, Mich	1
Goethite on psilomelane, Ironwood, Mich	1
Copper, Calumet, Mich	1
Barite, Bessimer, Mich	2
Aragonite, Ironwood, Mich	2
Calcite, Ontonagon, Mich	1
Calcite and copper, Hancock, Mich	1
Calcite and stilbite, Mass, Mich	1
Glenn, M. L., Erie, Pa.	
Alunite, Fire Clay City, Utah	1
Anorthoclase, Essex co., N. J	1
Stevensite, Essex co., N. J	1
Ankerite, 18 Mile Creek, Erie co., N. Y	1
Amphibole, Berkeley, Cal	1
Semseyite, Kisbanya, Hungary	1
Halotrichite, Erie, Pa	3
Fitts, William L., Springfield, Mass.	
Datolite, Westfield, Mass	6

Purchase

Law, Edward S., Charlemont, Mass.	
Ankerite, Hawley, Mass	1
	103

PALEONTOLOGY

Donation

Arnold, Benjamin Walworth, Albany
Trenton cephalopods from Fossil island 15 miles north of Manitoulin island, Canada 7

Bostock, Lillian D., New York
Pygidium of *Dalmanites perceensis* Clarke, Grande Grève limestone, Percé Rock, P. Q., Canada 1

Halsey, William D., Bridgehampton
Arca transversa, Pleistocene, Bridgehampton 22
Venus sp 3
Crepidula formacata 8
Columbella lunata 1
Undetermined lamellibranchs 3

Hudson, Prof. G. H., Plattsburg
Cephalopods from Lowville limestone, north end of Valcour island 8

Johnston, John S., Wellsville
Fossil sponge from Chemung sandstone, Hinsdale 1

Kinnear, W. T., Kirkbuddo by Forfar, Scotland
The following from the Middle Old Red Sandstone:
Palaeospondylus gunni Traquair and
Mesocanthus peachi Traquair (on one slab) 1
Palaeospondylus gunni Traquair 2

Lewi, Dr W. G.
Sponge boring in brachiopod, Berne, N. Y 2

McGill University Museum, Montreal, Canada
Baropezia (Sauropus) sydnensis Dawson, Coal Measures, Sydney, C. B. Cast from original in McGill University. Type Acadian Geology, Dawson (1878), p. 358, fig. 140.

Price, W. Armstrong
Clionolithes canna Price, from Conemaugh series, Brush Creek limestone, Preston co., W. Va 1
Clionolithes canna (in shell of *Derbya crassa*) (Meek & Hayden) from Pottsville series, Kanawha group, Winifrede limestone, Raleigh co., W. Va. 1

Exchange

Buffalo Society of Natural History, Buffalo
Cladoselache fyleri Newberry, Cleveland shale, Lindale, Ohio 1
Eurypterus pittsfordensis Sarle, Pittsford shale (Salina), Pittsford, N. Y 2

Greger, D. K., Columbia, Mo.
Trilobites from Louisiana limestone, Chouteau, Mo 30

Purchase

Luther, D. D., Naples
Fossils from various formations, mostly western New York 475
Crinoids mostly from Keokuk group, Crawfordsville, Indiana 22

Plourde, Anthony

Fossil fishes (Devonic) from Migouasha, P. Q., Canada.......... 84

Ward's Natural Science Establishment, Rochester

Olenellus thompsoni, Lower Cambrian, Lancaster co., Pa.. 8

Neolenus serratus Rom., Middle Cambrian, Mount Stephen, B. C. 2

Ptychoparia cordillerae Roemer, Middle Cambrian, Mount Stephen, B. C.. 1

Bathyuriscus rotundatus Rom., Middle Cambrian, Mount Stephen, B. C.. 1

Streptelasma strictum, Port Ewen beds, Port Ewen.... 1

Eatonia medialis var., Port Ewen beds, Port Ewen...... 1

Schuchertella woolworthana, Port Ewen beds, Port Ewen 1

Stenocisma acutiplicatum, Port Ewen beds, Port Ewen 3

Slab of Esopus shale with Leptocoelia flabellites.... 1

The following fossils from the Acadian (Burgess) Burgess Pass, near Field, British Columbia:

Marrella splendens Walcott........................... 1

Ottoia prolifica Walcott.............................. 1

Eldonia ludwigi Walcott.............................. 1

Hymenocaris perfecta Walcott......................... 1

Grande Grève limestone fossils from Grande Grève, P. Q., Canada..1700

Mastodon bones found near Perkinsville

Collection

Clarke, John M., Albany

Part of a pygidium of Dalmanites perceensis, from Grande Grève, Percé, P. Q., Canada. This pygidium is 5 feet 7 inches long and 8 inches wide at anterior margin; the original complete trilobite was probably 22½ inches long.................................. 1

Ruedemann, Rudolf, Albany

Utica, Lorraine and Frankfort fossils from Mohawk and Black River valleys, Lorraine gulf and Pulaski region................2000

ZOOLOGY

Donation

Birds

Conway, Mrs M. J., Troy

Green heron, Butorides virescens (Linn.).................. 1

Killdeer plover, Oxyechus vociferus (Linn.)................ 1

Ruffed grouse, Bonasa umbellus (Linn.)...................... 1

Short-eared owl, Asio flammeus (Pont.)..................... 3

Screech owl, Otus asio (Linn.).............................. 4

Sharp-shinned hawk, Accipiter velox (Wilson)............ 1

Blue jay, Cyanocitta cristata (Linn.)...................... 1

Fox sparrow, Passerella iliaca (Merrem).................. 1

Robin, Planesticus migratorius (Linn.)..................... 1

Schell, Elvira A., Albany
Case of twelve foreign birds.
Edwards, Harriet A., Port Henry
Herring gull, Larus argentatus Pont. 1
Dewey, Melvil, Lake Placid
Goldfinch, Geothlypis trichas (Linn.) 1
Ruby-throated hummingbird, Archilochus colubris (Linn.) 1
Little, Miss E. E., Menands
Red-shouldered hawk, Buteo lineatus (Gmel.) 1
Conservation Commision, Albany
Rose-breasted grosbeak, Zamelodia ludoviciana (Linn.) 1

Birds' Nests

Conway, Mrs M. J., Troy
Kingbird, Tyrannus tyrannus (Linnaeus) 1
Alder flycatcher, Empidonax traillii alnorum Brewster . . 1
Least flycatcher, Empidonax minimus (W. M. & S. F. Baird). 3
Bobolink, Dolichonyx oryzivorus (Linnaeus) 1
Red-winged blackbird, Agelaius phoeniceus (Linnaeus). 1
Orchard oriole, Icterus spurius (Linnaeus) 1
Baltimore oriole, Icterus galbula (Linnaeus) 2
Goldfinch, Astragalinus tristis (Linnaeus) 4
Arkansas goldfinch, Astragalinus psaltria psaltria (Say) 1
Vesper sparrow, Pooecetes gramineus (Gmelin) 4
Grasshopper sparrow, Ammodramus savannarum australis Maynard 1
Chipping sparrow, Spizella passerina (Bechstein) 2
Field sparrow, Spizella pusilla (Wilson) 4
Indigo bunting, Passerina cyanea (Linnaeus) 8
Cedar waxwing, Bombycilla cedrorum (Vieillot) 3
Migrant shrike, Lanius ludovicianus migrans (Palmer) 1
Red-eyed vireo, Vireosylva olivacea (Linnaeus) 11
Warbling vireo, Vireosylva gilva (Vieillot) 3
Bell s vireo, Vireo belli Audubon 1
Yellow warbler, Dendroica aestiva (Gmelin) 12
Chestnut-sided warbler, Dendroica pennsylvanica (Linnaeus) 1
Yellow-breasted chat, Icteria virens (Linnaeus) 1
Redstart, Setophaga ruticilla (Linnaeus) 8
Catbird, Dumetella carolinensis (Linnaeus) 2
Brown thrasher, Toxostoma rufum (Linnaeus) 1
Long-billed marsh wren, Telmatodytes palustris (Wilson) 6
Chickadee, Penthestes atricapillus (Linnaeus) 2
California bush-tit, Psaltriparus minimus californicus Ridgway 1
Wood thrush, Hylocichla mustelina (Gmelin) 1
Veery, Hylocichla fuscescens (Stephens) 1

Birds' Eggs

Conway, Mrs. M. J., Troy	No. of sets
Western grebe, *Aechmophorus occidentalis* (Lawrence)..	1
Eared grebe, *Colymbus nigricollis californicus* (Heermann)........	1
Puffin, *Fratercula arctica* (Linnaeus)........	1
Murre, *Uria troille* (Linnaeus)........	3
California murre, *Uria troille californica* (H. Bryant).	1
Razor-billed auk, *Alca torda* Linnaeus........	1
Kittiwake, *Rissa tridactyla* (Linnaeus)........	1
Iceland gull, *Larus leucopterus* Faber........	1
Black-backed gull, *Larus marinus* Linnaeus........	1
Herring gull, *Larus argentatus* Pontoppidan........	2
Ring-billed gull, *Larus delawarensis* Ord........	1
Mew gull, *Larus delawarensis* Ord........	1
Franklin gull, *Larus franklini* Richardson........	2
Forster tern, *Sterna forsteri* Nuttall........	1
Common tern, *Sterna hirundo* Linnaeus........	1
Arctic tern, *Sterna paradisea* Brunnich........	1
Roseate tern, *Sterna dougalli* Montagu........	1
Least tern, *Sterna antillarum* (Lesson)........	1
Sooty tern, *Sterna fuscata* Linnaeus........	1
Black tern, *Hydrochelidon nigra surinamensis* (Gmelin)........	1
White-winged black tern, *Hydrochelidon leucoptera* (Temminck)........	1
Noddy tern, *Anoüs stolidus* (Linnaeus)........	1
Black Skimmer, *Rynchops nigra* Linnaeus........	1
Fulmar, *Fulmarus glacialis* (Linnaeus)........	1
Leach petrel, *Oceanodroma leucorhoa* (Vieillot).......	1
Gannet, *Sula bassana* (Linnaeus)........	1
Common cormorant, *Phalacrocorax carbo* (Linnaeus)...	1
Double-crested cormorant, *Phalacrocorax auritus* (Lesson)........	1
Farallon cormorant, *Phalacrocorax auritus albociliatus* Ridgway........	1
Brandt's cormorant, *Phalacrocorax penicillatus* (Brandt)........	1
Green-winged teal, *Nettion carolinense* (Gmelin)........	1
Blue-winged teal, *Querquedula discors* (Linnaeus)......	1
Redhead duck, *Marila americana* (Eyton)........	1
Trumpeter swan, *Olor buccinator* (Richardson) laid in captivity........	6
White ibis, *Guara alba* (Linnaeus)........	1
White-faced glossy ibis, *Plegadis guarauna* (Linnaeus)...	1
Least bittern, *Ixobrychus exilis* (Gmelin)........	1
Great blue heron, *Ardea herodias* Linnaeus........	1
Snowy heron, *Egretta candidissima* (Gmelin)........	1

	No. of sets
Louisiana heron, *Hydranassa tricolor ruficollis* (Gosse)	1
Little blue heron, *Florida caerulea* (Linnaeus)	1
Green heron, *Butorides virescens* (Linnaeus)	1
Black-crowned night heron, *Nycticorax nycticorax naevius* (Boddaert)	1
King rail, *Rallus elegans* Audubon	1
Sora rail, *Porzana carolina* (Linnaeus)	1
Florida gallinule, *Gallinula galeata* (Lichtenstein)	2
Northern phalarope, *Lobipes lobatus* (Linnaeus)	1
Black-necked stilt, *Himantopus mexicanus* (Müller)	1
Spotted sandpiper, *Actitis macularia* (Linnaeus)	1
European curlew, *Numenius numenius* (Brisson)	1
Whimbrel, *Numenius phaeopus* (Linnaeus)	1
Lapwing, *Vanellus vanellus* (Linnaeus)	1
European golden plover, *Charadrius apricarius* Linnaeus	1
Killdeer plover, *Oxyechus vociferus* (Linnaeus)	1
Ringed plover, *Aegialitis hiaticula* (Linnaeus)	1
Pea fowl, *Pavo cristatus* Linnaeus	1
Valley quail, *Lophortyx californica vallicola* (Ridgway)	2
Prairie chicken, *Tympanuchus americanus* (Reichenbach)	1
Mourning dove, *Zenaidura macroura carolinensis* (Linnaeus)	1
Cooper hawk, *Accipiter cooperi* (Bonaparte)	1
Red-shouldered hawk, *Buteo lineatus* (Gmelin)	1
Sparrow hawk, *Falco sparverius* Linnaeus	3
Desert sparrow hawk, *Falco sparverius phalaena* (Lesson)	1
Screech owl, *Otus asio* (Linnaeus)	1
Burrowing owl, *Speotyto cunicularia hypogaea* (Bonaparte)	1
Yellow-billed cuckoo, *Coccyzus americanus* (Linnaeus)	2
Black-billed cuckoo, *Coccyzus erythrophthalmus* (Wilson)	1
Downy woodpecker, *Dryobates pubescens medianus* (Swainson)	1
Red-headed woodpecker, *Melanerpes erythrocephalus* (Linnaeus)	1
Flicker, *Colaptes auratus luteus* Bangs	3
Red-shafted flicker, *Colaptes cafer collaris* Vigors	1
Nighthawk, *Chordeiles virginianus* (Gmelin)	1
Black-chinned hummingbird, *Archilochus alexandri* (Bourcier & Mulsant)	1
Anna's hummingbird, *Calpte anna* (Lesson)	1
Allen hummingbird, *Selasphorus alleni* Henshaw	1
Scissor-tailed flycatcher, *Muscivora forficata* (Gmelin)	1
Kingbird, *Tyrannus tyrannus* (Linnaeus)	7

	No. of sets
Arkansas kingbird, Tyrannus verticalis Say	1
Crested flycatcher, Myiarchus crinitus (Linnaeus)	1
Phoebe, Sayornis phoebe (Latham)	8
Black phoebe, Sayornis nigricans (Swainson)	1
Western wood pewee, Myiochanes richardsoni (Swainson)	1
Alder flycatcher, Empidonax trailli alnorum Brewster.	2
Least flycatcher, Empidonax minimus (W. M. & S. F. Baird)	1
Prairie horned lark, Otocoris alpestris praticola Henshaw	1
Magpie, Pica pica hudsonia (Sabine)	1
Blue jay, Cyanocit a cristata (Linnaeus)	2
Long-crested jay, Cyanocitta stelleri diademata (Bonaparte)	1
California jay, Aphelocoma californica (Vigors)	1
Crow, Corvus brachyrhynchos Brehm	10
Startling, Sturnus vulgaris Linnaeus	1
Bobolink, Dolichonyx oryzivorus (Linnaeus)	3
Cowbird, Molothrus ater (Boddaert) (Eggs)	10
Dwarf cowbird, Molothrus ater obscurus (Gmelin)	1
Yellow-headed blackbird, Xanthocephalus xanthocephalus (Bonaparte)	1
Red-winged blackbird, Agelaius phoeniceus (Linnaeus).	8
Bicolored red-wing, Agelarus gubernator californicus Nelson	2
Tricolored red-wing, Agelaius tricolor (Audubon)	2
Meadowlark, Sturnella magna (Linnaeus)	1
Western meadowlark, Sturnella neglecta Audubon	1
Arizona hooded oriole, Icterus cucullatus nelsoni Ridgway	1
Orchard oriole, Icterus spurius (Linnaeus)	1
Baltimore oriole, Icterus galbula (Linnaeus)	2
Brewer's blackbird, Euphagus cyanocephalus (Wagler).	2
Purple grackle, Quiscalus quiscula quiscula (Linnaeus)	5
Housefinch, Carpodacus mexicanus frontalis (Say).	1
Goldfinch, Astragalinus tristis (Linnaeus)	2
English sparrow, Passer domesticus Linnaeus	3
Arkansas goldfinch, Astragalinus psaltria (Say)	1
Vesper sparrow, Pooecetes gramineus (Gmelin)	3
Grasshopper sparrow, Ammdramus savannarum australis Maynard	1
Lark sparrow, Chondestes grammacus (Say)	1
Chipping sparrow, Spizella passerina (Bechstein)	12
Field sparrow, Spizella pusilla (Wilson)	1
Song sparrow, Melospiza melodia (Wilson)	42
Heermann's song sparrow, Melospiza melodia heermanni Baird	1
Towhee, Pipilo erythrophthalmus (Linnaeus)	2

	No. of sets
Anthony's towhee, Pipilo crissalis senicula Anthony..	1
Cardinal, Cardinalis cardinalis (Linnaeus)................	1
Gray-tailed cardinal, Cardinalis cardinalis canicaudus Chapman	1
Rose-breasted grosbeak, Zamelodia ludoviciana (Linnaeus)	1
Black-headed grosbeak, Zamelodia melanocephala (Swainson)	2
Indigo bunting, Passerina cyanea (Linnaeus)...............	3
Dickcissel, Spiza americana (Gmelin)......................	2
Scarlet tanager, Piranga erythromelas Vieillot...........	1
Cliff swallow, Petrochelidon lunifrons (Say)........	1
Barn swallow, Hirundo erythrogastra Boddaert...........	1
Tree swallow, Iridoprocne bicolor (Vieillot)..............	1
Bank swallow, Riparia riparia (Linnaeus)................	3
Rough-winged swallow, Stelgidopteryx serripennis (Audubon)	1
Cedar waxwing, Bombycilla cedrorum Vieillot............	3
California shrike, Lanius ludovicianus gambeli Ridgway	1
Migrant shrike, Lanius ludovicianus migrans Palmer..	2
Red-eyed vireo, Vireosylva olivacea (Linnaeus)........	2
Warbling vireo, Vireosylva gilva (Vieillot)...............	1
Bell's vireo, Vireo belli Audubon..........................	2
White-eyed vireo, Vireo griseus (Boddaert)................	1
Worm-eating warbler, Helmitheros vermivorus (Gmelin)	1
Yellow warbler, Dendroica aestiva (Gmelin)..............	4
Black-throated green warbler, Dendroica virens (Gmelin).	1
Oven-bird, Seiurus aurocapillus (Linnaeus)..............	1
Yellow-breasted chat, Icteria virens (Linnaeus)............	1
Long-tailed chat, Icteria virens longicauda Lawrence...	1
Hooded warbler, Wilsonia citrina (Boddaert)..............	1
Redstart, Setophaga ruticilla (Linnaeus)..................	4
Meadow pipit, Anthus pratensis (Linnaeus)...............	1
Dipper, Cinclus mexicanus Swainson........................	1
Mockingbird, Mimus polyglottos (Linnaeus)................	1
Catbird, Dumetella carolinensis (Linnaeus).............	16
Brown thrasher, Toxostoma rufum (Linnaeus).............	1
California thrasher, Toxostoma redivivum (Gambel)......	1
House wren, Troglodytes aedon (Vieillot)................	1
Long-billed marsh wren, Telmatodytes palustris (Wilson)	2
Chickadee, Penthestes atricapillus (Linnaeus).........	1
California bush-tit, Psaltriparus minimus californicus Ridgway	2
Wood thrush, Hylocichla mustelina (Gmelin)............	7
Veery, Hylocichla fuscescens (Stephens)...............	4
Robin, Planesticus migratorius (Linnaeus).............	11
Western robin, Planesticus migratorius propinquus (Ridgway)	2
Bluebird, Sialia sialis (Linnaeus)........................	14

Mammals

Conway, Mrs M. J., Troy
Mink, *Mustela vison* Schreber 1
New York Aquarium
Bottle-nosed dolphin, *Tursiops truncatus* (Mont.) 1
Downing, Dr A. S., Albany
Skunk, *Mephitis putida* Boitard 1
Conservation Commission, Albany
Virginia deer (fawns) *Odocoileus virginianus* (Auct.) .. 2

Reptiles and Batrachians

Albee, Mrs M. E., Mohawk
Milk snake, *Lampropeltis doliatus triangulus* (Boie) 1
Clarke, N. T., Albany
Cricket frog, *Acris gryllus* LeConte 1
Newt, *Diemictylus viridescens* Raf 1
Casey, George W., Elsmere
Bullfrog, *Rana catesbiana* Shaw 1

Invertebrates

Araneida

Clarke, N. T., Albany
Araneus sericatus Clerck 1
Dolomedes fontanus Emerton 1
Araneus patagiatus Clerck 1
Stoddard, Miss A. G., Dunkirk
Araneus cornutus Clerck
Araneus sericatus Clerck
Araneus trifolium (Hentz)
Araneus marmoreus Clerck
Lansing, Howard A., Menands
Araneus benjaminus (Walckenaer) 1
Conway, Mrs M. J., Troy
Horseshoe crab, *Xiphosura polyphemus* Brunnich 1
Gunn, Elmer D., Albany
Squid, *Loligo pealeii* Lesueur 1

Exchange

Birds

Victoria Memorial Museum, Ottawa, Canada
Gannea, *Sula bassana* (Linn.) 3
Razor-billed auk, *Alca torda* Linn 1
Black guillemot, *Cepphus grylle* (Linn.) 2
Puffin, *Fratercula arctica* (Linn.) 1
Common murre, *Uria troille* (Linn.) 2

Purchase

Amphibian casts

Franklin, Dwight, New York

Toad, *Bufo americanus* LeConte	2
Tree toad, *Hyla versicolor* LeConte	2
Pickerel frog, *Rana palustris* LeConte	1
Marbled salamander, *Amblystoma opacum* (Graveu.)	2
Newt, *Diemictylus veridescens* Raf	1
Newt, red land stage, *Diemictylus viridescens* Raf	1
Mud puppy, *Necturus maculatus* Raf	1

Domestic Pigeons

Hartley, B. M., West Haven, Conn.

Priest	2
Bluettes	2
Hungarian hen	2
Ice pigeon	2
White king	2
Satinette	2
Polish lynx	2
Black barb	2
English carrier (black)	2
Mokee (narrow tailed)	2
Frillback	2
Turbiteen	2
White English pouter	2
Saubian	2
Turbit	2

Mammals

Boyd, Harold, Rensselaer, N. Y.

Woodchuck, *Marmota monax rufescens* Howell	5
Skunk, *Mephitis putida* (Shaw)	1

Collection

Birds

Bank swallow, *Riparia riparia* (Linn.) ad	3
Bank swallow, *Riparia riparia* (Linn.) yg	8
Nests, Bank swallow, *Riparia riparia* (Linn.)	3
Eggs, Bank swallow, *Riparia riparia* (Linn.)	5
Robin, *Planesticus migratorius* (Linn.)	3
Nest, *Planesticus migratorius* (Linn.)	1

Mammal

Bat, *Eptisicus fuscus* (Beau.)	1

Reptiles

Summer snake, Liopeltis vernalis (DeKay) 1
Peeper, Hyla pickeringii Storer 3
Cricket frog, Acris gryllus LeConte 1

Arachnida

Araneida

List of species

Theridion montanum Emerton
Theridion frondeum Hentz
Theridion murarium Emerton
Theridion sexpunctatum Emerton
Theridion tepidariorum C. Koch
Ceratinella brunnea Emerton
Prosopotheca communis (Emerton)
Bathyphantes nigrinus (Westring)
Bathyphantes alpinus Emerton
Bathyphantes zebra Emerton
Linyphia insignis Blackwall
Linyphia phrygiana C. Koch
Linyphia marginata C. Koch
Linyphia communis Hentz
Linyphia pusilla Sundevall
Linyphia nearctica Banks
Tmeticus armatus Banks
Oedothorax montanus (Emerton)
Oedothorax bidentatus (Emerton)
Oedothorax microtarsus (Emerton)
Araneus trifolium (Hentz)
Araneus marmoreus Clerck
Araneus sericatus Clerck
Araneus angulatus Clerck
Araneus patagiatus Clerck
Araneus cornutus Clerck
Araneus cucurbitinus Clerck
Araneus corticarius (Emerton)
Araneus labyrintheus (Hentz)
Araneus arabescus (Walckenaer)
Argiope trifasciata (Forskal)
Argiope aurantia Lucas
Tetragnatha laboriosa Hentz
Eucta lacerta (Walckenaer)
Dictyna foliacea (Hentz)
Agelena naevia Walckenaer
Cicurina brevis (Emerton)
Cryphocca montana Emerton
Pirata minutus Emerton
Pardosa distincta (Blackwall)
Pardosa mackenziana (Keyserling)
Castaneira descripta (Hentz)

Clubiona canadensis Emerton
Neon nellii Peckham
Evarcha hoyi (Peckham)
Pellenes decorus (Blackwall)
Sitticus palustris (Peckham)
Dendryphantes marginatus (Walckenaer)
Dendryphantes mccooki (Peckham)
Misumena vaţia (Clerck)
Liocranum calcaratum Emerton
Dolomedes sp. im.
Steatoda borealis (Hentz)
Erigone sp.
Phalangida

List of species taken

Oligolophus pictis (Wood)
Mitopus montanus (Banks)
Leiobunum vittatum (Say)
Leiobunum politum Weed.
Leiobunum calcar (Wood)
Leiobunum nigropalpi (Wood)

ARCHEOLOGY

Purchase

E. P. Bouton, jr

Shell gorget

Ward's Natural Science Establishment

(Articles from Richmond Mills)

Bone awls	65
Fish plate	
Bone needle fragments	11
Bone chisels	4
Bone punches	9
Tubular bone tool	1
Raccoon penis bones	4
Bone harpoon	1
Digging tools	2
Bone spatula	1
Parts of skeleton	
Patella bone	1
Cupped stone	

(Articles from Lima, Tram site)

Gun barrel fragment	1
Pestle and fragment	2
Battering stone	1
Grooved axe	4
Celts and fragments	10
Hammer stones	6
Net sinkers	2
Stone natural perforation	1
Small polished stone	1

Gouge	1
Worked stone	1
Adz	1
Beads, strung	800
Pottery fragments	40
Tray containing beads and metal objects	10
Bone fish hooks	2
Clay pipe fragments	4
Iron axe heads	3
Iron side plates of musket	2
Iron knife blades	3
Metallic fragments in tray, European	5
Juvenile lower jaw	2
Tray containing animal teeth and beads	

Donation

W. R. Blackie, Williamsbridge	
Stone grooved axe	1
Arrow points	5
Scrapers	3
Bone punch	
H. L. Bowers	
Clay pipes	2
Leona Babcock	
Glacial pebble	1
Wooden scoop or ladle	1
A. A. Schmidt	
Pestle, cylindrical	1
E. H. Gohl, Auburn	
Clay pipe	1
Arrow point	1
Clay pipe fragments	
Phalanx	1
Bone awl	1
Bone needle fragment	1
Unio shell	1
Potters clay	1
Tempering stone	1
Net sinkers	8
Hammer stones	1
Muller, broken	1
Potsherds	35
Sections of clay pots	2
Section long neck clay vessel	10
Sections clay pots	7

Exchange

American Museum of Natural History, New York	
Potsherds	38
Parts clay pots	42
Quartzite chips	2

Deer antler parts	4
Clay pipe fragments	3
Bar amulet, fragment	1
Banner stone fragments	3
Red slate fragment	1
Oyster shell	1
Clay concretion	1
Flattened stone	1
Gorget	1
Bone awls	9
Charred hickory nut	1
Pigment	1
Arrow points	64
Blades	14
Chipped implements	7
Drills	2
Net sinkers	7
Scrapers	4
Gorget fragments	2
Mortar	1
Axe, grooved	4
Hammer stones	5
Adz	1
Paint cups	2
Pestles	2
Celt	1
Gouge	1
Steatite	2

XIII

SCIENTIFIC PAPERS

THE PHILOSOPHY OF GEOLOGY AND THE ORDER OF THE STATE

President's address before the Geological Society of America, Albany, December 28, 1916

BY JOHN M. CLARKE

Once each year we come together to renew our strength in unison, like Antaeus, by touching the earth.

I am conscious of taking some degree of liberty in departing from the usual form of this established function — the annual address. It would gratify me and might in some measure have diverted or persuaded you, if this occasion were given to the illumination of some specific technical theme. But the spirit of the hour seems to impel me rather to read from my experience and observation, or at least to portray as I see it, some part of the obligation of the state to our science and the responsibility of this science to the state.

The occasion is perhaps opportune, not so much in this place of meeting which happens to be the seat of government of but one of the many states here represented, and in the presence of members from two great federated governments; but essentially because, for the sake of all parties of interest, we must recognize more clearly the civic element in geological science and insist more pertinaciously on the immediate as well as the ultimate dependence of a state, if organized to endure, upon the demonstrated laws of this science.

I wish I might extend to my colleagues among the official geologists of many states an assurance that this address is to be devoted to some added demonstration of the obligation of the state to exploit to the utmost its geological resources, for the sake of the commercial interests of its community, but such public arguments are now superfluous. It is a primary impulse and an almost elemental instinct in the state to develop the commercial assets of its rocks. The appeal is so direct, so simple, so imperative that no state can afford to ignore a well-directed official effort to increase thus the general well-being and comfort of the commonwealth. The broad proposition is not debatable; the proposition in detail has always been debatable and debated. Too often and too much in representative public opinion is the existence of the official geological organization justified by certain perfectly obvious considerations which subtend a large angle in the public consciousness. Gold and silver, iron and coal, petroleum and natural gas, and terms like these are made too often to set forth a reasonable vindication of official geology. But you and I may well insist that such factors as these reckoned in terms of the wealth of the state are not the justification of official geological research. We may as well draw back the veil — private enterprise will pretty effectively take care of such things as these without much help from us. Against such factors which we may term the obvious sources of wealth must be weighed the more recondite products which have seldom entered into the estimate of the law-making body or the public knowledge.

It is in these that many of our states are richest, not in those obvious factors. In a state like this, which I cite not for comparison but for illustration, the unexploited iron ore would seem to be well over a billion tons, while the actual value of the annual product of iron is not more than one-tenth that of the annual output from thirty or more different mineral products. And we can not even begin to estimate for our state the vast reserves in products undeveloped or conceive the now unknown applications to industry and the arts which our commonest geological compounds are competent to supply in response to the demands of the state.

I can see in such a state or in a union of states and governments such as ours, the demand for every human need, today actual and tomorrow possible, which is in any way dependent on the rocks of the earth, fully met here without reliance on any outside source. And it is of eminent importance that the state take counsel with itself to magnify such independence, at the sacrifice of its commercial ease, for dependence in commerce means no less than does dependence in the scheme of nature, that is, degeneration or stagnation.

I counsel therefore, you who are official servants of the state, to urge, within your power, upon the state this primary obligation: to take from no other what it can itself as well produce from its own stores. Insist, as the right is in you, that the state shall take account of the knowledge you possess for the full but conservative development of its own resources, and neglect no occasion to enforce the claims of the man who knows best, to precedence in these councils of the states.

I would not seem to profane my high office by stating in this presence the elemental conceptions of the science, but it is most imperative that I here, and you elsewhere, shall be lucid, exact and comprehensive in setting forth its claims, namely and briefly: that there is no substantial conception of property apart from the products of the rocks, the soils, the mines, the water, the air — and these in all their functions are geological factors; that there is no correct understanding of the meaning of human life, individually or in its complex community relations, if we stand with our backs to the great panorama of events which have builded the earth and the trains of life which have moved over it from the dawn of its history. It is most essential that every state should above all things comprehend these facts.

The current of my thoughts is toward the well-established principles of geology which have constituted the state; not the state as a geographical section of the earth, and not just now those principles which have laid its material foundations, builded its rocks, formed its veins and beds of ore, made its soil, established the sources of wealth as expressed in terms of human market; but unavoidably I turn to those principles which illumine the trail of humanity and have given it direction. My time has been long enough to ripen some of the green fruit of experience and enforce some deep-seated lessons. In the light of this experience and these associations there is no escape from the earnest conviction that the things of supremest value to mankind, the refined essences of the earth, lie in its records of the life which has gone before us. As the emergence of what we call the living, quoting Professor Chamberlin, is the transcendent event in the history of the earth, there is certainly no other fact in the presence of humanity so vital as that and the vast procession of the ages with the key it holds to our present state and future hopes. Need I say to this audience what I would wish to say to a wider: We are passing, we have stopped only to see the march of life and play our small part in the tremendous and endless pageant, happy indeed if, endowed with powers of divination, the rays of truth have dawned upon us from out of the past, to light the imagination on toward better things.

To what extent, then, are we fortified by the evidence of the past career of life in reading its oracle for our present guidance? This inquiry sets plainly before us, first, the paramount question as to the oft-alleged and too often magnified imperfections of the record of life upon the earth.

In many, probably in most, expositions of the science of geology and paleontology, prepared for the use of students and general readers, the so-called imperfections in the record of past life are brought out with a vivid intensity. These expositions are, I think, in large part due to a more or less unconsciously apologetic attitude on the part of the authors, as though they were in some way, being apostles of the science, likely to be held to account for any overstatement of its claims; and these attorneys in bankruptcy are not inaptly, to my mind, comparable to buyers of ancient but damaged rugs, torn, raveled, worn bare of their patterns: ostentatiously declaring their defects while overlooking the beauty, the symbolism, the perfection of the design seen clear through all the ravages made by the wear of time.

I find myself out of sympathy with such deprecating portraitures. Neither my experience nor my philosophy finds support for pessimistic conceptions of the ultimate hope of completing our tapestries from the patterns we know and the threads we are yet to pick up. For a few years, as we reckon human history, we have scratched with our hammers some surface exposures of the tablets of the law in parts of the earth most easily accessible to us, and the occasional explorer into remoter parts has gathered the life records in haphazard way, here a few pounds weight, there a few tons. Not one-fiftieth part of the exposed rocks of the earth has yet been closely scrutinized for these life records, and of the unexposed but known strata, practically none at all in the great total. This State of New York covers 47,000 square miles, two-thirds of which are underlaid by life records of the earth. This fossiliferous area is one eighteen-hundredth part of the land area of this globe, about one eleven-hundredth part of the exposed fossiliferous rocks. In this State the work of assembling the evidences of the life record has proceeded continuously in organized attack for eighty years. An eminent French geologist has intimated that there are few places of equal area in the world where the life record is so completely assembled — and yet every year brings new and necessary additions to our quiver. What shall we say of the other 1099 equal areas of fossiliferous rocks on the earth? Many of them have indeed been studied with precision but there remains and must remain for long years yet an overwhelming balance of the unknown. In the abundance and perfection of the life that is preserved in these rocks only the living seas themselves are comparable. I have estimated the number of individuals of a few of the species occurring in one insulated mass of marine Devonian strata known as the Percé rock, a section which above the waterline represents a sea deposit 300 feet thick, 1300 feet long and about 250 feet wide; and the figures for these few species run into the hundreds of millions of individuals — and yet the rock is not richly fossiliferous, in the customary use of that expression.

It seems to be my experience, too, that the most closely studied formations have already yielded up a large percentage of their actual fauna. For some well-studied formations in limited areas the known fauna is, approximately speaking, a true and fairly full expression of the actual fauna. I can not of course pursue this matter here into its further details with its brilliant vistas already before us of learning the inchoate life of the primitive soils and first impounded waters, but I think I shall venture to enter the lists on call, to contend that for plant and animal life alike the records of the rocks where unaltered, are unimpeachable for adequate suggestiveness of the designs which the threads of life have woven. And when the imputation is too often made of imperfection through loss of anatomical detail, or the destruction of essential structures, compare by way of simple illustration compressed into the emergencies of this occasion the growth of knowledge of fossil anatomy within the fragment of the lifetime of one man. Fifty years ago all that was known of the ventral organization of the trilobite was a mere suggestion embedded in a nest of speculations; of its ontogeny a few discrete facts. So far has knowledge advanced that today we seem to know these animals in all their essential details and development; and if aught is left to become known of internal anatomy or ecology, the lessons of the past are the promise of the future. What was known of the Eurypterida fifty years ago was little but their outline and their grosser form. Today their ontogeny is understood almost from birth onward, their anatomy almost to ultimate details, their habits at least as well as those of vast numbers of living animals, their phylogeny as well as or better than the phylogeny of any living race subjected to this speculative treatment. Supplement these illustrations, which are nearest to me, with the scores of others known to you and with the tremendous strides made in this same period of time among the extinct vertebrates, and within the realm of lost floras where sheaves of knowledge have piled higher with every year.

These are the theses I should wish to nail on the doors of our temple:

Nature makes for the individual. This truth is registered on the tablets of the earth; it lies also in human observation and in human experience. Its recognition is of paramount importance; its acceptance sweeps away cobwebs of vagrant hypotheses which befog the pages of writers on political and social economics.

In the progressive line of development which in the present terminates in us, the procedure of nature has been one of only limited concern for the family and of tried out and abandoned experiment for social partnerships and the division of labor. To perfect the individual inconceivable safeguards have been thrown about him. The individual is creation's unit in terms of which all progress in life is to be reckoned. With unsparing hand she makes and wastes these units, both for her greater purposes and those which we may call her lesser ones. Units of purpose are wiped away to make place for units of other purpose. Yet the unit type remains; remains with its full seeding of possibilities, armored for its fight with double portions of food supply, of sense organs, of locomotive means, with an inexpressible superfluity of reproductive supply. Whether a given unit survive till its work be done or perish in the doing, it is the individual type that is at stake, it is against this individual type that all the powers outside it are imposing their obstacles.

This the geologist knows: There has been no cooperation in the historic development of the life in which we are directly concerned. We may not yet know the trend of many life lines for far in their history, but wherever such lines are best known, within the limitations of large natural divisions, those that run through from limit to limit and point the way both backward and ahead, and those other lines collateral to ours which have ended and determined fruitlessly — these all can be conceived in no other way than variant expressions of the individual. And in the history of human life is it aught else than the individual that has stood for the progress of mankind? Was it the barons at Runnymede, was it some bill of rights, some declaration of independence, some joint action of human agencies that have been the crowns of our achievements? Or was it the Aristotle, the Plato, the Socrates, the Christ, a solitary Shakspere, an incomparable Franklin, a rebellious Darwin, or the historic twenty individuals, who have stood for the progress of the race?

I say this only for the purpose of saying *per contra,* that the history of the excellent life (and by that I mean the line of life that is best perfecting its psychology), has shown the futility of attempts at progress through any other agency than the independent individual. This is so important a conclusion to every state taking cognizance of its dependence on natural laws that it is highly essential to consider nature's own alternatives to such individualistic effort, her own experiments in trying out other modes of ascending heavenward. For "individual liberty," said President Butler speaking before the Constitutional Convention of this State, "is the cornerstone of the free state." That is the decree which is written in burning letters on every milepost of the course of life. "The perfection of the individual is the perfection of the race" says Professor Hoffman. "But," he adds, writing on the organization of the state, "the individual can have no rights or duties that conflict with the good of the whole"— a supplement for which it is exceedingly doubtful that any substantiation can be found in nature.

a It has been my environmental control to study and, I hope, to learn some of the lessons of life from their simplest and most easily legible expressions — a result that has come from living and laboring in a state built from the early waters with their undifferentiated expressions of life. The panorama of successive early worlds of life glows with the simple expressions of law which become more involved, supplemented and beclouded as the passing of the ages complicates the process of higher evolution, and produces expressions which, in terms of existing life alone, would be difficultly intelligible. The study of the meaning of existing life without the light of its vast history leads nowhere.

It is safe to say, I think, that living beings at the start, animated nature whatever its composition, had an equal chance for progress and improvement. How soon that chance became forfeit we can not say, but it is obvious that life was not long begun and its greater stocks established when their courses throughout existence were set and determined. Nothing is more obvious in chronology than nature's deliberate failures, nothing more clear in paleontology than her set purposes.

The vast subkingdom of the Mollusca started well with bodily independence, fully equipped with locomotive powers, an excellent innervation, but they sold their birthright for ease and content. They soon became dependent upon the movements of the waters and waited for the waves to bring them food. Compact in their protection and adaptation, these types of life have come crowding down through the ages in inexpressible variety. They and their allied phyla in the great subkingdom to which they belong have, it would seem, struggled now and again to regain their primitive independence and maintain it, but the early condemnation of the law has overawed them and out of them all has come, and can come nothing better. They had their chance. That chance was missed; for untold millions of years they have failed to improve. They still cumber the earth and teach the lesson of an incurable heritage. You who are students of ancient life know how great is thè multitude of lessons like this.

None of the observations of the competent have afforded any evidence that the lines of development through such groups of lowly animals have led to anything of promise or of excellence. The ages have rolled away and left them still with us, progressed, arrested or degenerate within their own narrow limitations, as the case may be. There is no evidence to indicate that these great groups from which nothing can be expected were deprived of their equality of opportunity as contrasted with the other great subkingdoms of the annelids and the articulates from one or the other of which, or from one and the other in succession, our own line has been derived.

The lesson then is this, that dependent conditions of life, however we may see them, throughout untamed nature or in our own communities, are not primitive, are not in the essence of things, but they are set back so far in the history of life that they are now or seem to be unavoidable and unconquerable.

These evidences I have discussed before this society on previous occasions. The field of observation and of inference as well, is greatly to be enlarged and well justifies the appeals that have been made on its behalf, but so much at least is indicated: that here and in analogous cases parasitic existence in whatever group in nature, and with whatever expression in the natural assemblage or the community group, involves the essential abandonment of normal direct upright living and the benefactors thereby are types of life which nature has cast out and aside as hopeless.

It is probably yet to be determined, at least there is no record I can find, that even in the passing of the ages nature has ever set up again upon its feet an organism or group of organisms once fallen into this dejected mode of life.

It is well the state should recognize this harsh truth which is a law. With a police power guided by intelligence and sympathy, some of the harshness in this inevitable human condition may be ameliorated, but the paleontologist looking at the record of life on the earth says to this state: Be intelligently guided in the treatment of hereditary community parasites, defectives, congenital or confirmed misdemeanants, whatever the form of degeneration may be, by recognition of the presumption that in so far as they can not be physiologically corrected, they are abandoned types in which there lies little hope of repair. I can state this conclusion only thus succinctly without here attempting to present or argue its many ramifications.

b Soon after the great outburst of articulate life in the Cambrian, wherein, so far as our present knowledge permits, we find the lines along which have come the complicated expressions of today; somewhere in there, we may not say securely now, branched out the great phylum which led into the world of insects. We are wont to say that the first whirr of insect wings was made by the dragon flies and great cockroaches of the Devonian forests — an admission which of course implies that long earlier ages saw the differentiation of this type of life. At all events the six-legged type of articulates adapted to life in the water and air, full of vivacity and agility, with full independence, equipped with all potentialities that come from abundant innervation — this type, this six-legged articulate expression of existence, the insecta, started reasonably early on its career. It is my desire to note only in passing that, however close and direct may be the derivation of the vertebrate type from the primitive articulate stock, we have no inheritance from and hence only a collateral interest in this six-legged type of articulate life. Yet the outcome of development along this line has led to most extraordinary displays of morphological and psychic differentiation. A distinguished naturalist has said that the brain of an ant is the most marvelous speck of matter in existence. I hardly need, before this audience, to recall the exquisite and minute specialization in morphology, physiological function, performance and, I should say, conscious or at least psychic behavior among the most advanced attainments of development in the six-legged articulates, the social insects. The ant colony is the ideal of differentiation of function. Its members are by birth and inheritance, food and training, destined to certain specific duties in the colony. Armies are marshalled, wars are waged, the wounded nursed, the captives are trained for their duties, gardens are planted and crops are harvested; the stock is fed and food is stored, and a score of marvelous concerted doings which amaze us by the perfection of their totality, which is — the welfare of the community. Here the individual is actually constructed nervously and physically, anatomically and physiologically for the niche in the community which he is destined to fill. No human community where cooperative efficiency has submerged the individual and has been the objective and the attainment, no such human community has ever yet reached such an ideal of joint effectiveness as has a colony of ants. The ants are nature's great triumph, her highest performance in communistic effort and in cooperative achievement. And what has come or can come of development along this line?

Let us look back a little into the antecedents of the ants. Says Professor Wheeler, "So many genera and species of these insects appear full fledged in the early Tertiary we are compelled to believe that they must have existed in the Trias or even in the Lias, but belonged to so few genera and species, or lived in such small communities that they left no remains." This distinguished student cites 276 Tertiary species as indicative of their sudden outburst, or perhaps it would be safer to say the development of better modes for their preservation, and he has further stated that there is no reliable observation to prove that polymorphism was existent among the earliest ants of this long period. This differentiation does, however, show itself in the fossil ants of the Quaternary.

This paramount attainment of intellectual activity in the line of insect development, in the line of the six-legged type, would seem thus to have been accomplished largely through the same period of time when the human line was perfecting its mentality. The psychology of the two ultimate results is separated by processes and directions of development as wide apart as the poles. Neither is to be expressed, perhaps, in terms of the other. The results too are wide asunder — one a deadly communism, a moribund partition of labor, a lethal socialism; the other an active, progressive and fertile individualism. For the former the student of nature's history sees no outcome. These too are nature's experiments. The six-legged type with all its purposes in its highest expression lies prostrate on the ground at our feet, it and its achievements have risen to nothing higher than an ant hill, its communistic relations and subservience are entirely apart from the true genius of humanity. Socialism and communism have been tried out and found wanting, and nature holds conspicuously before the eye of the state the warning that they have nothing either for the growth of the spirit or the progress of the intellect.

c I regard as peculiarly a doctrine of paleontology, one whose demonstration or confutation would be hopeless in the hands of the biologist, that of palingenesis, or recapitulation, or in other words the broad and familiar statement of the fact that each individual carries in himself and his development history, the history of the race to which he belongs, however accelerated or however retarded it may be. I am trenching familiar ground, but it is because I would remind this audience that not the mere existence but the panorama of life is essential to this conception and that the law remains only an assumption of probability as long as its manifestations are pursued only among creatures of high specialization. In our bodies politic the more complicated our existence becomes the more like a tangled web of ordinances become our statutes. Forty-five thousand new statutes it is said have been enacted in the last five years in these states for some of us to trip and fall over, and just as it is difficult to pick our way through this tangle of expediential legislation, so it is likewise difficult to read in highly specialized organisms the leading of this great governing principle of biogenesis. If we do trip and fall among the entanglements of the statutes, the difficult mechanism of our present community life, let us remember that also back even of the bewildering, confusing, interlocking webs of the physiological mechanism of evolution lies, outspoken and luminant, the simpler expressions of the basic law on which rests the whole superstructure of evolution whether of the individual or of the state.

d It is well for us, well for the state, that we read aright the teaching of the greater past upon the doctrine of majority control, for whatever enduring virtue it has takes its roots in these past procedures of life when laying the foundations of its phyla. Over and over again the dominant race has started on its career as an insignificant minority struggling for its existence against an overburden of mechanical and vital obstacles, armed only with specific virtues which have little by little fought their way into the foreground, and by so doing consummated their upward purpose. If I refer to the geological history of the phylum to which we belong, the Mammalia, it may stand for the oft-repeated procedure which has in various forms come under the notice of every paleontologist. The Prototheria, or the first of all mammals, appeared upon the scene in the Jurassic, diminutive, mouselike creatures even yet retaining from reptilian ancestors the function of ovulation, possibly having already developed a marsupial pouch for their nurslings, insectivorous in dentition, creeping inconspicuously through sheltered places of the forests or among the crevices of the earth, their minute but agile brains by which they were steering their course, tremendously exceeding in proportion the brains of the giant reptiles whose variant forms constituted the majority and made them masters of earth and air and sea — whose gigantic physique and fleshly lusts had outstripped the early promise of their cephalic ganglia and left them hopelessly decephalized. Insignificant in size and number, but equipped with the vigor of phyletic youth, agile adaptability, locomotive independence left unimpaired through excessive food supply, with such equipment, good balance between cephalic and motor nerve centers, these inconspicuous and feeble folk started on their career of triumph over an overwhelming majority. Time passed and the deed was done. The agile-witted founders of the race had spread abroad through the earth. They grew vast in number and variety, adapted to all media of earth and air and sea. To them at last came the temptations of the flesh pots; they grew great in bulk, slow in body, weaker in locomotion and feebler in proportion. They too had met their impasse and there was nothing beyond. The majority had arrived, but the majority had fed itself fat on the spoils of the conquest and was moribund. Once more out of this majority arose the protest of the minority and again the keener witted, better cephalized, unimpaired, but obscure and diminutive minority, strong always at the head, emerged from the welter of self-indulgence to save the race. Robbed of luxuriant food supply by a mantle of ice, its vitality quickened and stimulated by the invigorating cold, imperiously compelled by a world chill which hung upon the earth unknown years to purge itself of indirection and seek the straightest way to physical salvation through the practice of simple virtues; from out of such conditions came the human stock.

If we do not recognize fully the fact that a majority control in our governments is purely a matter of expediency in the handling of civic affairs, let us remind ourselves of it on this occasion. We need only the reminder, for however often the man in the ward and the voter at the polls conceive that a majority is the paramount issue at stake, it is too often forgotten that the majority is purely numerical while wisdom and truth may rest with the minority. Amidst the inevitable expediencies of government this is its salvation — that the minority, if clear and strong at the head, like an antecedent river, will cut down mountains of opposition.

"The triumphs of liberty have been due to minorities" said Lord Acton. "The rule of the tyrant is tyranny whether he have one head or many. The principle of absolute majority rule is as profoundly immoral and as profoundly undemocratic as is the principle of the divine right of kings. Majority rule is a practical device for the working of free institutions and not a principle without limits or bounds upon which free institutions may be based."

This is the teaching of our science; the ephemeral worth of majority control is always obvious; the voice of the people is not the voice of God.

e We have come to a point in our researches where observation and inference teach us that life originated in unicellular microbic forms under conditions which have been indirectly indicated by the Chamberlins, father and son, as governed by and intimately associated with a conjunction of soil and moisture, with obstructed air, and probably without direct exposure to the actinic action of the sunlight. There has already been interesting and substantial confirmation of the presence of actual bacteria in the most ancient rocks of continental origin antedating the Cambrian, and many well-demonstrated expressions. The discovery of fossil bacteria is to be accredited to several students, Van Ingen among others, but their existence in this age preceding the primordial outburst of life, in times when by every line of sequential reasoning they should exist, this important determination is among the brilliant results of Walcott's researches.

So now every legitimate evidence of fact and deduction points to the origin of microbic unicellular life in the moist, subaerated soil away from the direct sun; and the soils of today are alive — a mighty host — with such microbic creations existing under paranerobic conditions. This army, we are coming to understand, is endowed with specialized functions; and if this statement is, and is to remain, approximately correct, then the acquisition of such special functions speaks of a long past with its gradual and cumulative inheritance. It still remains to be demonstrated that the cycle of life is renewing itself from day to day by the continued transmutation of the inorganic to the organic, however such a possibility may lie in the lap of logic. But it is well for us to realize that this microbic life which in the passage of time has become adapted to such special functions that we recognize among them germs of disease as well as of benignancy, has the historic impress of hostility to the direct rays of the sun. Microbic disease is disease only from the human standpoint, from the point of view of the host of the disease-causing parasite. For the germ — the microbic parasite itself — it is normal living. I think we may well urge upon the attention of pathogenists the importance of estimating the historic impress which is, in all disease-making bacteria, the natural primitive and inherited hostility to the sunlight. In the adjustments and readjustments of these parasites to special hosts and specific toxic processes some may have overcome in a measure this natural antagonism, but for the most their work is in the dark. The marvelous results which have been attained in the treatment of tetanus during the present war, by simple and constant exposure to the sunlight, encourages us to believe that in similar pathology a like treatment would be historically and logically correct.

Fifty years ago when President Andrew D. White published his " Warfare of Science and Religion," he said, "A Truth written upon the human heart today in its full play of emotions or passions can not be at any real variance with the truth written upon a fossil whose poor life ebbed forth millions of years ago." These fifty years since have enabled us to say with equal security that the record written on the fossil is the candle by which we must read the fate of the community, the passions and emotions of the human heart.

We have been shocked into a consciousness that not all the virtues abide in us. You may recall the ancient days of Rome when the people annually gathered to pay an offering of oil and wine, of milk and violets to the spirits of their ancestors, from the study of whose examples they gained for themselves and inculcated in others a respect for the virtuous past. So we say our *aves* to the great past out of which we and all our guiding principles in individual life, in the community, in the state, have come.

Our broader vision which must be the bloom of our intense specialization is like the dream of the patriarch who, resting his head on a pillow of stone, saw a ladder reaching from this earth to heaven and beheld the angels of God ascending and descending on it.

THE PALEONTOLOGY OF ARRESTED EVOLUTION

BY RUDOLF RUEDEMANN

Address by the President of The Paleontological Society, Albany, December 1916

When last year your society honored me in electing me your president, it was my first desire to present in my address a general survey of the work in which I have been most interested, namely, the analysis of the faunas of the graptolite shales and their correlation. Fear that this theme might not be of sufficiently general interest, and still more the discovery of new facts in the last two years, calling for further investigations of the Ordovician shales, have influenced me to select another problem for presentation in which I have also been interested for some years. This is the Paleontology of Arrested Evolution, as seen in the persistent types and relicts. Unfortunately, this problem, also, as here presented, is still far from being solved, and I have to beg your indulgence for obvious shortcomings.

INTRODUCTION

The student of fossil faunas, both for stratigraphic and biologic ends, can not fail to be struck by the remarkable differences in the ranges of the various species, genera, families and higher groups. As a rule, the broad stream of organisms that passes our view in geologic history changes quite regularly from formation to formation, but there are certain species and genera which reappear again and again without any or with but slight variation, often in totally different faunal associations. These types which thus remain unchanged throughout a number of formations have been designated as *persistent* or *conservative types,* in contradistinction to the *variable types.* As pointed out by Osborn (*The Age of Mammals,* p. 7), it was early observed by Huxley,[1] Cope and others, that Cuvier's broad belief in a universal law of perfection was erron-

---

[1] Huxley, in his anniversary address to the Geological Society of 1862 on "Geological Contemporaneity and Persistent Types of Life" (reprinted in "Lay Sermons, Addresses and Reviews," 1906, p. 176) has, in a general way, established the existence of persistent types of structure, and from a general survey of the development of the organic classes reached the conclusion that the common doctrines of progressive modification which suppose that modification to have taken place by a *necessary progress* from more or less embryonic forms, or from more or less generalized types within the limits of the period represented by the fossiliferous rocks, are negatived by the evidence of the persistent types, for it either shows no evidence of any such modification, or demonstrates it to have been very slight.

Our purpose and scope of investigation in the present paper is different from that pursued by Huxley.

eous, and these authors began to perceive the difference between *persistent primitive types* (Huxley) and *progressive* or *advancing types.*

The causes underlying the variation of species have been, since Darwin's time, and are still the storm center of discussions of evolution; the negative side of the question or the continuous failure to vary has been thought hardly worthy of notice, partly because its frequency impresses itself principally upon the paleontologist only, and partly because it seems to promise little of importance to that discussion. Various facts, however, have come to our notice which bear on this problem and appear to invite a brief investigation of the causes of persistence, principally as it appears among invertebrate fossils.

Persistence of types, generic and specific, presupposes the avoidance of two antithetic causes of extinction; to be persistent a type must not be variable, for if it develops into another type it becomes extinct as the former type and, though living in its descendants, it is *relatively extinct;* further, it must not become *absolutely extinct* through death of the race. Variability is the general means to adaptation and progressive development, and so persistent types must, generally speaking, be in the peculiar position of being not so highly vitalized or *alive* as the developing and climacteric forms, and yet still too vigorous to become extinct or permit the death of the race.

It seems to us that the generic units permit the clearest survey of the persistence of types. We shall therefore make this unit the principal subject of our investigation.

The ranges of the persistent genera, as here given, are extracted from Zittel–Eastman's *Textbook of Paleontology* (1913), and I have here defined as persistent all genera which pass through more than two periods.

Tables of Persistent Types

The most striking cases of persistence are among the *Foraminifera,* as follows:

Ordovician — *Recent*	Saccamina
Silurian — *Recent*	Lagena, Nodosaria
Carboniferous — *Recent*	Ammodiscus, Dentalina, Endothyra, Lituola, Rheophax, Textularia, Valvulina, Ammobaculites
Carboniferous — Tertiary	Nummulites
Triassic — Recent	Bulimina, Cristellaria, Frondicularia, Glandulina, Globigerina, Lingulina, Marginulina, Orbulina, Polymorphina, Vaginulina, Miliola, Placopsilina, Trochamminoides

Jurassic — Recent .... Astrorhiza, Rhabdammina, Marsipella, Bathysiphon, Rhizammina, Planorbulina, Pulvinulina, Rotalia, Polystomella, Cornuspira, Nubecularia, Ophthalmidium

Cretaceous — Recent .... Calcarina, Discorbina, Operculina, Sphaeroidina, Bolivina, Ellipsoidina, Chilostomella, Allomorphina, Dimorphina, Hauerina, Alveolina

Not only the genera possess this remarkable persistence but also many species persist, according to Parker, Jones, Brady, Bagg and others, throughout a number of formations (see p. 126). In general, the persistence of the Foraminifera surpasses that of all other orders which are known in fossil condition. The Radiolarians were probably as persistent in their genera but the group is still very imperfectly known in its fossil representatives, especially the Paleozoic. Their minute and delicate skeletons are, however, known to have been as abundant and diversified in the past ages as at present.

The *sponges,* contrary to expectation, furnish but very few persistent fossil types:

Cambrian — Carboniferous ... Hyalostelia
Devonian — Cretaceous ..... Peronidella
Carboniferous — Jurassic ..... Cnemidiastrum (Hinde)
Carboniferous — Cretaceous .. Doryderma (Hinde)
Triassic — Cretaceous .... Corynella, Raphidonema, Sestrostomella
Jurassic — Tertiary .... Craticularia
Cretaceous — Recent .... Cystispongia

A great number are found among the *corals:*

Ordovician — Devonian .... Anisophyllum, Aulacophyllum, Columnaria, Halysites, Heliolites, Plasmopora

Ordovician — Carboniferous .. Amplexus, Aulopora, Cyathophyllum, Emmonsia, Favosites, Petraia

Silurian — Carboniferous .... Clisiophyllum, Strephodes, Syringopora, Zaphrentis

Carboniferous — Jurassic .... Chaetetes

Triassic — Cretaceous .... Isastraea, Stylina

Triassic — Tertiary .... Astrocoenia, Astraeomorpha, Calamophyllia, Dimorphastraea, Montlivaultia, Phyllocoenia, Thecosmilia, Dimorpharaea

Triassic — Recent .... Stephanocoenia

Jurassic — Tertiary .... Comoseris, Cyclolites, Leptoria

Jurassic — Recent .... Cladocora, Favia, Goniastraea, Orbicella, Stylophora, Trochocyathus, Thecocyathus

Cretaceous — Recent .... Caryophyllia, Ceratotrochus, Coelosmilia, Diploria, Lophosmilia, Sphenotrochus, Goniastraea, Porites, Turbinaria, Heliopora

Among the *graptolites* we have Dictyonema from the base of the Ordovician to the Carboniferous, Desmograptus from the Ordovician to the Devonian.

Among the *Anthozoa* in general, the number of persistent genera, ranging through more than two periods, is remarkably large; the number would be more than doubled if the genera living through two periods only were to be added.

Among the *Crinoidea* we find:

Silurian — Carboniferous	Cyathocrinus, Saccocrinus, Eutaxocrinus
Triassic — Recent	Isocrinus, Monachocrinus
Cretaceous — Recent	Rhizocrinus

There are no persistent genera among the *Cystoidea;* among the *Blastoidea,* only Codaster extends from the Silurian into the Lower Carboniferous.

Among the *Ophiuroidea* all are short-lived; among the *Asteroidea* we find:

Devonian (?) — Recent	Astropecten
Jurassic — Recent	Oreaster
Cretaceous — Recent	Calliderma, Nymphaster, Comptonia

In regard to the *Ophiuroidea* it is stated that in the lower, middle and upper Jurassic are found brittle-stars closely allied to the recent Ophiolepis, Ophiocten, Ophiura and Ophiomusium; and that it is possible that some of these are really congeneric with recent species.

The persistent *Echinoidea* are:

Silurian — Carboniferous	Koninckocidaris
Carboniferous — Jurassic	Miocidaris
Triassic — Cretaceous	Hemicidaris (subgenera) (Subgenus Hypodiadema, Triassic-Cretaceous)
Triassic — Recent	*Cidaris* (culminates in Jur.-Cret.; artificial subgenera) (Subgenus Rhabdocidaris Jurassic-Recent; Leiocidaris Cretaceous-Recent)
Jurassic — Recent	Hemipedina, Centrechinus (Diadema auct.)
Jurassic — Tertiary	Cyphosoma, Nucleolites (Echinobrissus), Pseudodiadema, Cyphosoma
Cretaceous — Recent	Linthia, Salenia, Echinus, Echinocyamus, Fibularia, Rhynchopygus (subgenus of Cassidulus), Palaeolampas

The *Vermes* have furnished a few persistent genera of Polychaeta or Marine Worms, namely:

Ordovician — Recent	Spirorbis
Ordovician — Devonian	Cornulites
Ordovician — Carboniferous ..	Ortonia
Silurian — Recent.............	Serpula (collective name for various forms)
Jurassic — Recent	Terebella

Some remarkable ranges are cited among the *Bryozoa,* namely:

Ordovician — Devonian ...... Corynotrypa, Ceramopora, Discotrypa, Eridotrypa, Hallopora, Monotrypa, Monotrypella, Pseudohornera, Petalotrypa

Ordovician — Carboniferous .. Lioclema, Rhopalonaria, Vinella, Heteronema

Ordovician — Permian........ Rhombopora

Ordovician — *Recent!* .... *Berenicea* (culminates Jur.-Cret.) *Stomatopora,* Proboscina

Silurian — Carboniferous .... Allonema, Ascodictyon, Chilotrypa, Eridopora, Hemitrypa, Meekopora, Acanthoclema

Silurian — Permian .... Fistulipora, Polypora, Thamniscus, Batostomella, Cystodictya, Dichotrypa, Coscinium, Fenestella, Pinnatopora, Phyllopora

Triassic — Recent .... Ceriopora

Jurassic — Tertiary .... Diastopora, Fasciculipora, Theonoa

Jurassic — Recent .... Entalophora, Heteropora, Idmonea, Lichenopora, Spiropora, Crisina, Membranipora, Onychocella

Cretaceous — Recent .... Crisia, Filisparsa, Phalangella, Actinopora, Eucratea, Cyrtopora, Reticulipora, Discocavea, Hornera, Cribrilina, Lepralia, Lunulites, Floridina, Smittipora, Micropora, Membraniporella, Porina, Selenaria, Schizoporella, Smittina, Mucronella, Porella

Among the *Brachiopoda* we find:

Ordovician — Devonian ..... Dalmanella, Glassia, Scenidium, Atrypa, Atrypina, Schizocrania

Ordovician — Carboniferous .. Leptaena, Pholidops, Rhipidomella

Ordovician — Permian .... Chonetes

Ordovician — Cretaceous .... Orbiculoidea

Ordovician — Recent .... Crania, Lingula (two maxima of Crania, one in Ordovician, another in Cretaceous)

Silurian — Carboniferous .... Schizophoria, Schuchertella, Camarotoechia, Wilsonia, Cyrtina, Nucleospira, Spirifer

Devonian — Permian .... Dielasma, Strophalosia, Seminula

Carboniferous — Jurassic .... Spiriferina

Triassic — Cretaceous .... Aulacothyris

Jurassic — Recent .... Acanthothyris, Lacazella, Magellania, Megathyris, Muehlfeldtia, Terebratella, Terebratulina

Cretaceous — Recent .... Agulhasia Argyrotheca

The persistent types among the *Pelecypoda* are:

Ordovician — Devonian ...... Cleidophorus

Ordovician — Carboniferous .. Pterinea

Silurian — Carboniferous ..... Aviculopecten, Cardiomorpha

Silurian — Jurassic .... *Posidonomya*

Silurian — Recent! .... *Leda, Nucula* (over 200 fossil and as many recent species)

Devonian — Triassic	Solenopsis, Pleurophorus
Devonian — Cretaceous.........	Pseudomonotis
Devonian — Tertiary	Parallelodon (maximum in Coal measures)
Devonian — Recent	*Modiolus, Pteria*[1]
Carboniferous — Cretaceous.	Entolium, Myoconcha
Carboniferous — Recent	Atrina, Lima (subgenera: subgenus Limaea: Jurassic-Recent), Ostrea, Solemya, Lithophagus (Lithodomus)
Triassic — Cretaceous	Homomya, Opis, Pleuromya, Tancredia, Unicardium
Triassic — Tertiary	Gervillia
Triassic — Recent	Alectryonia, Cardita, Cardium (subgenera), Chlamys, Corbula, Gastrochaena, Hinnites, Limopsis, Mytilus, Pedalion (Perna auct.), Plicatula, Thracia, Lucina
Jurassic — Tertiary	Anisocardia, Gryphaea
Jurassic — Recent	Amusium, Anatina, Anomia, Arctica, Camptonectes, Corbis, Cucullaea, Cuspidaria, Cyrena, Cyrtopinna, Isocardia, Pholadomya, Pholas, Pinna, Spondylus, Tellina, Teredo, Trapezium, Venus, Trigonia
Cretaceous — Recent	Acila, Acharax, Yoldia, Batissa, Chama, Clavagella, Crassatellites, Dosinia, Glycimeris, Panope, Pecten, Pseudamusium, Sphaerium, Spisula, Venericardia, Ungulina, Thyasira, Paphia

Among the *Scaphopoda* the persistent types are represented by:

Silurian (?) — Recent	Laevidentalium
Carboniferous — Triassic	Plagioglypta
Cretaceous — Recent	Antalis, Fustiaria, Cadulus

The *Gastropoda* furnish the following persistent genera:

Cambrian — Silurian	Trochonema
Cambrian — Carboniferous .	Subulites
Cambrian — Triassic	Murchisonia
Cambrian — *Recent!*	Capulus (see p. 116)
Ordovician — Devonian	Cyclonema, Eunema, Holopea, Lophospira, Oxydiscus, Sinuites
Ordovician — Carboniferous ..	Omphalotrochus
Silurian — Carboniferous	Diaphorostoma, Lepetopsis, Metoptoma, Holopella, Natiria, Orthonychia, Platyceras, Platyschisma
Silurian — Permian	Bellerophon
Silurian — Triassic	Euomphalus, Loxonema, Macrocheilus, Scalites (?)
Silurian — Triassic	Straparollus

[1] Several subgenera, among them Meleagrina, Jurassic-Recent; Oxytoma, Triassic-Cretaceous.

Silurian — *Recent!*	Acmaea, Eotrochus, Patella, Pleurotomaria (subgenera, see p. 116), Trochus (subgenera), Turbo (?)
Devonian — Triassic	Naticopsis
Devonian — Cretaceous	Zygopleura
Carboniferous — Jurassic	Bourgetia
Carboniferous (?) — Tertiary	Pseudomelania
Carboniferous — *Recent!*	Actaeonina, Emarginula, Fissuridea (?), (Fissurella auct.), Vermicularia (Vermetus auct.), (?) (Subgenera)
Triassic — Cretaceous	Amberleya, Cylindrites, Fibula
Triassic — Tertiary	Discohelix
Triassic — *Recent!*	Astralium (subgenera), Calliostoma, Cylichna, Delphinula, Eulima, Epitomium (subgenera), Monodonta, Natica (subgenera), Nerita (?), Neritopsis, Niso, Turritella (subgenera)
Jurassic — Tertiary	Pileolus, Tornatellaea
Jurassic — Recent	Aporrhais (subgenera), Bullaria (?), Bullina, Cerithium (subgenera), Cypraea, Etallonia, Fusus, Hydatina, Liotia, Littorina, Mathilda, Melania, Rimula, Rissoa, Rissoina, Scurria, Solarium
Cretaceous — Recent	Acteon, Ancilla, Bithinia, Calyptraea, Chrysodomus, Clavatula (subgenera), Cominella, Conus (subgenera), Crepidula, Diastoma, Erato, Fasciolaria, Galeodea, Hipponyx, Hydrobia, Latirus, Megalomastoma, Melanopsis, Murex (subgenera), Nassa, Nyctilochus (Tritonium), Oliva, Phasianella, Philine, Pleurocera, Pseudoliva, Potamides (subgenera), Pyramidella, Pyrula, Rapana, Rimella, Ringicula, Scaphander, Siliquaria, Strombus, Tonna, Tudicla, Turricula, Turris (Pleurotoma) (subgenera), Typhis, Vivipara (subgenera), Xenophora

The *Pulmonata* contain as persistent genera:

Jurassic — Recent	Auricula, Carychium, Lymnaea, Planorbis, Physa
Cretaceous — Recent	Glandina, Megaspira

There are also persistent types among the *Pteropoda*, namely:

Cretaceous — Recent	Clio (subgenera), Vaginella

Conularia is recorded as ranging from Ordovician-Jurassic; Hyolithes from Cambrian to Permian.

The *Cephalopoda* furnish the following persistent genera, all among the Nautiloidea:

Ordovician — Devonian	Clinoceras, Cyclostomiceras, Zitteloceras
Ordovician — Carboniferous	Actinoceras (subgenera), Geisonoceras, Loxoceras, Poterioceras, Spyroceras

Ordovician — Permian ....Cycloceras
Silurian — Carboniferous .....Kionoceras, Protobactrites, Thoracoceras

There are no persistent genera among the *Ammonoidea* and *Dibranchiata.*

The *Trilobites* contain a few persistent genera, namely:

Ordovician — Devonian ......Goldius (Bronteus), Calymmene, Conolichas, Cyphaspis, Hoplolichas
Ordovician — Carboniferous ..Proetus

The *Branchiopoda* contain:

Devonian — Pleistocene ....Estheria
Triassic — Recent ....Apus

The *Ostracoda* have the following persistent genera:

Ordovician — Devonian ....Beyrichia, Primitiella
Ordovician — Carboniferous ..Aechmina, Bollia, Entomis, Leperditia, Ulrichia
Ordovician — Permian ....Primitia
Ordovician — *Recent!* ....Bairdia (maximum in Carboniferous), Bythocypris, Cypridina, Cytherella, Macrocypris
Silurian — *Recent!* ....Pontocypris
Permian — *Recent!* ....Cythere
Jurassic — Recent ....Cytheridea
Cretaceous — Recent ....Cythereis, Cytherideis

The *Cirripedia* contain the following persistent genera:

Cambrian (?) — Devonian ....Turrilepas
Ordovician — Devonian ......Lepidocoleus
Cretaceous — Recent ....Chthamalus, Scalpellum

The *Malacostraca* contain a small number of persistent types, namely:

Triassic — Cretaceous ....Glyphaea, Lithogaster
Jurassic — Recent .... Callianassa
Cretaceous — Recent ....Astacus (?), Homarus (?), Nephrops (?), Panopeus

There are no arachnid (save the extinct Merostomata given below), myriapod, or insect genera recorded as passing through two or more formations. Among the *Merostomata* are:

Ordovician — Devonian ...... Pterygotus
Ordovician — Permian........Eurypterus
Triassic — Recent ....Limulus

Among the *fishes* the following Selachians are persistent:

Triassic — Cretaceous ....Acrodus
Jurassic — Recent ....Cestracion, Hybodus, Pristiurus, Rhinobates
Cretaceous — Recent ....Acanthias, Callorhynchus, Carcharodon, Centrophorus, Lamna, Pristiophorus, Odontaspis, Raja, Scapanorhynchus, Scyllium, Squatina

The *Dipnoi* contain:

Triassic — Recent ....Ceratodus

The *Teleostei*:

Cretaceous — Recent .... Diplomystus (in rivers of New South Wales and Chili)

There are no persistent genera among the *batrachians*, and none among the *reptiles* save the turtle Chelone which ranges from Cretaceous — Recent.

No persistent genera, as here defined, are found among the *birds* and *mammals*.

In the following table we have compared the number of persistent genera of each group cited in Zittel's textbook with the total number of genera cited there, adding the percentage of persistent genera:

	Number of persistent genera		Total number of genera cited		Percentage		Average	
	A Zittel-Eastman 1896	B Zittel-Eastman 1913	A	B	A	B	A	B
Foraminifera	29	48	77	86	38	56	38	56
Sponges	7	9	90	149	8	6	8	6
Corals	42	46	242	237	17	15	17	15
Echinoderma: Crinoidea	10	5	169	277	6	2		
Echinoderma: Cystoidea	1	.....	38	96	3	..		
Echinoderma: Blastoidea	2	1	23	23	10	4	6.5	4.5
Echinoderma: Ophiuroidea	.....	.....	17	25	....	..		
Echinoderma: Asteroidea	5	5	32	43	16	11		
Echinoderma: Echinoidea	8	19	194	191	4	10		
Bryozoa	49	68	225	306	21	22	15	15
Brachiopoda	29	33	298	384	10	9		
Mollusca: Pelecypoda	71	78	452	446	15	16		
Mollusca: Scaphopoda	3	5	14	18	21	27		
Mollusca: Gastropoda	108	126	376	420	29	30		
Mollusca: Pteropoda	5	5	17	17	29	29	14	15
Mollusca: Pulmonata	8	7	67	65	12	11		
Mollusca: Cephalopoda: Nautiloidea	12	12	170	170	7	7		
Mollusca: Cephalopoda: Ammonoidea	.....	.....	455	455	....	..		
Mollusca: Cephalopoda: Dibranchiata	.....	.....	....	....	....	..		
Crustacea: Trilobita	7	6	53	131	13	4.5		
Crustacea: Ostracoda	16	18	45	68	35	26.5		
Crustacea: Cirripedia	5	4	20	20	25	20	20	14
Crustacea: Malacostraca	9	7	147	134	6	4.5		
Arachnida[1]	3	3	42	66	7	4.5	....	...
Selachii	16	.....	168	....	....	9.5	....	...
Dipnoi	1	.....	....	....	....	....	....	...
Teleostei	1	.....	....	....	....	....	....	...
Reptilia	1	.....	....	....	....	....	....	...

[1] Including Merostomata.

It is obvious that some of these figures are misleading in some regards. They give a fair representation of the percentages in the entirely or nearly extinct classes, while in those which are now culminating or just beyond their climacteric period, the percentage is too high, the great number of recent genera not being taken into account.

Immortal Types

Of greatest interest are the types which range from the Paleozoic to the present time. These, one might well term *immortal types.* They are principally found among the Foraminifera (11 genera and 13 from the Triassic-Recent); Pelecypoda (9 genera); Gastropoda (13 genera and 12 genera from Triassic-Recent); and Ostracoda (7 genera). It is, however, to be considered that at least some of these extreme ranges may result from as yet incomplete knowledge of the forms, especially among the Pelecypoda and Gastropoda. Thus, of the two immortal bryozoans, Berenicea and Stomatopora, the latter has lately been shown by Bassler to differ from the Paleozoic forms hitherto referred to them, and in the case of the gastropods, Perner restricts Pleurotomaria to the Mesozoic genera, separates Platyceras from Capulus of Tertiary and recent age, but points to the great resemblance of the Paleozoic forms to this latter genus.[1]

Considering, however, the close study that has already been given to the lower invertebrates both here and abroad, it does not seem to us probable that these figures will be greatly reduced. On the contrary, a comparison of the figures given in the preceding table and taken from the editions of Zittel-Eastman of 1896 and 1913 even brings out a considerable increase in the more important groups, namely, in the Foraminifera from 29 to 48, the Corals from 42 to 46, the Bryozoa from 49 to 68, the Pelecypoda from 71 to 78, the Gastropoda from 108 to 126, all in the short period of seven years, as the result of the discovery of longer ranges of forms.

But even if it be conceded for the sake of argument that the majority of these persistent genera may, on further study, be found to be still divisible into successive groups and that the absolute persistence is hence merely a deception due either to lack of knowledge or to extremely slow but still perceptible variation and development, then the fact of their extremely slight change and relative stability as contrasted with the rapid development of the

[1] He cites as gastropod genera remarkable for their longevity: Carinaropsis, Clisospira, Euryzone, Hercynella, Palaeacmaea, Loxonema, Platyostoma, Turbonitella and Eotomaria. The four genera Bembexia, Calloconus, Mourlonia and Trochonema are peculiar for their manner of reappearing after long periods of absence (*Geol. Mag.,* Aug. 1911, p. 374.)

great mass of the organic types, would still remain true and invite investigation of its underlying causes.

General Inferences from Tables

From a general survey of the percentages of persistent types of the classes and of their subdivisions, we may draw the following inferences:

1 *The lower classes tend in general to have more persistent types than the higher.* This is exemplified by the higher percentages of the Foraminifera, Corals, Molluscoidea and Mollusca in contrast with those of the Arthropoda and Vertebrata. And the extreme cases of longevity, the immortal types, occur only among the lower classes. Most of them are found among the Foraminifera; then follow the Molluscoidea and Mollusca, and a few are also met among the Crustaceans, but none among the other arthropods and the vertebrates.

2 *Within each order and class, again the lower subclasses tend to furnish the greater percentage of persistent forms.* This is best exemplified by the Pelecypoda (16 per cent) and Gastropoda (30 per cent) in contrast with the Cephalopoda (2 per cent), and within the latter by the fact that the Nautiloidea contain all the persistent types and the Ammonoidea and Dibranchiata none. Also within the Crustacea, the Ostracoda (26.5 per cent) and Cirripedia (20 per cent) contrast with the Malacostraca (4.5 per cent). Among the vertebrates the primitive Selachians contain nearly all the persistent types.

This would seem to verify the assertion of some authors (*cf.*, for example, Neumayr, *Stämme des Thierreichs,* p. 106) that groups that have been overtaken by their more advanced relatives and descendants, become stagnant and either die out or continue to exist in unvariable forms. These are the genera that trail in their existence after the group when it has passed its climacteric period. This feature is well illustrated by many diagrams seen in works on fossils showing the range of divisions and having in general the following form[1]:

[1] As seen, for instance, in the diagrams given by Beecher for the ranges of the orders of the trilobites in Zittel-Eastman, p. 638. Also Walcott, *Cambrian Brachiopoda,* U. S. Geol. Surv. Monogr. 1913, p. 316.

All the lower classes that in their turn have been overtaken by more rapidly developing dominant classes are more or less in this persistent, stagnant condition. Thus, the cephalopods, the ganoid fishes, the amphibians and reptiles have successively dominated, been overtaken and become stagnant in most of their subdivisions. Among the plants the Lycopodiaceae and Equisetaceae have the characters of typically persistent and stagnant groups.

Types of this class were variable at first and became persistent later in the phylogerontic stage of the class.

3 A closer study of the phylogenetic relations of the persistent genera shows, however, that frequently they form a *central primitive stock* from which numerous shorter lived genera branch off, while they themselves continue vigorously to the end. Such a genus is, for instance, Eurypterus among the curyterids. It persists from the Ordovician to the Permian and is the most common and most vigorous genus of the order, which dominates in numbers of species and individuals its relatives and descendants. Many other such persistent, vigorous genera could be named, such as Cidaris, Camarotoechia, Leptaena, Spirifer, Leda, Nucula, Modiolus, Lima, Ostrea, Mytilus, Pholadomya, Murchisonia, Strombus, Cypraea, Tellina, Platyostoma, Loxonema, Fusus, Murex, Oliva, Pyrula, Geisonoceras, Poterioceras, Spyroceras, Kionoceras, Calymmene, Primitia, Cypridina, Carcharodon, Lamna. All these persist through many periods and are everywhere among the vigorous dominant forms. It should be noted that these genera not only show their virility in their persistency, but also in their cosmopolitan distribution. In contrast to these primitive long-lived central stocks stand the aberrant groups which, as a rule, die out in short time.

4 In general it seems true that all specialization which restricts and adapts the types to certain narrow conditions of life, while producing a short period of luxuriance, leads to extinction when these conditions change.

In contrast with these restricted and changeable conditions stand (1) the *stable conditions of the open ocean and deep sea*, as shown by the remarkable immortality of the genera of the Foraminifera, and (2) the *subterranean conditions*. Types that bury themselves out of sight, both on land and in the sea, seem to tend to become persistent. This is shown by such genera as Lingula, the persistence of the boring pelecypods (Lithophagus, Carboniferous-Recent; Pholas; Teredo, Jurassic-Recent), scaphopods, the mud-burrowing trilobites Conolichas, Hoplolichas, and also by the many relicts of extinct groups among the recent burrowing animals, as Amphioxus, the Caeciliae, Limulus, etc. Even among the extremely variable insects we find in the cockroaches, which are given to a secretive life under stones and logs, a group of remarkable persistence of characters which have changed relatively little since Paleozoic time.

5 A perusal of the percentage table shows further that *the sessile forms contain more persistent types than the vagile benthos.* Thus the Corals have 15 per cent, the Byrozoa 22 per cent, the Cirripedia 20 per cent. Likewise many of the immortal and very long-range persistent types in the other classes are more or less sessile forms, as Crania, Schizocrania, Pholidops, Spirorbis, Ortonia, Serpula, Terebella, Ostrea, Chlamys, Camptonectes, Entolium, Pseudamusium, Platyceras, Capulus, Acmaea, Patella.

On the other hand, the sessile sponges and Crinoidea show but relatively small percentages of persistent forms.

In the case of the sponges we are sure that the Paleozoic forms are only very imperfectly known owing to the sporadic occurrence of the sponge fields. Thus the Dictyosponges, which in the New York Upper Devonian have furnished a great variety of forms, are only rarely met with elsewhere (Carboniferous of Mississippi valley, Devonian of France and Poland) and their range is therefore probably greater than known at present. The Hexactinellid sponges which culminated in the Jurassic and Cretaceous time, have withdrawn into the greater depths of the oceanic basins and through this different habitat undoubtedly been forced to change. The Crinoidea display a great multitude of rapidly developing, short-range forms in their climacteric period in the Carboniferous; their persistent types do not appear until later.

It is further noteworthy in this connection that the Rudistae, typically sessile pelecypods, and the Richthofenidae, most remarkably modified, sessile brachiopods, were extremly short-lived. In both cases we have groups that were widely divergent from the primitive central stock of their classes, and it can be claimed as a general proposition that groups that diverge widely from the median expression of a class do not become persistent.

A distinct example of the different influence of the sessile and vagile modes of life on the longevity of forms is furnished by the graptolites. The writer has in other places shown the contrast between the Dendroidea which remained sessile to the sea bottom and the Graptoloidea which became first pseudoplaktonic, being sessile to seaweeds and later free-drifting or floating. Among the Dendroidea, Dictyonema persists from the top of the Cambrian to the Carboniferous, while among the Graptoloidea we meet kaleidoscopic changes throughout the Ordovician and Silurian, the cause of this rapid development having been the departure from the sea bottom and the suspended position of the colonies.

In general it can be asserted that the sessile mode, if taken up by a whole class, tends to persistence of the types. This inference would, at first glance, seem to disagree with the previous conclusion that stability of physical conditions is essential to the persistence of types, for sessile forms are largely found in the littoral zone because there the physical conditions most require sessility. But since these same conditions are there also most apt to change, it follows that by becoming sessile, types would seem to expose themselves to early extinction. If the conditions of existence change, the organisms can react only in three ways. They either die out or emigrate or adapt themselves. The last reaction leads to new forms. There is hence left only emigration, and this would seem to be the very road to salvation which the sessile forms have closed to them. But it is to be considered here that the principal change of the littoral zone consists in its wandering up and down the continental shelf through the relative movements of the oceans and continents which take place so slowly that the sessile forms, which, moreover, are as a rule provided with very mobile young growth stages, are well able to follow them, as instanced by the persistency of the littoral corals.

Another factor of the persistence of the sessile forms lies, in our view, in the hard and massive protective covering which most of these types had to develop and which tends to counteract the variability otherwise induced by changing conditions.

6 A further inference that appears distinctly in the percentage table is that *the persistent types*, as defined here, *prevail in much greater number among the marine forms than among the land and fresh-water animals.* This is shown by the 11 per cent of persistent Pulmonata as against the 30 per cent of the other Gastropoda and by the scarcity of persistent types among the old classes of Arachnida, Myriapoda and Insecta, the only persistent arachnids, for instance, being found among the marine Merostomata. This could be *a priori* inferred from the fact that the climatic and physical conditions in general have changed much more frequently

and thoroughly on land through glacial periods, mountain folding, etc. than they did in the oceans.

Nevertheless we find some remarkable cases of persistence on the continents, as that of Ceratodus, ranging from Triassic to recent time, and of Diplomystus, a teleost which arising in Cretaceous time still exists in the rivers of New South Wales and of Chili; of the phyllopod Apus, persisting since Triassic time; of the pulmonate genera Auricula, Carychium, Lymnaea, Planorbis, Physa, persisting since Jurassic time.

Among the continental forms again *the limnal and fluviatile forms appear to be more persistent than the terrestrial forms.* This is indicated by the greater number of persistent limnal snails (as Lymnaea, Planorbis, Physa); such very ancient Phyllopods as Estheria and Apus, and the fact that all the relicts (see below) among the ganoids and amphibians (Phanerobranchia and Cryptobranchia) are fresh-water forms. It is possible that this greater persistency is only apparent and principally due to the greater probability of the water organisms to become entombed in the rocks and thus preserved; but it is also to be noted that the limnal and fluviatile faunas are to a much greater percentage composed of the lower classes of animals which are more apt to become persistent than the higher terrestrial faunas; and finally, isolated river systems, like that of the Nile, and land-locked lakes, like those of Mexico, produce conditions clearly more isolated and favorable for the continuation of ancient types than any terrestrial regions, other than islands, can afford.[1]

[1] Related to the persistent terrestrial and limnal types are the *relicts* that survive as the last of their races in slightly changed forms. They have been termed persistent types by several writers. Thus Henn (*Amer. Naturalist*, vol. 46, 1912, p. 543) has discussed as persistent forms, what we prefer here to call, with the Germans, relicts (or "Relicten"), and found that they owe their presence to their (1) insular, or (2) subterranean habitats, and (3) their insignificant size. All these features tend to shield them from the battlefields of the struggle for existence. The famous surviving Rhynchocephalous reptile Sphenodon or Hatteria of some islands off New Zealand is a striking example of such a relict. Having no fossil record of it, we can not consider it as a persistent form. Other such curious relicts of antiquity are the Australian organisms, some of which, as Ceratodus, date back almost unchanged to great antiquity; the primitive Insectivora, as the shrew, which are protected by their small size, and the few surviving Ganoidea, as Polypterus, etc.

All these relicts owe their survival principally to their isolation. Suess in the final volume of his *Antlitz der Erde* has pointed out that there are regions where the terrestrial population has not been exposed for a long time to any physical changes, transgressions and orogenic forces. He calls these *asylums* and distinguishes four, namely, Laurentia, Angaraland, Gondwanaland and Antarctica. These have not taken part in upfoldings since the Carboniferous. He shows the biological peculiarities of the asylums, of which it may be mentioned that all the oldest fish types live in them, as Ceratodus in Australia

(Antarctica), Polypterus and Protopterus (Gondwanaland), Lepidosiren in Brazil (West Gondwanaland), and finally Amia and Lepidosteus in North America (Laurentia).

Abel in his excellent "Grundzüge der Palaeobiologie der Wirbeltiere" (Stuttgart, 1912), has pointed out other regions as existing *Refuges* or *Sanctuaries,* namely, the Indo-Malay Archipelago where the Miocene vertebrate fauna persists till today; central Africa where the Pliocene Eurasian vertebrate fauna still persists, and the central Asiatic steppes where the European glacial vertebrate fauna still survives. He asserts that these survivals are not especially strong and resistent species, but weak and effeminate types which have disappeared everywhere where conditions of life changed, the more resistent forms having there adapted themselves and changed to new types. Inasmuch as the conditions in these *"refugien"* have not changed from those of the respective former ages, it can be claimed that the animals were not forced to change there, the lack of changing conditions not reacting upon their possible variability.

It is certainly true that insular forms, though more persistent than the continental forms show a fatal weakness as soon as they come in contact with the continental types. This is shown by the rapid extinction of many insular floras and faunas, as that of St Helena, New Zealand, etc., as soon as these asylums are invaded by the more vigorous continental types brought there by human agencies. Even faunas of isolated continents may acquire this fatal weakness, as was shown by the rapid extinction of the various South American ungulates in the middle Pliocene when South America became again connected with North America. In this case the invading host brought with it large rapacious animals which had not been present in South America.

There are no asylums for marine forms in the open oceans. It had been claimed that the Pacific ocean, in distinction from the Atlantic ocean, contained the old types or relicts, but Philippi has shown that all oceans contain a fairly equal number of relicts. It had further been claimed or expected formerly that the abyssal depths of the ocean would contain Paleozoic types. The actual fauna obtained by later dredging proved to be derived from Mesozoic forms, which fact had led to the conclusion that the deep oceans are not older than Mesozoic time. Thus Abel (p. 452) has pointed to the fact that all abyssal fishes belong to very young families. He sees the reason for the young age of the abyssal fauna in the entire extinction of the older abyssal fauna through the cold waters which during and since the glacial period have reached the abyssal depths.

On the other hand although the abyssal depths do not at present contain any forms that can be considered as persistent types of great antiquity, it is certain that the abyssal life is in such stagnant condition that no progress will take place and the entire fauna will become a persistent one. Austin H. Clark in his suggestive paper, "On the Deep Sea and Comparable Faunas," (Internationale Revue der gesammten Hydrobiologie und Hydrographie, vol. 1. Leipzig, 1913. p. 17–30, 132–46), from his study of the deep sea crinoids, arrives at the following conclusion (op. cit., p. 23) :

The *ocean abysses are regions of uniform and absolutely unchanging conditions;* the temperature is very low, approaching the minimum at which the body liquids can be maintained in liquid form; the pressure is enormous; food, all of an animal nature on account of the absence of light, is scarce, and is, as ingested, adulterated with an enormous amount of waste matter, either extraneous inorganic or internal excess of liquid. Altogether *conditions are very unfavorable for animal life,* and of course plant life in any form is quite impossible. What animal life there is, existing under *absolutely constant conditions,* has no *incentive other than internal* (here as will be seen reduced to a minimum) to *cause it to produce variants* or to give rise to new forms, and there is not the slightest evidence that any markedly differentiated new animal type ever originated in the deep sea.

But, while the abyssal forms are now in a persistent condition, they are derived from the most vigorous stocks of former faunas, according to the studies of the same author, who states (op. cit., p. 134) :

"Thus the deep-water fauna is composed of the relics of all the previous shallow-water faunas, and is in effect an incongruous and heterogeneous collection of what were once dominant, adaptable, widely spread and exception-

7 The claim which was made by Henn regarding the relicts, that they are *small and inconspicuous forms,* is also applicable to the persistent types of geologic history. The immortal forms are throughout of the most lowly organisms, as the Foraminifera; the brachiopods of the Lingula and Crania types; gastropods of the Capulus and Patella types; small pelecypods as Leda, Lucina, Nucula and Modiola.[1]

---

ally vigorous types which, at the summit of their vigor, extended downward to depths which were physically the same as the great abysses of today; and thus the deep-water types of one area reappear as shallow-water types of another into which competing forms have never intruded, and types found from the littoral to great depths in one part of the world are confined to great depths in another."

There is no isolation in the air as there is on islands, in the rivers or in subterranean life. Hence we find hardly any persistent types and relicts among the insects and birds.

A group of ancient types has found isolation in a *nocturnal habit.* Austin H. Clark (op. cit., p. 19), in discussing the "types of faunal restriction," has pointed out this fact as follows:

"The *strictly nocturnal habit, now known to be a characteristic* of a number of fishes and other organisms once supposed to be confined exclusively to the deep sea, and long appreciated in regard to a number of diverse terrestrial groups, is *an attribute of ancient types,* or of *types which have not been able to maintain themselves under normal conditions,* and is therefore *comparable to a habitat in the deep sea or in any other biologically unfavorable situation.*"

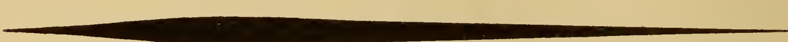
As typical relicts among the mammals of nocturnal habits we may cite the Proximii or lemuroids of Madagascar and India, among them the lori (Stenops) and Kobold maki (Tarsius spectrum) which has large spectacle-like eyes, and our opossum.

[1] The number of examples among the vertebrate relicts is immense; among the most striking are the insectivores, notably the shrews; the monotremes, marsupials, Xenarthrae (armadillos, ant-eater, sloths) with their gigantic ancestors in South America; the Kiwi (Apteryx) of New Zealand, as the last survivor of the gigantic Mioas; the small reptiles as the survivals of the Mesozoic giants. Animals of immense proportions are in all classes a post-climacteric phenomenon; gigantism indicates already the decline and approaching extinction of the race. Such animals lack a compensatory element in the environment, which fact leads to their destruction. The gigantic reptiles, the Dinosaurs, the gigantic crocodiles, snakes, all became extinct, but the small representatives of these orders survive. The mammals are now furnishing the giants in the whales and pachyderms, but it is doubtful whether mammals larger than man will survive. It is obvious to every one that the small forms, as the mice and shrews, hold their own better under all conditions than the larger types, just as the small mammals did in the Mesozoic age against the gigantic reptiles.

Likewise the lizards (Lacertilia) which are throughout small as compared with the extinct reptiles, are one of the latest and most flourishing side branches of the reptiles and not until now reach their climax. Among the amphibians the partly gigantic Stegocephali have become extinct in Paleozoic and early Mesozoic time, while the pigmaean salamanders and frogs and burrowing small Caecilia are very well able to hold their own against the higher reptiles, birds and mammals.

Special notice in this connection is deserved by the remarkable Phanerobranchia with exterior gills (represented by the Axolotl, Siren, Proteus, Menobranchus) and the Cryptobranchia with "gill-apertures" (Amphiuma, Menopoma, Cryptobranchus). These remarkable relicts are *persistent ontogenetic stages* of the salamanders, as is especially shown by the Axolotl (Siredon) which under certain circumstances may change into a salamandroid form. It is also interesting to note the asylums these strange relicts have

8 *Many persistent types* whose geologic history is well traceable in the rocks *show a slow development,* a distinct climacteric period and a long postclimacteric period. Good examples of such genera are the bryozoan *Berenicea* which is "rare in Ordovician, very abundant in Jurassic and Cretaceous, less frequent in Tertiary and Recent"; the coral *Halysites* which begins in the Ordovician, culminates in the Silurian and extends into the Lower Devonian; the echinoid *Cidaris* which appears in the Permian, is very abundant and variable in its climacteric period in the Jurassic and Cretaceous and persists until today; the worm *Serpula,* which appears in the Silurian, culminates in the Mesozoic and still persists; also the Paleozoic representatives of Lingula, which begin in the Ordovician, culminate in the Silurian and Devonian, and decline in the Carboniferous and Permian; the ostracod *Bairdia* which develops in the Ordovician, reaches its maximum development in the Carboniferous and then continues in diminished numbers until the present day. The diagram of such slowly developing long-range genera would appear like this:



We believe that the life history of most long-lived genera when fully known will be found to have possessed this mode of development, in contrast to all rapidly developing genera which as a rule disappear as quickly, either by changing through their variability into new genera or by extinction. This contrast is well shown in the Cephalopoda by the difference between the slowly developing Nautiloidea with their fair number of persistent genera in a relatively small number of genera (12 in 170) and the Ammonoidea, which are so variable that they count 452 genera and change so rapidly that they have no persistent forms.

Connected with the preceding factor of persistence in genera is the following fact: that the *persistent genera which slowly develop never produce many species during a single geological period.* Genera that produce a great number of species, as a rule become soon extinct by progressive development to new generic groups and a crowding out of the older primitive stock by the descendants.

9 There are a number of *minor factors* that pertain to great longevity in the organic world and that are clearly present in some of the persistent genera. (*a*) One of these is an extreme *individual*

---

found, as, for example, Proteus the subterranean caves of Carinthia in Austria, Siredon the land-locked lakes about Mexico City, Cryptobranchus the volcanic lakes of Japan, and the others the asylums cited by Suess.

vitality. To cite one example: Schuchert comments on the wonderful vitality of Lingula and Crania. He states Bul. Geol. Soc., vol. 22, 1911, p. 263):

It is also desirable to point out here the wonderful vitality of the living inarticulate brachiopods. Lingula is exposed on the tidal flats of Japan for hours without injury, and on account of its accessibility is regularly gathered by the poorer people for food. At high tide these animals are covered with 3 to 4 feet of water. Their habitat may be brackish or foul with decomposing organic matter, even to such an extent that all other shell fish may be killed off, but Lingula will continue to live under such adverse conditions. Yatsu, who has studied living Lingula, tells us that on little estuaries in certain bays of southern Japan their habitats may be covered by sand and mud brought down by stream freshets, so that all of the burrowing shell fish will be destroyed, but Lingula will still live in such stinking places and the individuals tunnel themselves to the surface. The burrows are from 2 to 12 inches long, and the movements of the animals up and down in the holes are made by means of the highly contractile and regenerative peduncle. It is thought that Lingula may attain an average of 5 years or even more. Yatsu kept them alive in aquaria with the water fetid, and Morse did the same, keeping his specimens alive for six months in almost unchanged water. Joubin kept Crania, taken from great depths, alive in jars under very adverse conditions for 14 months. In these statements we see the very adverse conditions under which the burrowing Lingula may live, and that the tenacity of endurance is also very great with cemented Crania. In this adaptability lies the probable explanation of why the lingulids and craniids have lived since the Ordovicic. Lingula and Crania have endured all of this vast time apparently without change other than the superficial ones of form, size and ornamentation.

b Many of the still existing persistent forms are known to produce *immense broods,* as *e. g.* Ostrea and Limulus. Of the latter it is told that the quantity of eggs deposited on the sandy shore of New Jersey is so great that scows loaded with supposed shore-sand were found to be filled with Limulus eggs and had to be reemptied when the sand became alive! Also some of our noted relicts are remarkable for the great quantity of the eggs they produce, as, for example, the sturgeon.

c Further, it is sure that many of the persistent forms are *eaters of carrion and refuse* and thus being easily fed are able to subsist where other more fastidious types had to leave. The Capulidae, which already in Carboniferous time began to live on the excrements of crinoids, and the oyster, exemplify this group.

Persistence in Species

Before attempting a synthesis of the factors obtained by an analysis of the persistence of the genera, we will, in order to obtain a wider view of our problem, briefly survey the persistence of the smaller units, the species, and also that of the higher units, the families and orders.

The longest ranges are again found among the Foraminifera. We cite here, to illustrate this striking persistence, the following cases mentioned by Bagg:[1]

Anomalina ammonoides (Reuss)	Cretaceous — Recent
A. grosserugosa (Gümbel)	
Bolivina textilarioides Reuss	Cretaceous — Recent
Bulimina pyrula d'Orbigny	Triassic — Recent
Cristellaria crepidula (Fichtel & Moll)	Triassic — Recent
C. rotulata (Lamarck)	Triassic — Recent
Discorbina turbo (d'Orbigny)	Cretaceous — Recent
Gaudryina pupoides d'Orbigny	Cretaceous — Recent
Globigerina bulloides d'Orbigny	*Devonian — Recent!*
Lagena acuticosta Reuss	Cretaceous — Recent
L. globosa (Montagu)	*Carboniferous — Recent!*
L. gracilis Williamson	Cretaceous — Recent
L. marginata (Walker and Boys)	Cretaceous — Recent
L. sulcata (Walker and Jacob)	*Silurian — Recent!!*
Marginulina costata (Batsch)	Lower Jurassic (Lias) — Recent
M. glabra d'Orbigny	Lower Jurassic (Lias) — Recent
Miliolina oblonga (Montagu)	Cretaceous — Recent
M. tricarinata (d'Orbigny)	Lower Cretaceous — Recent
Nodosaria communis (d'Orbigny)	Permian — Recent
N. consobrina (d'Orbigny)	Cretaceous — Recent
N. farcimen (Soldani)	*Permian — Recent*
N. pauperata (d'Orbigny)	Lower Jurassic (Lias) — Recent
N. soluta (Reuss)	Cretaceous — Recent
Nonionina scapha (Fichtel and Moll)	Cretaceous — Recent
Orbulina universa d'Orbigny	Lower Jurassic (Lias) — Recent
Polymorphina compressa d'Orbigny	Lower Jurassic (Lias) — Recent
P. problema d'Orbigny	Lower Jurassic (Lias) — Recent
Pulvinulina elegans (d'Orbigny)	Jurassic — Recent
P. repanda (Fichtel and Moll)	Cretaceous — Recent
Textularia agglutinans d'Orbigny	Cretaceous — Recent
Truncatulina lobatula (Walker and Jacob)	*Carboniferous — Recent*
T. ungeriana (d'Orbigny)	Cretaceous — Recent
Vaginulina legumen (Linnaeus)	Triassic — Recent

Among the brachiopods such types as *Atrypa reticularis,* which ranges through the Silurian and Devonian throughout the world, and *Leptaena rhomboidalis,* which ranges from the Ordovician (Trenton) into the Lower Carboniferous (Waverly) in America and Europe, come here readily to mind. Also the coral *Halysites*

[1] Rufus Mather Bagg jr, *Pliocene and Pleistocene Foraminifera from Southern California.* U. S. Geol. Surv. Bul. 513. 1912. p. 15ff.

catenulatus which appears in the Ordovician, flourishes in the Silurian and still persists into the lower Devonian, may be cited here. Some of these, as Halysites, belong under the heading of persistent sessile forms; the others, as *Atrypa reticularis* and *Leptaena rhomboidalis,* are clearly forms of extreme robustness and fertility but slight variability.

That the persistence of these species is but more or less relative was interestingly brought out in a discussion at the New Haven meeting (1912) of the Paleontological Society, when Prof. H. S. Williams mentioned *Leptaena rhomboidalis* as a form that is persistent because it is a form of great plasticity and very variable in every locality and horizon where it occurs; therefore, he believes it has not been separated although its differences are as great as those of several genera, like Leptostrophia and Stropheodonta. Dr E. O. Ulrich asserted that it is not so variable in each place, there being but little variation of individuals, but that it is made up of a multitude of species of different horizons that can be distinguished. Dr A. F. Foerste has, indeed, distinguished some of these species. The fact that *Leptaena rhomboidalis* has so long been left undivided by paleontologists who are ever ready to distinguish species would still indicate that it represents a long-existing compact group of little changing forms of a relatively persistent type.

Persistence in Higher Groups

There are also a number of *families and orders* that are remarkable for their wonderful persistence without material change. Such are the limulids among the Merostomes, which begin in the Devonian; the scorpions, arising in the Silurian and culminating in the Carboniferous, but still in vigorous existence today with but little change; of the Carboniferous Eoscorpius it is stated (Z. E. p. 788) that it does not differ in any important respect from living forms; the Pedipalpidae, known in a considerable number of types from the Carboniferous and but little different today; the cockroaches which, with 300 species from the Paleozoic of North America alone, were then the prevailing type of insects and still flourish but little changed, the true Blattinidae beginning in the Mesozoic; various families of the bryozoans, especially of the Cyclostomata; the lingulids etc.

The causes of persistence here applied to the genera also hold true in a more generalized form, for the larger groups. In some cases, as in the scorpions, a superior set of offensive and defensive arms (the pincers and poison glands), early developed, have greatly helped to give the group stability; in others, the limulids, the burrowing habit combined with an excellent leathery defensive armor have allowed the little offensive and sluggish animals to persist through an astonishing length of time.

The whole class of turtles which, in contrast to the Dinocerata, still flourishes today, although already arising in the Triassic, is an example of a group that has successfully *specialized for protection* and thereby survived, while the Dinocerata, in spite or in part because of their gigantic dimensions, are extinct (Wieland).

Persistent Types Originally the Most Vigorous Stocks

We have seen that a great number of persistent types and relicts have found isolation in restriction to regions with a minimum of ecological competition, that is, by withdrawing to greater oceanic depths, to a burrowing habit, to underground water on land, to islands, to lakes and old rivers of ancient continents (as Ceratodus in Australia and some fishes of Africa), to very saline water, to a nocturnal habit, etc. All these persistent forms are to be considered as senescent types which are in a very delicately balanced condition and would quickly succumb if younger and more vigorous forms should intrude upon their ecological territory. While they thus now appear as weak forms, *they were, however, originally the most vigorous stocks* which were able to reach and adapt themselves to the more abnormal conditions at the periphery of the ecological field. It is not probable that a mature or senescent form can be forced into new territory; when subjected to competition by younger and more vigorous species it merely dies away. This relation of the old types to the younger types still in process of evolution has been clearly recognized by Austin H. Clark (op. cit. p. 136ff) from his studies of recent crinoids. He writes:

> It must be remembered that, although we are at present concerned only with deep-sea forms, internal specific pressure due to enormous increase in the numbers of individuals within a species operates not only to cause a species to colonize bathymetrically undesirable locations, or unnaturally cold and uncongenial regions such as the polar seas, but also to force species into small localized areas, or as it were pockets, possessing special and circumscribed unfavorable characteristics where they may be able to remain uninfluenced by the changes in the general fauna of which they once formed an integral part. Thus we find such genera as Artemia, and in fact all the phyllopod crustaceans, Carcinoscorpius, Tachypleus, Xiphosura (collectively known to palaeontologists as "Limulus"), Lingula, and many others occupying special areas into which no competing younger forms have ever forced themselves. . . .

Living under the normal conditions, which are fixed and vary only very slightly in all parts of the world, we find the vast majority of phylogenetically new forms with a few still vigorous less young types; under the conditions grouped in the second heading, which show an almost infinite variation, we find the vast majority of all the older forms still persisting, and a very few of the more recent types.

If we are ever to find recent representatives of such past types as the cystideans, blastoids, trilobites or eurypterids we shall find them living under abnormal conditions to which they became adapted when at the height of their vigor and from which no subsequently developed competing type has succeeded in ousting them. We must look for them in the deep sea, in fresh, very saline, acid or alkaline water, in regions of great cold, great heat or great climatic change, or in some such situation far removed from the optimum conditions under which marine life is maintained. It is probable, however, that none of these types were possessed of such vigor that they were able to colonize localities of such a nature that they could not be reached by competing forms of later development or with a subsequent period of maximum vigor.

Summary of Factors of Persistence

In summing up, our evidence appears to show that the lower classes and within each class again, the lower divisions tend to have more persistent types than the higher ones, or in other words, that the groups that have been overtaken by their more rapidly advancing relatives are apt to become stagnant and persistent; as a corollary, persistent types appear more frequently after the climacteric period of a group than before or during the same; in some cases, however, they clearly form the central vigorous stock from which the shorter lived types branch off. In such cases they are primitive types or forms that vary little from the general class-type in contrast with the aberrant and specialized types which as a rule are short lived, however well adapted they may be to special conditions. Sessile classes, further, show a greater number of persistent types than vagile forms; the persistent types prevail more among the marine forms than among the terrestrial or fluviatile types. Isolation, as by a subterranean habitat was further recognized as favoring longevity of types. On the continents the absence of transgressions of the sea and orogenic movements through long stretches of geologic periods have been favorable to persistence of types (asylums). As factors contributory to generic longevity were further mentioned small and inconspicuous size, individual vitality, production of large broods, restriction to most easily procurable food. In some cases the early development of superior offensive and defensive arms appears to have been of great effect in making the race conservative.

If we try to reduce this multiplicity of factors to a few controlling agents, we find that these are the fixation of overtaken and postclimacteric types, the presence of *stable physical conditions,* and *withdrawal in various ways from the fields where the struggle for existence is fiercest.* The stable physical conditions have been found by many in the open ocean, by some in the deeper littoral regions of the oceans, by others again in subterranean fields, by some in the rivers and lakes of continental regions that remained undisturbed from folding. Withdrawal from the struggle for existence with other organisms has been accomplished by a variety of means, as by isolation, burrowing life, small, inconspicuous size, superior, often deadly, offensive and strong defensive arms, through restriction to poor fare, great power of endurance, etc.

Analysis of Biologic Factors of Persistence

In any analysis of the biologic factors that have permitted persistence in the tremendous stream of organisms that has evolved since the Paleozoic age, we must distinguish between the two entirely different groups of persistent types mentioned repeatedly, (1) the postclimacteric types, and (2) the primitive central vigorous stocks.

Stable physical conditions and withdrawal from the arena of the struggle for existence, as far as possible, are the only means for the salvation of the postclimacteric persistent types; the primitive stocks, however, which persist are frequently dominant in the very seats of war. While the first group are among the "overtaken," and are mostly the gerontic groups which, though once the most vigorous of their race, are affected with a sort of congenital weakness or diminished vitality which renders them less fit for the struggle for life, the second group frequently contains what Beecher has termed "radicles" or the stocks from which the specialized groups continually branch off, while they live on vigorously though primitively. We will term the first *persistent terminals* the others *persistent radicles.* The first class has reached fixity; the latter retained variability.

A partial explanation of the possibility of the existence of two such radically different groups of persistent types we may find in the views of Simrott.[1] According to this author: "Organic evolution is dependent on the action of two opposing factors: that of

[1] W. Simrott. The Fixation of Character in Organisms. *The American Naturalist,* 47: 705–29. 1913.

progressive fixation which tends universally toward greater rigidity and conservatism in all characters during evolutionary advance; and that of natural selection, which tends to maintain or increase the variability of those characters important for survival by eliminating individuals where such characters have become so fixed that the organism fails to possess a necessary degree of adaptability."

According to this conception it is possible that the persistent types which, so far as they belong to the class of postclimacteric forms or fixed terminals and are not among the dominant forms, have become so fixed in all their characters as to make them persistent, partly by the factors of progressive fixation and partly by the fact that they have in various ways, as we have shown, avoided the opposing factors of natural selection which otherwise would have maintained their variability. Their conservation is then due in part to their gerontic condition and in part to the comparative constancy and peacefulness of their surroundings.

In the central, frequently dominant stocks, or the persistent radicles, the persistence, on the other hand, is the result of the fact that through their primitive nature they are still adapted to a greater variety of conditions and that while there may be and probably always is considerable variation, it is around a still unspecialized, primitive form and thus difficult of recognition, and further that the plastic and variable characters which, according to Simrott, are essentially those of size, shape, color and texture, are not always quite apparent or observable to the paleontologist, especially where the hard parts are not readily affected by the variations in the soft parts.

If this conception is true, only the persistent terminals will be *actually fixed* and are *true persistent types,* but it would also appear that the taxonomic characters, by which we recognize them as persistent, are of little or no functional influence.

Seen from another angle, that of the physiologist, the problem resolves itself into one of difference of selection of adaptability. Albert P. Mathews[1] writes as follows:

> In the evolution of animals two movements may be perceived: a spreading out and a progress; a diversification and a movement forward. The question which I wish to raise is whether these two movements which are at right angles to each other, may not be due to the natural selection of two different kinds of adaptation; first, adaptation of form and function to different kinds of environments; and second, the natural selection of the func-

[1] Adaptation from the Point of View of the Physiologist. *American Naturalist*, 47: 90ff. 1913

tion of instability, or, in other words, to the selection of adaptability, or the adaptation to changeableness of environment. Selection of the first kind of adaptation may have given rise to varieties, species, genera of the same type of animal, and have produced spreading or diversification, while selection of the second kind of adaptation may have produced the movement onward and upward of all animal forms.

The two kinds of adaptations do not always go together and selection of the one may outweigh the other. It is because selection to a specific environment sometimes is more important than selection of adaptations to changeableness, that not all organisms have progressed in the scale of evolution equally rapidly; but some have persisted in special environments with slight changes of structure for very long periods, or may even have retrogressed; while other forms in which the second adaptation has been vigorously selected, have moved rapidly onward and upward, and show little adaptation to any special environment.

The clearest conception of the biogenetic causes of persistence we obtain, it seems to me, through Osborn's law of the four inseparable factors.[1] This fundamental biological law is: "The life and evolution or organisms continuously center around the processes which we term heredity, ontogeny, environment and selection; these have been inseparable and interacting from the beginning; a change introduced or initiated through any one of these factors causes a change in all."

We must then infer that since no changes or but extremely slow and insignificant ones are apparent in the characters of the persistent forms, the fundamental condition of persistence is that each of the four factors, heredity, ontogeny, environment and selection, remains constant and no changes are originated through any of them. We have already seen that environment and selection are processes which comprise all competition, survival or elimination of individuals, and which appear under different forms as important factors of persistence. Heredity is, according to Osborn, by far the most conservative and stable of the four processes involved in life and evolution, because it is embodied in a form of matter (germ-plasm) least subject to changing external influences, but it is also a fact, according to the same authority, put forth through paleontological observation, that many origins of new characters are through some internal action in heredity (both

---

[1] H. F. Osborn. Evolution as It Appears to the Paleontologist. *Science*, n.s., 26: 744. 1907.

Also H. F. Osborn. The Four Inseparable Factors of Evolution; theory of their distinct and combined action in the transformation of the Titanotheres, an extinct family of hoofed animals in the order Perissodactyla. *Science*, n.s., 27: 148. 1907.

the continuous mutations of Waagen and the discontinuous mutations or saltations of de Vries). It then appears that in these persistent types the process of heredity has become entirely fixed and rigid. While heredity is the most stable of the four processes, ontogeny is the most unstable. That no changes originate from this factor, requires entire stability in the habit and the use of the organs.

Of the four factors, heredity, ontogeny and environment evidently work toward fixity after the climacteric period, since the evolutionary advance in each phylum tends to result in the decrease of variability, which becomes a hereditary character, and since the early ontogenetic stages repeat these characters which were most conservative and firmly fixed in their ancestry, this condition progresses into later and later ontogenetic stages and leads thus to a loss of the potentiality of introduction of new characters during ontogeny. The environment in all postclimacteric persistent types is notably stable.

But while in persistent types heredity, environment and ontogeny are rigidly stable factors — heredity especially to be considered as fixed in the postclimacteric forms — selection can not be fixed but is still ready to act whenever the other factors introduce slight variation. It then follows that the possibility of slow development continues and that all persistent types may still develop, perhaps infinitely slowly. There are, then, theoretically *no absolutely persistent types,* and the differences but those of rate of development.

The difference between the two groups of persistent types, the relatively rigid terminals and the more variable radicles, consists according to this view in the fact that in the former all factors have become fixed and unresponsive to stimuli, only the selection still slowly acting, while the latter are so well adapted to a variety of conditions that no changes readily originate through any of the processes of environment, ontogeny and selection, which affect the whole stock, while at the same time no changes in the germ-plasm are induced through hereditary tendencies.

General Conclusions

The evidence here gleaned from the persistent types and equally supported by both groups of persistent types, the persistent radicles and persistent terminals, leads necessarily to the general conclusion that there is no inherent propelling force of variation or of development, and that all evolution in the last analysis is largely dependent on the exterior agencies supplied by the ever changing physical conditions, which stimulate the four inseparable factors of evolution. As seen from the side of the persistent forms, variability and development in the organic world stop when the physical conditions become stationary.

This conclusion from the persistence of types is corroborated by evidence from the opposite phenomenon, that there are periods of rapid development under the stress of severe and rapidly changing physical conditions, such as, for instance, obtained in the periods of maximum emergencies of the continents that separated the geologic eras.

While we stand in awe before the orderly and apparently wilful steady development of the organic world to its highest expression, man, the persistent types remind us what might have happened if the surface of the earth had remained unchanged and unchangeable, if the advancing and receding seas, rising and sinking continents and mountain ranges, drying up seas, rivers and lakes, changing climates and other physical factors had not continuously subjected the organic world to new conditions and new stresses, ever propelling them forward, letting the oceanic organisms into the epicontinental seas and forcing them back again into the oceans, or driving them into the rivers and thence upon the dry land, in successive waves of worms, insects, arachnids and vertebrates; and from the dry land even into the air. There is no doubt that without these driving forces a stagnant, lowly organized world of relatively persistent types would have resulted.

GEOLOGY AND PUBLIC SERVICE[1]

BY GEORGE OTIS SMITH

Director of the United States Geological Survey

The subject on which I have been asked to speak presupposes a science that is practical — one that serves others than its devotees. It is only utilitarian geology that I shall discuss — that side of the science by some termed economic geology, by others applied geology, but for utilitarian I shall take the definition credited to Tolstoi — solely what can make man better. This human side of scientific work is simply part and parcel of its wider purposes, and to recognize its utility is to ennoble Science rather than to degrade it.

Five years ago, in the presidential address of the Geological Society of Washington, Mr Brooks gave some quantitative expressions of the marked tendency in geology toward practical problems. This growth in the utility of our science during the last quarter of a century was measured by the activities of state geological surveys and of universities, as well as of the federal survey. Further, as Mr Brooks pointed out, the trend that has made applied geology the dominating element in our science has not been limited to the North American continent; it has been worldwide.

The United States Geological Survey was created for public service in the widest sense. Congress intended it to be a large factor in placing " the work of national development and the elements of future prosperity upon the firm and enduring basis of truth and knowledge." To quote further the language used in the debate of thirty-eight years ago, " the institution and continuance of an effective geological survey " was then regarded as a measure such " as will prevent the waste of natural resources, clear the way of progress, and promote the triumphs of civilization." Such a declaration of purpose, though more eloquent, was in full accord with the report of the National Academy of Sciences and surely leaves the federal geologist free to devote his science to public service without fear of just criticism.

The present status of our science forecasts an even larger usefulness in the future. In oil geology alone the profession has won a place in the business world undreamed of ten or even five years ago. When we see single corporations having in the field more oil

[1] Delivered at the Albany meeting of the Geological Society of America, December 1916.

geologists than the United States Geological Survey, we realize that our federal service must rest its claim to consideration on something other than size.

In other lines, too, the science of geology is gaining the recognition that we perhaps feel has too long been withheld. Especially gratifying is the tendency of constructing engineers to consult geologists in matters related to large engineering projects. To the trained geologist, familiar with the many kinds of rocks and their varied habits of assembling together, it has seemed strange indeed that so many engineers have gone ahead on the theory that rock is rock and that nothing can be learned of the third dimension of the earth's crust in advance of actual excavation. Possibly, however, some of this blame may be laid at our own door, for geologists do not always seem firm believers in the practical side of their own science, and only in these later years have we learned to talk of the facts of geology with any approach to the quantitative exactness that engineers expect. Even now a wide difference in degree of scientific accuracy and refinement may be noticed in the manner in which we handle data in our own particular specialty and data relating to some other phase of geology or to another branch of science. This lack of respect for specialized science may sometimes be found in our own midst, even though we call ourselves specialists.

The opportunities for expansion are plainly before us, for the practical worth of geology is now widely acknowledged. How can we best increase the contributions of geology to mankind? Has the science other possibilities? What is its relation to public service?

In the last three years it has been gratifying to see the preparedness issue broaden so as to include the contingencies of peace as well as of war, to hear of industrial as well as of military preparedness. But back of both, and indeed including both, there needs to be a more vital preparedness — the preparation for citizenship. In any day and generation this test can and should be applied to any religion, philosophy or science: Does it make good citizens? It is therefore with real concern that we ask ourselves this question: Does geology contribute to citizenship?

The president of this society, in a thought-inspiring address at the University of Chicago convocation this year, made reference to a little red-brick building here in Albany, which this city does well to preserve — the laboratory of James Hall. And I believe Doctor Clarke is right in regarding that small and plain structure as the source of broad conceptions of the philosophy of evolution, which, radiating outward, have influenced not only our science but also your State and our country.

The sciences of geology and astronomy are founded upon postulates which they in turn have done much to make real — the permanence and universality of natural laws as we of today know them. By training and almost by second nature the geologist may be a conservative in politics; at least, the believer in natural law should possess the patience to wait for results in this particular epoch of this geologic era. By training the eye to see far back into the earth's remote past, geology can add to our power to put correct values on the events and changes in the brief present in which we happen to live.

There is another way in which geology especially contributes to the training of an enlightened citizen. Someone has said that a man's breadth of mind is measured by the diameter of his horizon. Geology as a study and especially as a profession leads to wide travel, and travel surely maketh the broad man. This advantage may seem to us so much a matter of course that we underestimate its silent influence in fitting us for citizenship. The geologist has the opportunity to think in terms of country rather than of community, of continents rather than of country; and his broader outlook over the world surely gives perspective, just as his longer view back into the past gives poise.

In an address at the University of Illinois I referred to the inspiration and incentive which come from Professor Chamberlin's conclusion that there is good reason for measuring the future habitability of the earth in millions or tens of millions if not hundreds of millions of years. This belief in the high probability of racial longevity is, as you know, the result of an exhaustive analysis of the past as revealed by geology and of the future as forecast by astronomy. But now I wish to add my personal acknowledgment to our greatest American geologist for the inspiration gained from a talk with him several years ago, when I realized that it was this scientific expectation of the evolution of humanity continuing through these millions of years that was prompting him to public service not limited to his own city or country.

The geologist's appreciation of that delicate adjustment of earth to life by means of which "life has been furnished a suitable environment for the uninterrupted pursuit of its ascensive career" and the geologist's vision of the continued adaptation of the earth to the uses of man together constitute a real call to larger service.

No one has more reason than the geologist to believe that wise utilization of nature is essential, now that man the engineer has become so effective a geologic agent; nor can the geologist overlook the need of a social organization that will adequately serve the larger and higher demands of humanity, now that man himself controls in large part the adaptation of this earth to man in his further evolution. We believe that the Golden Age is in the future, but it will be of man's own making.

This tribute was paid a year ago to the work of the geologist and engineer by one in high official position who has a vision of things as they are and are to be — Secretary Lane: "This is a glorious battle in which you are fighting — the geologist who reads the hieroglyphs that nature has written, the miner who is the Columbus of the world underground, the engineer, the chemist, and the inventor who out of curiosity plus courage plus imagination fashion the swords of a triumphing civilization. Indeed, it is hardly too much to say that the extent of man's domain and his tenure of the earth rest with you."

Keeping in mind these thoughts of the larger things of time and space, I desire to mention what may be termed the professional obligations of geologists. As scientists, working in a practical world on problems that have come to have very practical bearings, we may need to take special care that our scientific ideals be not lowered. As an associate in a large group of geologists I have been proud to see the science of geology win this larger recognition in the market place, for I hope to see our science cooperate in the further raising of business ideals. There can, however, be no double standard for geologists — one for guidance in research work in pure science, the other for purposes of professional exigency. As geology enters into the larger sphere of usefulness, there naturally come to the geologist opportunities somewhat different from those of the laboratory or lecture room. The profession in its newer activities encounters stresses for which new factors of safety must be figured. As I look at the demands now made upon geologists, the temptation to lower our ideals comes not so much when our task is to find something as when we may be called upon to prove something.

The geologist sent to South America to determine the extent of an ore body or to Oklahoma to discover an oil pool must needs bring into play every resource of a trained mind in order to wrest the truth from secretive nature. This is a contest which calls for geologic science at its best and in which scientific ideals are in no danger. A demand of another kind, however, is made upon the geologist who is asked to certify to some doctrine in the conservation creed, it may be, or to testify in support of some contestant in a court of law. Professional demands of this type may cause our scientific ideals to tremble, if indeed they do not suffer a tumble. It is for this reason that a geologist's ideals are safer in the field than in the court room; Mother Nature is a better associate than the goddess who goes blindfold.

Yet the problem faces us and we must answer our own question: What are the professional obligations of the geologist? Possibly the official geologist is less exposed to temptations of this type: he is allowed to make his testimony follow the evidence. At least I remember that the Survey geologist published, uncensored, his estimates of coal reserves, even though his statement did not fit in with the popular argument for conservation; nor was the official opinion required by the statute as to the influence of forests on stream flow given until field examinations by geologists and engineers furnished a basis of fact; nor again do I believe that the federal geologists who testified as to the mineral character of petroleum were in any degree influenced in their opinion by the chance circumstance that this was the Government's contention. On another occasion the federal geologist whose duty it was to defend the official classification of land in a western state had definite instructions to reverse the Geological Survey's position in the matter if new evidence should indicate an error of judgment, even though such action would have enabled the railroad claimant to win the land. Nor should a Government geologist hesitate to file notice of a correction in some assays earlier introduced as evidence, even though he thereby strengthened the land claimant's contention. Here, of course, the issue was plain: the duty of the public servant was to see that truth prevailed, even though the Government might seem to lose its case. In two other of the instances I have mentioned some degree of temporary popular favor and freedom from current newspaper criticism could have been gained by a different course, but I believe that in the end the good name of science would have been besmirched.

Yet in courts of law we now see geologists testifying as experts on both sides of the case, and too often as experts on subjects on which they would not be regarded as specialists by their fellow geologists, or at least on specialized phases of geology which they themselves might hesitate to discuss before this society. But even when such opposing witnesses are both eminently well qualified, what is the spectacle presented to the public? One expert testifies that the thing under discussion is absolutely jet-black; the other that, as he sees it, it is purest white; whereas it may be that without the legal setting the same thing would present to most of us varying shades of gray, or perhaps some one using a higher power of lens might call its general color effect rather spotted. I regret to add that this suppositional illustration is almost paralleled by an important case in which two of my own friends, both honored fellows of this society, were the opposing expert witnesses; and afterward the judge told me that he could believe neither, although he would have taken the unsupported opinion of either one had this geologist been in the pay of the court! Does not such a statement by an eminent jurist put geologic experts on a par with other expert witnesses, and would it not be a "safety first" measure for geologists to decline professional work of this type until the day comes — and I think it is not far off — when the court will summon the expert witness and compensate him for his services to the state in telling the whole truth and not that special part of the truth which favors one litigant? This society wisely put itself on record last year as recognizing the urgent need of this reform in legal procedure, but to be effective resolutions need to be adopted by each individual geologist.

As first suggested to me, the subject on which I was invited to speak today was geology in the national service, but I feared if thus expressed my topic might seem to limit opportunities for service to the nation to those of us who are on the Federal Geological Survey. The president and more than a score of other fellows of this society are in the public service as officials of the several states; and too much credit can not be given to the long succession of state geologists who for nearly a century have both contributed to the science of geology and guided the development of their states. A few years ago Doctor White, in addressing the West Virginia Board of Trade as its president, referred to the function of the state geologist as that of "a kind of mentor or guardian of the state's natural economic resources."

Yet I would not limit the obligation for public service to those of us who happen to be public servants. The use of the United States Geological Survey as a training school for professional geologists in private practice can not be regarded as wholly a hindrance to the nation's business when viewed in a large way. The spirit of public service can be carried over into the work outside the official organization, and I like to believe that there is a persistence of this same purpose on the part of our Survey graduates that will lead them to do their share in planning for the utilization of the nation's mineral wealth, not merely so as to increase dividends for the corporations that employ them or to assist a few capitalists in speculative endeavors to corner some limited resource, but also so as to benefit society in a large way through future decades. Why can we not be trained scientists and professional geologists and loyal citizens at one and the same time?

President Vincent has referred to the sweeping indictment of professional schools, with all their modern efficiency, as turning out graduates "bent upon personal success and regarding the public as a mine to be worked rather than a community to be served." In whatever degree unwarranted, this criticism, as President Vincent points out, is in itself encouraging as a sign of general discontent with self-centered careers. And there is another approach to this subject of the civic obligations resting upon us as geologists. Those of us who have shared in the benefits of the American educational system, up to and including the university, must realize to what a large extent our education has been gratuitous. As Doctor Becker once expressed it to me: "Men who seek or use their university training solely for their personal advantage are almstakers. Only by public service can educated men repay the debt they incur and thus fulfil the designs of the founders."

It is a fortunate sign of the times that applied science is touching more and more upon the human and social side of its work. Measure of the breadth of view already attained in this public service idea is found in this month's issue of a leading technical journal, Metallurgical and Chemical Engineering, wherein the longest editorial bears the title "Expensive Slums." Social responsibility is acknowledged and civic duty set forth in the closing sentence of this editorial: "It is needful for industries that they be in good standing, and they can not maintain good standing so long as they have slum attachments."

So, too, it is eminently fitting that in a technical volume bearing the title "Iron Ores" the closing chapters should discuss the large social questions of public and private policy. The author, a geologist and fellow of this society, properly regards the social value of iron just as worthy of his thought as the purity of its ores. Indeed, it is simply the need of society that makes the mineral hematite an ore and thus the object of the geologist's special study.

In my administrative report for the past year I had occasion to refer to a professional paper by Doctor Gilbert now in press. In his wonderfully broad and complete investigation of the mining-débris problem in the Sierra Nevada the geologist began with the antagonism of mining and agriculture, but he soon found that his research also involved questions of relative values between commerce and irrigation and power development. So this report, thoroughly scientific in data and method, will illustrate how high a public service can be directly rendered by the geologist. Nor is this a new departure: some of us belong to the generation to whom Monograph 1 of the United States Geological Survey was a source of inspiration in our student days. That monumental work by the same author, a classic in its exposition of geologic processes, was the result of an investigation also planned as the answer to an economic question of large civic importance. Director King thus stated in 1880 the purpose of the Lake Bonneville monograph: "Is the desert growing still drier or is it gaining in moisture are questions upon the lips of every intelligent settler in that region."

Moreover, aside from making our science more human, there is the larger need of humanizing ourselves. Doctor Favill, of Chicago, in addressing a group of business men last winter, gave them this professional advice: "Have an outside interest"; and the outside interest he prescribed was political or social activity. This physician regarded it as conducive to individual happiness as well as helpful to society that "every honest, able-bodied, red-blooded, clear-thinking man should have his mind set on what is the right thing for him, for his community and his country to do."

The Austrian geologist Suess may furnish the best illustration of the happy combination of scientist and citizen. He was a leader not only in the science of the world but in the parliament of his country. A close student of geologic discovery even after reaching fourscore years, Professor Suess was equally keen to learn of political progress the world over, and in a letter to me within a year of his death he inquired particularly about the reforms in public-land administration in the United States.

Appreciation of civic duties has fortunately not been lacking in American geologists: one of the best volumes on citizenship was written years ago by Professor Shaler, and it is worthy of mention that in that book he emphasized not so much the opportunities for service in high station, for he states that the best work in the practice of citizenship is done in the town or precinct. "In these fields of activity the spirit of the freeman is made; if the local life be not of a high citizenly character, all the constitutions in the world will not give the people true freedom." And it has been said of Professor Shaler that he not only preached good citizenship, but, what was better, he never neglected his own political duty. While we must properly look upon enlightened citizenship as a 365-day-a-year undertaking, there is one day in each year, or two years, or four years when a special duty is laid upon each citizen of the state and nation, and in these times no one is better qualified to exercise the right of suffrage than the geologist. A few weeks ago, too, we learned that even in this great country of ours, where eighteen million ballots were cast at a single election, individual votes have not lost their power to influence the result. And how true it is that education of the scientific type is essential to a correct understanding of many of the issues of the day.

In a leading editorial, the day before election, a nonpartisan writer mentioned the discussion of prosperity as a campaign issue and remarked that "Analysis of the interminable political arguments about it would probably disclose that in the main they consist of about 95 per cent imagination and exaggeration, in equal proportions, 5 per cent of fact, and of unbiased opinion not a trace." A low-grade ore of that composition surely needs a citizen who is a scientist or engineer to make the necessary separation and concentration.

Take another political and economic issue that must be faced — the length of the working day. Professor Lee, of Columbia, recently emphasized the fact that the determination of the proper numbei of hours of work is primarily a problem of physiology, although too often economic and social considerations have been made paramount. Must we not agree with the physiologist, at least to the extent of admitting that it is all too evident that here is a present-day issue of large importance which deserves scientific rather than political treatment? Or we may say, Here is a civic question that demands the attention of citizens who have had scientific training. Who can better weigh the opposing elements of this question — on the one side the cumulative fatigue of the individual producer and on the other the economic requirements of society as the consumer?

To mention just one other of the larger issues of the moment, the railroad question is one so intimately tied up with the geographic relations of mineral resources that the geologist citizen is eminently well qualified to consider how dependent is industrial opportunity upon fair freight rates. When we realize that the railroad earnings from the transportation of the raw products of the mine alone exceed the earnings from passengers and also exceed the freight receipts on all products of both farm and forest, we have a measure of the interdependence of the mineral industry and the railroads. The proper regulation of common carriers thus becomes a prerequisite of the full utilization of our mineral resources, and on such a political issue no citizen should have a larger interest or more intelligent opinion than the geologist. It is therefore more than a happy coincidence that President Van Hise has rendered large service to society in his contributions to the railroad and labor problems; the broad training of the geologist is being utilized in the work of the publicist.

Have I not already shown that the geologist is well qualified by his special training to serve his day and generation, not only in the capacity of professional adviser but, better than that, in the rôle of fellow citizen? It may be rather late in this discourse for me to select a text, but there is an old saying in the book of Proverbs that has been much in my mind for several months — "Where there is no vision the people perish." Imagination is necessary in our science, and it is equally essential to the larger citizenship. I believe the geologist possesses the vision; his duty and privilege is to let that vision guide him to a larger public service.

PLASTIC DEFORMATION OF GRENVILLE LIMESTONE

BY D. H. NEWLAND

Some of the most interesting exposures of the Grenville limestone in the Adirondack region are found along the shores of Lake Champlain, on the New York side, where the series of ridges that confront the lake have been cut through to afford room for the tracks of the Delaware & Hudson Railroad. The rock faces still preserve their fresh appearance in contrast with the stained and weathered condition of the limestone in natural outcrop; and the vertical sections afford opportunity for observation of the rock in mass, with its complicated structures and deformation phenomena.

The accompanying series of photographs, contributed by Prof. G. H. Hudson, reveal the conditions found in the exposures just north of Porth Henry and within the limits of the Port Henry sheet of the United States Geological Survey map. This area has been described by Professor Kemp, whose report[1] contains a description of the limestones here depicted, as is later noted.

For students of Adirondack geology the vicinity of Port Henry holds much that is of interest; no other part of the mountains probably in so brief a compass has such variety of rock formations, illustrative of the principal types as well as of their general relationships and structural features. The Grenville strata include limestone, schists and gneisses in extensive development; while of the igneous rocks occur granite, syenite, gabbro and trap, and at no remote distance also anorthosite in typical exposures. The early Paleozoic beds which once covered the crystallines are preserved in small downfaulted patches at the lakeside, ranging in horizon from the Potsdam to the Trenton inclusive. At Mineville, 6 miles from Port Henry, are the largest of the Adirondack magnetite mines.

The Grenville limestone shown in the photographs forms only a small part of the exposed area and is divided into numerous bands interbedded with quartzose, rusty gneisses and schists. According to Professor Kemp's map, the Grenville strata altogether cover an irregular area that reaches some 2 or 3 miles to the north

---

[1] N. Y. State Mus. Bul. 138. 1910.

and south of Port Henry and as much to the west and is bordered by bathylithic masses of syenite and granite. Of this particular locality he makes the following mention:

Along the Delaware and Hudson Railroad tracks on the lake shore north of Port Henry where there is an irruptive contact of gabbro and basic syenite and limestone one can see the igneous rock tonguing out into the limestone and apparently pinched off at times by the dynamic disturbances. While it is entirely possible that the hornblendic rocks have been derived from aluminous bands in the original sediment, which might yield greater or less amounts of hornblende, yet we are dealing with a district in which are numerous intrusions of gabbro and basic syenite and where apophyses are abundant. The marked plasticity of the limestone under pressure tends greatly to disguise the relationship and to render a demonstration difficult. Igneous phenomena and their expiring effects must have been very general and have probably occasioned widespread recrystallization. Undoubtedly they have set in migration many heated solutions.

The limestone at times becomes extremely small in amount and may be represented by little more than calcareous streaks amid more siliceous rocks, such as mica schist and quartzite bands. The more resistant silicates having been involved in a plastic medium like calcite have been bent into shapes that seem almost beyond the power of brittle minerals to assume. The presence, however, of the limestone is indicated by the pitted and cavernous weathering.

Along the lakeside for the first mile or so north of Port Henry the Paleozoic beds alone are exposed, the strata representing a triangular block of which the western edge runs diagonally to the lakeshore and comes out to the lake in a little cove known as Craig harbor. Here they terminate suddenly in a single great fault which brings the Beekmantown beds on the south side in line with the Precambrian on the north side of the cove. The faulted beds dip toward the crystallines at a low angle. The two series are separated by the width of the cove, but the well-marked escarpment on the north side probably corresponds nearly to the plane of the fault; while the interval is represented by brecciated Beekmantown which by its rapid weathering has formed the embayment. A view of the fault-scarp on the north side of Craig harbor is shown in plate 1. This reveals the Grenville limestone in heavy beds resting upon a gneissic hornblende rock which at a little distance from the contact grades into recognizable gabbro. The contact, therefore, is igneous, but there is nothing to show the intrusive nature of the gabbro in the way of reaction effects upon the limestone or of offshoots of the gabbro into the latter. It is very likely that movement has occurred along the contact through underthrusting of the block of gabbro, causing the less resistant limestone to

Plate I

Fault scarp north side of Craig Harbor near Port Henry, exposing Grenville limestone at left overlying syenite gneiss at right. The down-thrown Paleozoic strata are concealed below the waters of the inlet.

Plate 2

Amphibolite band folded and disjointed in unbroken and massive limestone. Near Port Henry

Plate 3

A shattered band (dike?) of amphibolite, recemented by plastic flowage of the limestone from the walls. Port Henry

ride over the upper surface of the intrusive. The relations are interesting in that they give a clue probably to the extreme contortion and flowage effects exhibited by the succeeding photographs which are taken a little farther north in a second exposure of the limestone. The gabbro forms only a small boss and is succeeded by syenite gneiss in which occurs a band of limestone that forms the shore line for nearly a mile. It is in this area that the freshest faces of limestone are found.

The deformation that is revealed in the pictures is no doubt the result of squeezing between the more resistent igneous rocks which themselves have assumed more or less cataclastic and gneissic characters under the strain. The effects could only have been accomplished under conditions of cubic compression such as would be supplied by a thrust exerted upon the beds when they were heavily loaded or weighted down by many thousands of feet of cover.

The nature of the silicate bands in the limestone is something of a problem, as is remarked in the citation from Professor Kemp's bulletin. It is not unlikely that some of the bands are dikes derived from the gabbro and syenite magmas, as instanced by the dark amphibolite bands which in appearance and mineral character are scarcely distinguishable from the border phases of the basic intrusions. This type is illustrated by plate 2 in which is seen a small band of black amphibolite that has been folded and broken up under the pressure transmitted by the mobile limestone, itself giving no evidence of the deformation that has taken place. In plates 4 and 5 the bands are in part of a more siliceous character, and may well represent original impure layers in the beds.

Plastic deformation of the Grenville limestones is a common condition throughout the Adirondacks, if one may base an inference upon the circumstance that it is the purer beds alone that do not reveal its effects; in them the results would be masked even if present.

Plate 4

An exposure of siliceous limestone in which the silicate layers have been stretched, disrupted and folded under cubic compression. Cheever dock, near Port Henry

Plate 5

Limestone with bands of dark siliceous material which show disruption and folding. Near Port Henry

Plate 6

Recumbent isoclinal folds in the Grenville limestone. Near Port Henry

THE INTERESTING GEOLOGICAL FEATURES AT THE CHAMPLAIN ASSEMBLY, CLIFF HAVEN, N. Y.

BY GEORGE H. HUDSON

Visitors reaching the grounds of the Champlain Assembly by the Delaware and Hudson Railroad must notice that the last few miles of the journey are over an exceptionally level roadbed. The land at Cliff Haven is spread out like a plain which tips gently toward Lake Champlain with a drop of about 1 foot in 90. One marked exception to this general and rather widespread flatness of surface is the large rocky elevation on which the Hotel Champlain stands, elevated nearly 150 feet above the eastern edge of the assembly grounds.

If the visitor arrives by boat he will observe the very marked irregularity in the Lake Champlain shore line which is caused by the position of this elevated area, for here the lake is not only bordered by high and vertical rock cliffs, but these project into the lake itself, a part of the cliff face being nearly a mile east of a straight line connecting the Champlain Assembly bathing beach with the mouth of the Salmon river; hence the name "Bluff point."

A student of nature may well ask himself the reason of this great elevated rock mass to the south, now beautifully clothed with woodlands, affording a veritable sanctuary for birds and a flora of unusual interest. What were the forces which gave rise to this rock barrier, with its long and protecting seaward arm (shown in figures 1 and 2), and to the recess on the north, with its beautiful bay and sand beach so well protected from the waves of a "south blow" and forming a veritable "Cliff Haven"?

The thoughtful student should first of all visit the apex of the somewhat acute angle where the beach meets the cliff (indicated by arrows in figures 1 and 2) and there note the great difference in character between the kind of rock forming the south cliff and the kind of rock lying in contact with it on the north. A view of this contact is given in figure 3. The rock on the north side (the right) consists of sheets of a hard but brittle limestone with many partings of weak shale. This rock belongs to the Trenton formation and crumbles readily and rapidly under the action of frost, water, and the roots of trees. In the early spring the lake also reaches the cliff base (see figure 4) and lake ice and wave action help to break down this wall. That this wall is receding rapidly will be realized by noting the overhanging turf and tree roots (figure 3). Recent rock falls may also be noted at *a* and *b* (figure 4). A direct comparison should be made between the cliff itself and the view of it which is here presented.

The rock which forms the south cliff offers very marked contrasts to the Trenton which rests against it. It has successfully resisted the same influences which are so rapidly destroying the Trenton beds. The southern wall belongs to the Chazy formation, older than the Trenton. This stone is so good for building purposes that it was once extensively quarried here. When the United States spent a million or so in building Fort Montgomery (on the Canadian side of the United States boundary) the Cliff Haven stone was chosen on account of its excellent quality and many a fine block was taken from the now abandoned quarry just around the point shown in figure 2 and loaded on boats which were tied to a dock built for that purpose just outside the same point.

The answer to our first problem should now be apparent. The softer rock has been eaten away by the " tooth of time " while the harder rock has offered more effective resistance to all eroding agents. The bay and the protecting wall to the south are the result. If further evidence is desired one has but to ask why an artificial stone wall was built along a portion of the beach front and why to the north of this several breaches in a boulder-built wall were repaired and further fortified in the fall of 1916. The effects of wave action on a weak shore line are manifested in numerous localities between Plattsburg and Cliff Haven. In many places the Delaware and Hudson Railroad has had to build a sea wall and residents of Plattsburg can remember recent landslides which carried forested portions of the higher banks down to the lake level, where the waves of new storms could take care of the débris.

As soon as the student gets an answer to his first question he will be ready to ask another. How fast has the Trenton rock been receding and where was the shore line of this bay when the discoverer, Champlain, first passed through the lake? This question will not be so easily answered as the first. Quantitative analysis is always more difficult than qualitative. The former, however, usually yields results of the greater value. We may here point out one or two lines of investigation that will yield an answer to this question.

At *a* in figure 3 we may note what remains of a small tree whose age, at the time its trunk was lopped off by an axe, could be readily determined by counting its annual rings. When this tree started

1

2

Fig. 1 Distant view of south shore of bay at Cliff Haven; Hotel Champlain dock next left margin
Fig. 2 Nearer view of same; Trenton beds at right of arrow, Chazy cliff at left

Fig. 3 View of fault at Cliff Haven. From a photograph by the author in 1916.

Fig. 4 View of Trenton beds north of fault, showing the action of various agencies which have long been destroying the cliff and causing its recession

to grow it must have been at least a few inches within the border of the bank. Those of its roots which were directed lakeward may be made to tell approximately how far. At present the old stump has no support and is held in place only by a rather long and strong landward root. There is direct evidence here of a quantitative kind. Figures 3 and 4 will serve to indicate many others of a similar nature. In figure 5 is a view of the contact walls of these two rock formations as they existed in 1897. No face of any Trenton fragment here shown is the same as those seen in figure 3. In figure 5 a strong arched root is present in the upper left corner but no roots pass over the faces of the Trenton beds. In figure 3, however, a recent fall of Trenton fragments has revealed (at *b*) roots which, in their search for water and dissolved mineral matter had found a hidden fissure and occupied it. The wall which once protected them on the outside is gone. So too is the arched root of figure 5. If one will now examine the south or Chazy wall in figure 3 he will find some evidence of loss from portions that were in place when the photograph for plate 5 was taken, but *all* of the old smooth face is not lost. If one could recognize some feature of the south wall common to the two figures he would have additional testimony as to the rate of change.

To a student of the peculiar conditions which gave rise to Cliff Haven physiography another question will arise. Why is it that only bedrock of Trenton age is to be found for three and a half miles northerly, or along the shore from Cliff Haven to Plattsburg, while on going nearly three and a half miles southerly, or from the smooth, hard wall of the Haven bay recess to Valcour bay, only bedrock of Chazy age is to be found? The answer to this question will involve some geological knowledge of the utmost practical value — a knowledge that would have saved many residents of Clinton, Essex, and Warren counties from the loss of their savings through boring for oil where the geologic conditions are such that it could not possibly exist.

In the first place, the great Adirondack mass (*Adirondackia*) consists only of old crystalline rocks or those which have been subjected to tremendous pressure and great heat. Around this old land or at least on the north, east and south sides there existed the waters of an ancient sea and all along this sea margin wide sheets of sand were deposited which in places attained great thickness. Over 400 feet of these beds are exposed in Ausable chasm. The Morrisonville "oil well" penetrated rock of the same character to a depth of over 750 feet but did not reach the basal beds of the formation. Very interesting exposures of this same rock are to be seen along the Saranac river for some 2 miles above and below Cadyville. Here the thickness has been estimated to be over 1000 feet. The downwarping of the basin of the old Potsdam sea continued and its shore lines near Plattsburg retreated southwesterly. In off-shore waters new beds containing much lime were deposited on the top of the former sand beds. These newer rocks are easily recognized by their lithologic and other characters and have been named the Beekmantown formation because of their interesting exposures in Beekmantown township. Professors Brainerd and Seeley of Middlebury College gave much study to this formation in the Champlain valley and estimated its thickness to be in the neighborhood of 1800 feet. Beds of this age are well exposed along the lake shore for about a mile and a half south of Valcour bay. At the end of Beekmantown time there seems to have been a local cessation of deposit. On its recommencement the deposits were of a markedly changed character and were laid down on a much modified surface of the Beekmantown formation. The new deposits were named for the town in which they were well exposed and first thoroughly studied, constituting the Chazy formation. These are the rocks that form the great Bluff Point mass. Their thickness, as measured on Valcour island, is close to 988 feet. Over the Chazy beds there were deposited in succession those of Lowville and Black River age and over the latter the rock beds known as Trenton.

It will be proper here to ask how we may distinguish rocks of Trenton age from those of Chazy age. and as the outcrops at Cliff Haven show very many of the interesting differences in these deposits, we will call attention to a few of them.

Many of the ancient builders of Babylonia inscribed their bricks or molded them in inscribed forms. Because they did so we may now determine the date of the laying of many ancient pavements and corner stones. So too the maker of the Trenton pavement stamped it with his own easily recognized seals, which are far more numerous and more wonderful in character than any inscriptions left by either Sargon or Nebuchadnezzar. Trenton seals in the form of exquisite brachiopod shells, bryozoa and other remains of denizens of an ancient inland sea, may be found in the first rock ledge outcropping on the lake shore just south of the Cliff Haven steamboat landing. The southernmost Trenton exposures are more barren of life forms but even here the writer has found the beautiful stems of "stone lilies" and the delicate frondlike forms of

Fig. 5 View of fault at Cliff Haven. From a photograph taken by the author in 1897.

graptolites. Nobody as yet knows the total thickness of the Trenton beds in the Champlain valley, but the exposures are very numerous and easy of access. A short row from Cliff Haven brings one to Crab island, and by automobile Cumberland head or Long point are quickly reached. These are all excellent localities for studying Trenton beds and for collecting from them. There is a fascination in the study of these ancient stamps or seals, but we shall not really appreciate their significance until we become familiar with at least some of the lessons they can teach. It is of importance that we notice one of these now.

Bulletin 92 of the United States National Museum is entitled "Bibliographic Index of American Ordovician and Silurian Fossils." It is a work of 1521 pages. On pages 1448 to 1452 a list is given of 524 different species of fossils found in and described from American beds of Chazy age. Following this is a list of 1080 different species found in the deposits of Trenton age. On comparing these long lists the student will be surprised to find that only 8 species are common to both groups of rocks. Some of the fossils in these lists are known to range through all the various beds of a single formation but there are others that are restricted to a single "zone" or to a series of thin sheets of deposit which together measure but a few feet in thickness. Knowing the short ranging species and their mutations one can identify the particular zone of any formation now exposed at the surface; and knowing how thick the formations are in any given locality, a geologist is able to tell the seeker for mineral wealth just what formations he would go through and the approximate thickness of each, if he should sink a shaft in any thoroughly studied locality. For instance, a boring made in the immediate vicinity of the Boston Cottage would pass through postglacial deposits and then enter the boulder clay of the glacial period. About 30 feet below the surface the Trenton rock would be encountered. As the local thickness of this formation is not yet known and as the particular zone exposed here has not yet been determined, it would not be possible to give the actual depth at which the Black River formation would be reached. The Black River limestone would, however, be the next formation encountered below and would have a thickness of less than 10 feet. Under this about 20 feet of Lowville rocks would be encountered and under these the Chazy would be found. The thickness of the latter formation would here be about 900 feet. After passing through the Chazy beds we would enter those of Beekmantown age and the sequence is known to still greater depths.

A little knowledge of this kind would have saved many a foolish investment not only in Clinton county but in many other quarters of the globe. We may now see one reason for the fostering of geological knowledge and, as the mineral wealth of the United States in its buried coal, oil, potash and metalliferous deposits is of enormous value, a more accurate knowledge of the earth's crust is much to be desired. At the same time we should bear in mind that there is a "growing army of nature students," of "men and women who love nature, or love science, for the sake of nature or science, without any set and immediate utilitarian purpose. . . . Mere addition to the sum of the interesting knowledge of nature is in itself a good thing; exactly as the writing of a beautiful poem, or the chiseling of a beautiful statue is a good thing."[1] To encourage such work in the geological field, museums should be established at all centers of learning. These could show the fossils, rocks and minerals of the surrounding region and if carefully and accurately labeled would in time become of inestimable value. Much is yet to be learned of the manner of rock formation and of the translation of the evidence of ancient conditions as recorded on millions of thin sheets of the earth's sediments. For the present, however, we must leave the interesting field of seals and sediments and ask a new question. If Trenton rocks naturally belong over those of Chazy age, how is it that we now find them placed side by side in the corner of Haven bay? We will return to that locality and give it further study.

As shown in figure 3, the Chazy wall has been ground down to yield a very smooth but somewhat scratched surface. Between the Chazy and the upturned edges of the Trenton beds is a thick sheet of rock flour. This is the grist formed by the grinding of the rock walls against each other. We have here a very instructive example of what geologists call a normal fault. The earth's crust, after the deposit of the Trenton beds, was here cracked open on a line running N. 79° E. How far to the west this crack or fissure extended we do not know, but easterly it reached Rockwell bay on South Hero and still further easterly separated Chazy beds on the north from Utica shales on the south. At Cliff Haven the north wall settled down, slipping bit by bit, a foot or so at a time, and probably giving the country in its vicinity a long-continued series of earthquake shocks. The amount of downward movement or displacement, when the top of the Black River beds had reached that

---

[1] Theodore Roosevelt, at the opening of the New York State Museum, December 29, 1916. See Science, N. S., 45:8–9.

zone of the Chazy which now shows here, had already amounted to 450 feet, and the total displacement is equal to this figure plus the distance from the base of the Trenton to the zone of that formation which now rests against the Chazy at this place. This will in time be determined, but a necessary factor in this determination will be the careful collecting and comparison of the fossils from all the exposed Trenton beds of the Champlain valley or from borings which may subsequently be undertaken in some portion of the region.

So far, this fault has had much to tell us, but we have as yet translated only a very small part of its story. If we carefully examine the *slickensided* Chazy wall we shall find that the scratches produced by the movement of the other wall against this do not dip to the north, as the Chazy wall itself does, but their lower ends are carried easterly. We must remember that the scratches we now see were among the last to be made for no doubt this " slate " was used many times and the older scratches removed by additional grinding. Here we state a new problem. If the last large movements of the Trenton were still downward then it also moved eastward at the same time. How may we account for such an eastward movement? The truth of the matter seems to be that we can not; and if we study the locality a little more closely we may find that, in its later movements over this wall, the Trenton moved *westward* and therefore *upward*.

Walking along the Trenton beds which are exposed for about one-half of a mile to the north of the steamboat landing, we shall note that their slope (*dip*, the geologists call it) is easterly. South of the steamboat landing we may notice a marked change in the direction of this dip and as we approach the exposure shown in figure 4 we shall find that the dip is decidedly westerly. The Chazy rocks on the south, however, dip easterly. If this condition of things continues westerly we should soon have the base of the Chazy resting against rocks well up on the Trenton side. In other words, our fault with a displacement of say 600 feet at the lake shore might have a displacement of a thousand feet where the railroad crosses it. This is evidently a rotatory fault, or at least it became such near the end of its activity. Now if we will face the Chazy wall we may see that the twist of the Trenton side must have been clockwise, which would indicate an upward and westward movement of its beds where exposed in Haven bay. The scratches would partake of the nature of broken arcs of great circles, the axis of rotation being situated at some deeply buried point on a line perpendicular to the chords of these arcs. There is other evidence of an uplift of the east face of the Trenton where it lies near the fault plane, and this evidence we will now examine.

In figure 3 at *c, d, e* and *f*, there has been a strong upward bending of the Trenton beds just at the south of a clearly shown but minor fault plane. The beds at the right of this minor fault had their edges dragged down by the load which resisted the upward movement. At *g* and *h* still another minor fault plane is shown and the beds again have their edges dragged up on the south side. Near the northern end of this Trenton exposure the beds are again dragged up but here a little brook found an easy place in which to cross the barrier and it long since carried away all local trace of the fractured Trenton material. By taking a boat and going around the southern point of the bay we may note that the dip of the Chazy beds, near the fault plane, has also been altered by this local uplift.

If now we ask ourselves why late in the history of this fault the Trenton next it should have been lifted and tipped westerly we shall have to refer the movement to some period of great and extensive thrust from the east, such as that which existed during the Taconic or Appalachian revolutions. At these times mighty forces made themselves very manifest and threw many of the sediments of eastern North America into great folds. During these ancient, geologic revolutions old Adirondackia tried to play the part of a buffer state and remain neutral. When at last Vermont was conquered and compelled to join the attacking forces in the attempt to overrun New York territory she actually moved her boundaries from 10 to 30 miles westerly. The more solid Chazy rocks have shown less evidence of this revolution than the Trenton, which still plainly shows the effects of the ancient struggle.

The reader may perhaps say, " If there has been such a great dislocation of the rock foundations of Cliff Haven involving a downthrow on the north of, say 600 feet, why is it that the cliff at the south is not a sheer precipice now 600 feet high? If the Chazy on the north side of this fault is now covered by beds of the Lowville, Black River and Trenton formations, why do we not also find the same formations covering the whole Bluff Point or Chazy mass on the south?" These questions open the door to an interesting field of nature study.

So soon as any land mass is elevated it begins to feel the searching influence of the wind, and this robber not only carries away all the loose material that it can lift, but it uses this material to grind against and detach other particles of the surface. Those who will consult the more recent textbooks of geology, or the gradually increasing literature on the work of wind, will find that there is here an important and almost virgin field for quantitative experimental work.

So soon as any land mass is elevated it has a decreased thickness of atmosphere over it, and this allows more energetic action of insolation and radiation. The more rapid the changes in surface temperatures, the more quickly the flaking off of rock surfaces is accomplished. This process, producing exfoliation, can be studied on all exposed and elevated rock faces in the Adirondack region.

Elevation also reduces temperature and increases rainfall. The two together lengthen the annual period in which the expansive power of freezing water can come into play.

Elevation not only increases the amount of precipitation but it increases the speed of running water and we here have one of the most effective agents for loosening and transporting rock material. Any textbook of geology will help one to attain some comprehension of how this and still other factors work and we need not burden our paper with the mere mention of numerous erosive processes which are intensified through elevation. It should be enough for us to know that every molecule of rock above sea level has its ticket purchased for the sea and, though frequent " stop overs " are granted, it *must* make its journey, though this may be by an air route, by running water, by moving ice, or by depression of great land masses.

If the fault at Haven bay began to develop so far back as Utica or Lorraine times, and while as yet both sides were under water and receiving deposits, then, as the southern side was lifted nearer water level, wave and current action would remove its unlithified surfaces and deposit them in the deeper waters over the northern side. When at last the higher side emerged from the sea its destruction would still further add material to the depressed side. If the faulting began after the emergence of Utica or Lorraine beds the lower side would also be subject to erosion but the higher side would be worn away the more rapidly.

To the reader it may seem that our attempt at an explanation has only increased his difficulty for we have implied that not only was the present Bluff Point surface once covered by beds of Upper Chazy, Lowville, Black River and Trenton ages (which together might measure some 1000 feet or more in thickness) but we have added thereto some 1500 to 2000 feet or more of Utica and

Lorraine beds. Our purpose, however, is not to explain, but to encourage those who like to exercise their mental powers, not only for their own advantage and pleasure, but to increase the sum total of human knowledge.

Much might be written about the Haven Bay fault but enough has been said to establish its peculiar value as an index of the vast changes which may be brought about by long-continued action of natural causes. The "Mills of God" may grind "slowly" but their action never ceases. After all it is not the spectacular that counts in the long run.

One of these days we shall be able to narrate fully the changes which took place in the Adirondacks and the Champlain valley after Lorraine times. At present we know that the carving which gave rise to our hills, valleys and plains was accomplished in part by sun, wind, frost, running water and the powerful action of thick ice sheets or glaciers moving southerly. The last of these, the Wisconsin ice sheet, brought many a rock specimen to Cliff Haven from the far north and these "boulders" are strewn in remarkable profusion along the lake shore from the bathing beach to the steamboat dock. Glaciated surfaces are still to be seen on some of the rock ledges on the road to Hotel Champlain and in figure 6 we present a view of a fresh surface just west of the road by the "bluff," which was cleaned off for quarrying purposes in 1915. This figure well shows the plaining effect of the moving ground moraine. A part of this moraine is still seen in contact with the stone just as it was left at the close of the glacial period.

As the ice barrier melted away at the north it allowed an invasion of the sea, called the Hochelagan sea, and wave action cleaned off many rock surfaces. Just before crossing the Little Ausable river on the road from Plattsburg to Peru one passes by a gravel pit which is part of a recent beach line and which contains many species of sea shells whose present home is along our North Atlantic coast. The elevation of this beach is about 200 feet above the present Lake Champlain surface. When the land had sufficiently recovered from the "depressing influence" of the great ice sheet to be able, through recoil, to lift this "Peru beach" above water, the waves of the Hochelagan sea still beat against the Bluff Point mass. When this sea surface had dropped to a level about 80 feet above that of Lake Champlain, wave action removed part of the ground moraine seen in figure 6, and the level sod-covered shelf in the upper right corner is a present witness of deeds of a dim past. At a still later date the receding waters began to cut a shelf

Fig. 6 Glaciated rock surface at Bluff Point quarries. At upper right a portion of the ground moraine is seen and its grass-covered surface shows the position of an ancient water level of the Hochelagan sea.

in the weak Trenton beds near the Haven Bay fault. This ancient lake shelf is fairly well shown near the right edge of figure 2. Note that the present surface does not follow the slope of the bedding planes but cuts across their upturned edges. The strand line was then farther inland than now. When the lake was reduced to its present level it had to start near the outer point of the Chazy bluff and begin anew its carving of the Trenton.

In New York State Museum Bulletin 133, pages 159–63, will be found an article by the author dealing with evidence of a preglacial lake which he has named Lake Valcour. A still more ancient body of water worked long enough to cut the Trenton and other weak beds of the region down to a rather extensive local plane but it did not succeed in removing the harder Chazy mass now forming Bluff Point. The ice sheets of the glacial periods next began their grindings of Clinton county surfaces but they succeeded only in lowering Bluff Point from its more ancient domineering height and in rounding off its edges. These ice scourings, however, grooved the old wave-cut Trenton shelf and spoiled its flatness. This flatness the Hochelagan sea tried to restore by cutting down the hills of glacial deposits and using the removed material to fill up the hollows. Last of all a new brook system, draining into Lake Champlain, began to carve the region, but so far it has cut only rather narrow channels in the late sea bed. The general level of the country, which we first noticed, is due then to a sequence of causes involving ancient seas, glacial periods, and recent seas, all of which left traces of their work.

At different times during this elevated interval the rocks were in places cracked open to great depths, and these cracks were filled with molten lava. Two of these lava-filled fissures are to be seen at Cliff Haven. One of them is near the southern boundary of the Champlain Assembly grounds and is best seen from a boat. The lava filling this fissure proves, on analysis, to be like that first discovered by Bonet in the Monchique mountains of Portugal and is now known as Monchiquite. At another period in the history of this region the assembly grounds were again fissured, and this fissure filled with a very different lava called fourchite (from Fourche mountain, near Little Rock, Ark., where similar dikes are found). This fourchite is the only known dike of its kind in Clinton county and may be seen just north of the steamboat landing. It is 32 inches wide and runs about N. 95° W. or toward the extreme southern end of Crab island where a few displaced masses of it are still to be seen. This dike is also of unusual interest because soon after it was filled, and before the central portion had become cold, the fissure walls sprang wider apart and a new filling rushed up from below. Before its arrival, however, and under the low pressure of the newly opened walls, the bubbles near the older lava surfaces expanded and by that expansion further chilled their walls. They thereby saved their bubbles from obliteration by the new filling. A view of this dike is given in figure 7.

There seems to be evidence that these fissures never reached the ancient surface of the land. This evidence will be given in a forthcoming paper on the "Geology of Valcour Island." If the conclusions there given are supported by further study, we may hold that after this dike was injected into its fissure, some 3000 feet thickness of deposits have been removed from over its present exposed portion. The dikes of the Champlain valley have not yet been given the attention they deserve.

Fig. 7 The fourchite dike at Cliff Haven

SOME STRUCTURAL FEATURES OF A FOSSIL EMBRYO CRINOID[1]

BY GEORGE H. HUDSON

(With 1 plate)

While recently engaged in the study of a specimen of the genus Urasterella I found, associated with it, what appeared to be an embryo crinoid. The structure of its arms and their branches, however, revealed no definitely formed ossicles but in their place there appeared to be a linear series of irregularly shaped tranverse disks or semicircular wedges of developing stereom in an otherwise fleshy extension of epidermal or associated tissues. This structure was so like that of the spines and spinelets of Urasterella medusa, as revealed through gum mountings under cover-glass and photomicrographic stereograms (see plates 1, 2, 4, and 5 in article " On the Genus Urasterella with Description of a New Species " in the annual report for 1915 of the Director of Science) that for a long time I half suspected the specimen might be but a detached fragment of this sea star and its crinoidlike appearance to be due to an association of plates originally surrounding some body opening which was protected by a cluster of unusually long spines and connected with a tubular extension simulating a crinoidal column. Both plates and spinelike processes were fairly commensurate in size with those of the Urasterella next to which it lay (see upper part of figure 2 in stereogram illustrating this paper) and, if a crinoid, but two infrabasals, three basals, and two radials were to be seen and these, in part, in vertical section. A portion of the surface of the specimen had been removed by weathering but it appeared as if the sharp eye of the collector (Dr Charles D. Walcott) had noted the spinelike processes and cut along them with a knife to expose them to their tips. How carefully this was done is clearly revealed by figure 2.

After encouragement given by certain paleontologists, to whom I showed the stereograms, that I might trust my vision in this matter, and after seeing, on reexamination, a vertical line of zigzag sutures on the column, I finally exorcised the Urasterella ghost.

---

[1] Paper as read before the Paleontological Society, Albany, N. Y., December 28, 1916.

Two reasons have induced me to describe this embryonic form as a new species and give it the self-explanatory name of *Embryocrinus problematicus.* The first of these is because of the arm structure.

The gum process has enabled me so many times to reproduce sutures where others had long failed to detect them (as, for instance, in the anal and radianal plates of *Palaeocrinus stratus;* see New York State Museum Bulletin 149, plate 6, figure 1, and in recent work on Steganoblastus) that I must place some confidence in its ability to show such structures where they really exist. These crinoid arms show no trace of them. In studying the stereogram here presented comparison should be made with the four plates already mentioned as accompanying Doctor Clarke's recent annual report. It is doubtless true that some of the white partings in our present illustration are due to cleavage planes in the calcite, but it must be noted that the plates of the theca show but few such planes and their white partings reveal true structural characters. It must also be noted that in the pedicellariae of Urasterella medusa the spines and spinlets actually broke up into disks on decay. If the interpretation of structure here given be correct, then primitive arms in crinoids developed, so far as their main ossicles were concerned, much as did spines, and from such a linear series of mixed disk-shaped and wedge-shaped ossifying centers either a uniserial or a biserial arm might be evolved. The factors determining the ultimate outcome would in large measure be due to the amount and kind of motion given this arm during its period of evolution.

The second reason for presenting this specimen to the public is because it forms so fine an example of light penetration made possible by mounting in a transparent medium and under a coverglass, thus doing away with the surface scattering of light from the myriad points of an unpolished surface.

Embryocrinus problematicus, new genus and species

Theca subconcial, 0.75 mm wide at base, across basals 1.66 mm, height of cup 1.8 mm. Apparently four or five infrabasals, five basals and five still larger radials, two of which are clearly seen and one at the left carrying an arm is also apparently present. From radial to first fork of arms 2.5 to 2.8 mm. Column 0.6 mm wide, apparently of five series of plates, nine in 0.6 mm. These microscopic plates of the column are fairly well shown in the photo-

Fig. 1. x20 Fig. 2. x20

To be viewed through a stereoscope

Embryocrinus problematicus

graphic stereograms though details may be lost in the process of reproducing as a halftone.

Covering both column, infrabasals and basals is a coating of epidermal structures which measures about 0.08 mm in thickness. The numerous white dots shown are sections of spines between 0.02 and 0.03 mm in diameter. Near the arms are cross-sections of biserial pinnules with cover-plates. One of these cross-sections is less than 0.03 mm in diameter.

Specimen collected by Dr C. D. Walcott from the Trenton near Trenton Falls, N. Y., and now in the Museum of Comparative Zoology, Cambridge, Mass. It was loaned the author through the courtesy of Dr P. E. Raymond and Hon. Samuel Henshaw.

If the pinnule fragments belong to the specimen, which is extremely probable, they serve to increase the difficulty of interpretation. In the most primitive cystids brachioles were no doubt associated directly with short food grooves. The extension of the food groove possibly never involved the turning of a brachiole into an arm. Epithecal extensions like those found in Blastoidocrinus and the blastids were never developed from arms which were once exothecal; the recumbent arms of Malocystites may have had their origin in free arms like those of Canadacystis. If brachioles developed before supporting arms and if the arm structure was afterward developed to form a common food conduit, enabling the bracholar structures to function at some distance from the mouth and also allowing a large increase in their number, then one of our difficulties disappears.

NOTES ON THE BANNER STONE, WITH SOME INQUIRIES AS TO ITS PURPOSE[1]

BY ARTHUR C. PARKER, *Archeologist*

Among the many interesting objects of stone which the American Indian has left as a legacy to the archeologist, few appear more interesting than that which has been sometimes called the " banner stone." Objects of this character, with the gorget, the bird and boat-shaped stones, and a number of other forms, have been classed as " ceremonial objects."

The " banner stone " is peculiar to North America. Its range is approximately the United States east of the Mississippi valley, and southeastern Canada, (see figure 1). The material of which these objects are made varies greatly according to locality. They are, however, nearly always made from soft and easily worked stone, such as steatite, talc, pagodite, slate and marble. Some have been found, chiefly in southern New York and New England, made from bluestone and granite pecked into shape. These are not perforated, but have grooved sides. Most of the heavier granites have an incomplete perforation.

The forms of " banner stones " are many, some fantastic in the extreme and others severely plain and crude.

The principal classes are, first, those specimens having two thin, flattened wings extending in the same plane from a common centrum. This center may be socketed or it may be notched or grooved on either side. A comparison of these types is shown in plate 1.

The second form comprises the more solid varieties of the horn or " pick " shape and analogous forms. This class is represented in plate 2.

The third class consists of the one-armed or geniculate variety. This form is generally of a solid pattern and has a larger hole than the other forms. Unlike the cylindrical holes of all other drilled banner stones the geniculate form has an elliptical hole (see figure 1, plate 3). The elliptically socketed banner stone may or may not have an arm or " thumb." The form of this class suggests a closed fist, with or without the thumb held upright.

Banner stones belong to the period preceding and immediately following the era of the white man in America. They are found

[1]A paper read before the July 1916 field meeting of Morgan Chapter, N. Y. S. A. A., held on the John Dann farm, Honeoye Falls.

Fig. 1. Map showing the distribution of the banner-stone. These articles are found east of the Mississippi basin and southward into Florida. The northern range is the drainage basin of the Great Lakes and the St. Lawrence.

Plate I

Range of forms of banner-stones

Plate 2

Range of types in New York State of the lunate form, sometimes called horn or pick-shaped

throughout eastern North America and Canada on prehistoric village sites and in mounds. Mr E. P. Upham writes that of the approximately three hundred specimens in the National Museum, about one-half came from "mounds," a small number from village sites, and the remainder from ploughed fields or from the surface.

That banner stones should have been abandoned by the many tribes who used them, as they came in touch with the white invader, is significant. Does this not mean that they were given up because some more useful article was obtained from the white man? Certainly we know of several aboriginal utensils that became gradually obsolete with the coming of European goods. Or should we hold that banner stones were abandoned long before the coming of the European?

The varied forms in which the so-called banner stone is found suggest varied uses of this puzzling artifact. It seems probable that the pick or horned type, the thin-winged butterfly type and the elliptically pierced type may have been intended for distinct and separate purposes.

Banner Stones on Handles or Shafts

In many instances, by examination, it is found that the hole perforating the body of the banner stone tapers, as if for the insertion of a tapered rod. An examination of many broken specimens clearly indicates fracturing by internal pressure. Banner stones which have been made for experimental purposes and broken by internal pressure within the socket show fracture lines identical with those of ancient specimens. Thus, it seems reasonable to believe from the form of the stone and its perforation that banner stones were designed to be placed upon rods, spindles or shafts. By placing a banner stone upon a shaft and studying its poise and the use it suggests, we may arrive at some approximation of the actual purposes of the implement. In conducting our investigations, therefore, a thin-winged banner stone was placed on the rear end of a javelin shaft to see what effect this would produce. We found by experiment that an ordinary spear shaft headed with a sharpened flint does not fly with precision but rotates to a perceptible degree at the point of balance, causing both point and tail to describe circles, the circumference of which depends on the degree of rotation and the length of the shaft. Thus, a spear does not fly with absolute precision. To be of correct form for throwing, the shaft must have a certain taper. The taper offsets to a considerable degree the rotation of the extremes and has a well-defined mechanical effect on the shaft. A well-tapered rod can not be thrown small end foremost; if this is done it will turn in mid-air and proceed large end foremost.

Using a well-tapered shaft 5½ feet long and 1⅛ inches in diameter at the head and about one-half of an inch at the tail and placing a banner stone upon the tail, we conducted experiments in javelin throwing. It was found that the thin wings of the banner stone acted in a similar manner as the feathers do to an arrow. The javelin thus arranged could be thrown with greater precision, with greater poise and at least one-fourth farther, than a shaft without the banner stone. Although the banner stone consumed a certain amount of additional propulsive force, the advantage was so great through the addition of poise, that the projecting force was not expended in keeping up the wabbling flight. Besides giving poise and adding distance, the banner stone gives the additional advantage of greater weight, greater impact and greater speed.

It would seem that objects of so brittle a subtance would not stand the use of throwing. The writer, however, having made one of soft steatite threw it more than fifty times in an ordinary field with no breakage, except a slight one caused by the incomplete insertion of the shaft. When this breakage was sustained the stone was placed for experimental purposes with the wide end forward, although the reverse seemed to be the more effective method.[1]

The banner stone thus employed on the spear shaft does not break because the shaft strikes the ground at an acute angle, and if it does not strike into the ground it has but a slight distance to fall.

Banner Stone as a Spindle Whorl

By placing a shorter shaft in the hole of a banner stone another experiment was conducted. The pick-shaped banner stone resembles in miniature the war club of the modern Sioux and it will be noted that many of these decorative clubs had comparatively slender handles. By pushing the spindle through the banner stone for some distance so that three to five inches protrude, we find, by handling the arrangement, that there is a desire or tendency to whirl the shaft, the weight of the banner stone making the combination spin like a stem-heavy top. This gives rise to the idea of

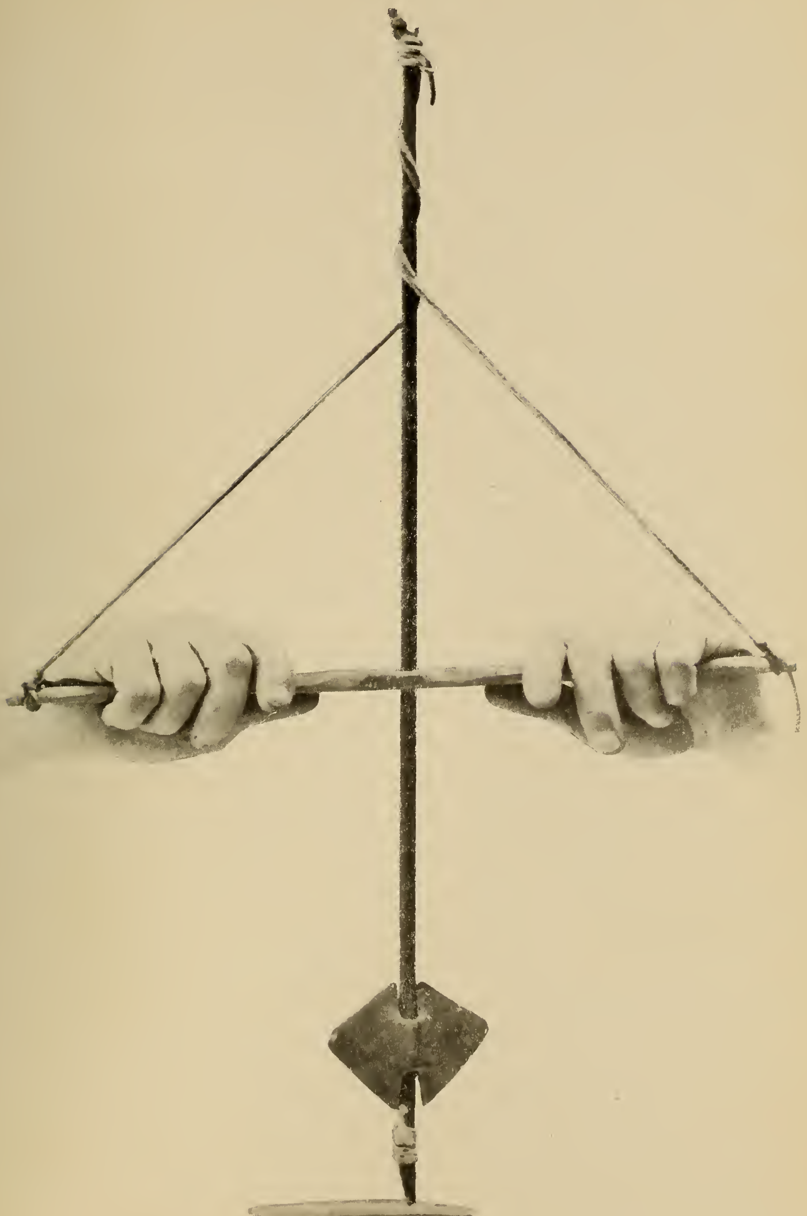
[1] These experiments were conducted during April and May 1899.

Plate 3

Fig. 1 Geniculate forms showing elliptical perforation and breakage due to internal pressure

Fig. 2 Banner-stones of compact, hard rock, partially drilled. The drilling is nearly always started on the wider portion

Plate 4



Showing method of using a pump drill with a bannerstone as a spindle whorl for perforating a slate tablet

its use as a spindle whorl for fire-making and drilling. In our experiments[1] we used nearly every type of banner stone with equal success and all forms of drilling were used, including the pull string, strap, bow and pump. The thin-winged forms were especially efficient, the air resistance giving weight and steadiness to the rotating shaft. This is so apparent that a pump drill worked on a smooth surface, in conjunction with a banner stone used as a fly-wheel, keeps the shaft rotating upon one point (see plate 4).

The value of the banner stone used upon a spindle must have been apparent to the banner stone maker. A simple twist of the spindle would reveal its possibility as a whorl and with this discovery its use would be suggested. We can hardly see how the aborigine of the polished stone age who made banner stones could have neglected to employ the banner stone as our experiments suggest.

This subject leads us to inquire into the prototype of the banner stone and to discover the reason for its various forms. The wings of the artifact suggest in some ways the wings of a flying bird, other forms suggest the ears of an animal sewed together or winged seed pods, or winged insects, while still others plainly represent horns. The centrum, by its one grooved side, suggests an original tube of cane from which wings expanded. Our knowledge of the Indian's veneration for the thunder bird and indeed his regard for the assumed magical qualities of birds, suggests the possibility that the banner stone wings were the heavy portions of an effigy designed to represent a bird, which was fastened to the spindle or shaft. The horned type of banner stone might represent the horns of a buffalo or some mythical monster that was believed to emit fire or to symbolize power. The horned type of banner stone in a considerable number of specimens has upon the surface at the centrum certain cross-hatched or incised projections which suggest, to the writer at least, an attempt to represent horns laced, sewed or tied together. Any student of Indian mythology will quickly recall the many legends of horned monsters, especially serpents.

Among the uses of the banner stone heretofore suggested is the theory advanced by Frank H. Cushing, which describes the banner stone as used on the stem of a calumet to prevent it from tipping over when placed upon the ground. Within our experience, we have not seen banner stones associated closely with pipes, although platform pipes are sometimes found on the sites yielding banner

[1] Experiments conducted during December 1915 and January and July 1916.

stones. We have not learned, however, of a banner stone and pipe from a grave that would bear out this theory.

An interesting specimen in connection with this idea occurs in a highly decorated form of pipe in the New York State Museum collection. The pipe is of European brass. About the bowl of the pipe extending from the neck-base upward is a large crescent-shaped object perhaps intended to be a moon effigy or more remotely a canoe, though the crescent is too thin to resemble one closely. On one side of the crescent is a figure of a man with an arm extended and holding a shaft having a weighted bottom. The pattern has been cut out and riveted on the crescent. In form this adjunct to the pipe somewhat resembles a banner stone, but we do not believe that the maker of this pipe was ever familiar with banner stones or knew of their actual value. This pipe of brass, which

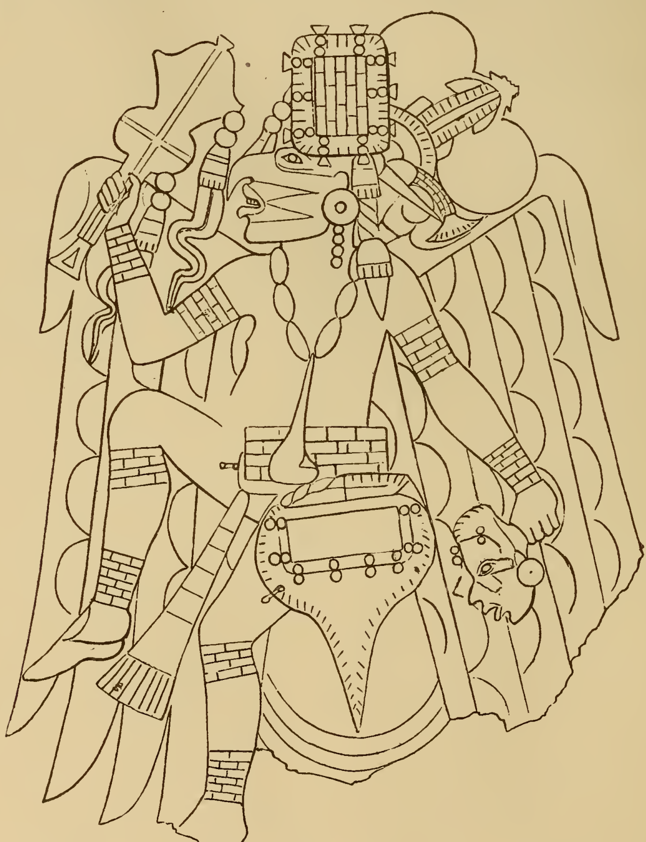
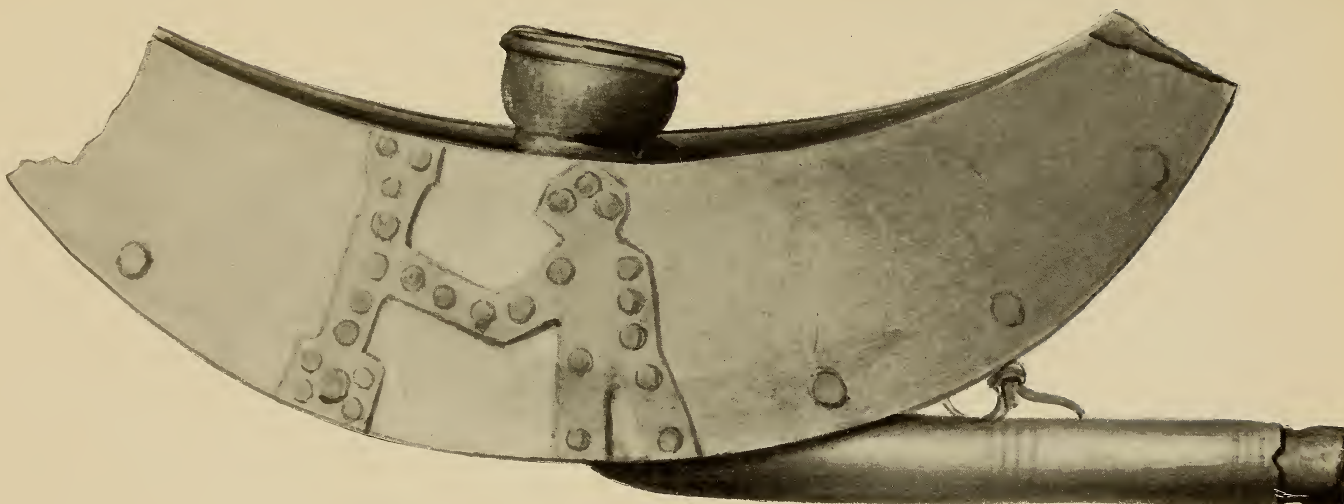


Fig. 2. Mound effigy of native copper. Note the wing-shaped ornament on the head. The people who made these embossed copper drawings used banner stones. Note the object held in the right hand.

Plate 5



Seneca pipe of brass thrust through a boat-shaped or lunate ornament of brass

has a wooden core and stem, has an earlier prototype in certain forms of prehistoric Onondaga clay pipes, the bowl of which is extended forward and backward to resemble a canoe. (See plate 5).

Another use of the banner stone is that of a helmet ornament suggested by certain human figures embossed on sheet copper from a mound (see figure 2). There is some merit in this conjecture when a study is made of the elaborate head dresses of the mound-building period. The Sioux and other Indians within modern times have decorated their heads with horns and the Iroquois cap had a spool-shaped socket at the crown in which an upright feather was placed in such a manner that it would revolve.

The allusion to the fish tail shape of the banner stone made by Dr George Byron Gordon, curator of the University Museum, Philadelphia, is given further significance by the conclusions of Dr Clarence B. Moore in his reports[1] in the Journal of the Academy of Natural Sciences of Philadelphia, volume 16. The results of Doctor Moore's expedition along the Green river, Kentucky, were made remarkable by the numerous banner stones which he discovered in graves, especially on "Indian Knoll," Ohio county, Kentucky. Here the banner stones were found associated with heavy hooked implements of antler, called by Doctor Moore "net knitting needles." The winged stones are called "mesh spacers" and a considerable argument is given supporting the theory. This idea is new to most American archeologists but the theory has some merit. We are not convinced, however, that it is without difficulties nor that it is quite so apparent that one is warranted in giving a "use-name" to the object hitherto called "problematical."

Some observers have suggested that the "knitting needles" were *atlatls* or parts of them and used as auxilliary devices for projecting javelins. Doctor Moore argues that this supposed use would also necessitate explaining the reason of the close association of the "mesh spacer" banner stone with the hook. He presents a valid objection when he says that no points of antler or flint were found that could have been used as "tips" for the shaft and further says that the hooked antlers are too short for use as *atlatls*. We may not be convinced of this entirely in view of our experiments with the banner stone as a tail weight to a spear shaft.

It is interesting to note that banner stones have been found in considerable numbers during the past two years. We mention again the discoveries[1] of E. W. Hawkes and Ralph Linton in New

[1] Philadelphia, 1916.

Jersey, on Rancocas creek near Masonville. Here banner stones were actually found in caches associated with the lowest stratum in which artifacts were present.

Implements Suggesting the Banner Stone

In connection with our studies of the banner stone as a whorl we have examined the drill spindles of various races in several of the larger museums. We find that the headpiece of a drill spindle employed by the Eskimo, for example, resembles in certain ways the knobbed or blunt ended banner stone of the horned type. The headpieces are rather more neatly made than the remaining portion of the drill among the Eskimo. The Eskimo top pieces are

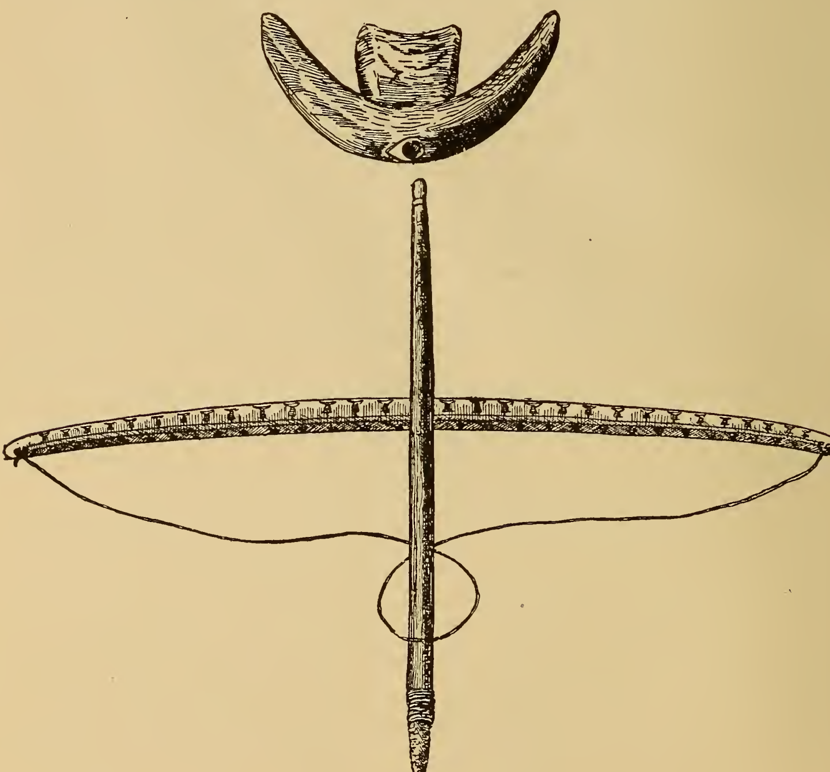


Fig. 3. Boring set used by the Point Barrow Eskimo. From Report National Museum, 1888, Hough. The top or mouthpiece resembles one form of the banner stone.

[1] A pre-Lenape site in New Jersey. Anthropological Publications, Pennsylvania University Museum, vol. 6, no. 3.

frequently carved of bone and have at their upper portion, that curve to fit the mouth, wooden projections which are used as handles and held in the teeth. On the lower side is the socket in which the top of the spindle is inserted. One of these headpieces worn through by long use and pushed down over the shaft would quickly suggest a new use. The possibility of wearing through is not remote because the holes were drilled in the bone to a considerable distance in order to prevent the slipping out of the spindle. Indeed, to prevent the rapid wearing into the bone or ivory the Eskimo even recently mortised into the headpiece small pieces of rectangular stone into which the hole was drilled. Not all headpieces take a similar form and there is a large individual variation. In general, however, the headpiece was curved upward so as to fit against the mouth, which gives a crescent or boat shape to many specimens.

The utility of such an object as a whorl, once discovered, would bring about many further variations and new outline motives would be employed. Dr George Byron Gordon in his study of banner stones[1] suggests that certain forms were derived by the lines suggested by a whale's tail and we see no reason why this idea should not seem plausible though tails of other aquatic creatures may have been likewise copied.

Our conclusion is that the banner stone is a portion of a more complex utensil or ornament and was designed to be placed upon a shaft or spindle. The manner in which this was done and the purpose is suggested by the experiments described. We can by no means be certain that any of these suggested uses were employed, but likewise we can not positively say that none of them are valid, especially in the face of the presumptive evidence we have advanced.

Notes on the Process of Manufacture

In the New York State Museum collections are some score of banner stones in the process of manufacture. We are able through an examination of these articles (specimens of which are found in almost every stage of the process of manufacture from the crude block of intermediate form to the finely polished specimen) to describe in a measure the various stages in the making of banner stones. The unfinished forms are usually not of slate, which was easily worked and quickly finished, but of compact shale, schist, sandstone or granite. The material out of which this series is made is tough rock not easily worked or perforated.

[1] Museum Journal, U. of P., June 1916.

The first process, after a suitable material had been found, was to chip the implement into shape, outlining the wings and centrum. With the exception of the central bulb from which the wings expand and the indentation on the upward curve, all these heavier specimens in form are kidney or bean shaped. The second process as indicated by our series was that of picking or pitting; the third process that of scouring or grinding, and the fourth finishing the polish. A set of these specimens also indicates that the hole or perforation was started in the centrum on the inward-curving side. Preparations for the perforation were also indicated on specimens which have merely been blocked out, by a picked-in indentation. It would seem, therefore, that the shaft which we postulate was placed in the centrum was inserted first at this point. It may be possible that the shaft was sometimes placed in the unfinished specimen.

Incomplete banner stones have been found throughout the State from Lake Champlain region on the north to Staten Island on the south and westward through the Mohawk valley to Chautauqua county (see figure 2, plate 3). Other specimens are reported from the St Lawrence valley, but a greater majority have been reported from the Finger Lake region of central New York and from the valley of the Genesee and its tributaries.

A fine incomplete specimen of laminated limestone containing chert is contained in the D. F. Thompson collection (T-27923) and was found at Waterford near the Mohawk river. This specimen has been roughly chipped to shape and shows some minor picking. The top side is indented to shorten the length of the centrum, but the perforating process has not been started.

An unfinished specimen chipped and roughly picked to form comes from the Susquehanna region a little east of Binghamton. It is a heavy specimen of compact schist containing a vein of sandy quartz. The centrum has been roughly blocked to shape, but there is no indication that the specimen had been sufficiently formed for the commencement of drilling. The material out of which this artifact is blocked appears entirely unsuited for the purpose and very likely this specimen was rejected in the unfinished form because of the defects in the material. This specimen is 6 inches in length and the measurement through the centrum diametrically is 2¼ inches and the weight is 28¾ ounces.

Another specimen of unfinished banner stone is of silicious sandstone. It has been picked completely to shape but one wing is longer than the other by nearly one-half of an inch. A chip, however, has been taken off from the longer point and if the specimen had been abraded to eliminate this chip it would have been fairly symmetrical. The centrum is well formed but on one side the central line is not correctly opposed to that of the other side. A most interesting feature is that the wings are placed at an opposite slant as if each had been grasped in the hand, the upper and shorter one being twisted to the right and the lower to the left, somewhat after the fashion of propeller blades. No attempt has been made to start a perforation. This specimen is from Schoharie county, but no detailed location is mentioned in the catalog.

Specimen C-25045 is composed of picked mica schist and has well-defined wings, though they are somewhat thick. The socket is well outlined on either side and the perforation has been indicated both at the top and bottom by slight concavities picked in. The drilling process has not yet started and there is no indication of surface polishing. This specimen is from site no. 38, explored by Mr Fred H. Crofoot.

A broken specimen similar in the stage of process was found by Mr Forest Ryder at Coxsackie, N. Y. The material seems to be decomposed granite. The centrum is well defined and on either side has been flattened in order that perforation may be started. The specimen is not polished, but still bears the marks of the abrading process. (Mus. 32871).

Specimen C-21154 is a heavy bulbous and bilobate banner stone from the Abel farm in the Genesee valley and was found by Mr Fred H. Crofoot. Like all specimens of unfinished banner stones in the State Museum, this one is drilled in the central portion, at the wider portion of the stone. The perforation continues nearly half the depth of the stone and is exceedingly smooth. It appears not to be a tubular drill hole. There is a depression on the under side, but no drilling has been attempted there. A portion of the surface of the stone has been polished and it is thought that the specimen was intended to be used approximately in its present form. The weight is 26 ounces.

A very fine specimen of picked sandstone banner stone of incomplete form was collected by Prof. D. F. Thompson at Hoosick Falls, N. Y. (T-29792). The centrum is especially large at the upcurved end and probably the picking process has not been completed. The specimen shows no signs of polishing, but a perforation nine-sixteenths of an inch in diameter has been started, the broken portion of the drill core being visible at the bottom of the perforation which is about seven-sixteenths of an inch in depth. The weight of this stone is 16¼ ounces. The wings are not uniform in length, there being a difference of more than one-fourth of an inch in length. The twist of the wings, right and left, is also apparent in this specimen.

A narrower specimen of unfinished banner stone (M-2419) was found at Arius lake, Rensselaer county. The specimen is 6¼ inches in length and weighs 15½ ounces, the width through the centrum being 1¼ inches. The perforation has been started and the drill core projects from the drilling, which is about three-sixteenths of an inch in depth. There is a groove on the upper or outer side of the specimen which appears to have been slightly polished, but the general surface of the stone has been scoured only enough to remove the deeper pitting. One of the lower corners has a chip taken out which shows the material to be an impure marble quartz.

A fine specimen of unfinished sandstone banner stone from Atwood, Perth county, Ontario, Canada, is in the Museum collection and is interesting for the purpose of comparison. A twist in the wings of this specimen is also evident. The bulbous centrum is flattened on each side and drilling has proceeded about two-thirds the diametrical length of the centrum. A broken core shows as a break at the bottom.

Specimen M-21591 is an unfinished granite banner stone with the drilling at the expanded portion and carried to the depth of about three-eighths of an inch. This specimen shows drilling by tubular perforation. The indented and in-sloping top of the stone has a rather high polish, but the under side has been only roughly picked and ground into shape, though there is an indentation in which the perforation was to be made.

A very interesting specimen of a dark drab slate banner stone (Y-29632) comes from the Hudson valley in Orange county. This specimen has been undoubtedly finished, though the perforation is only about one-half the depth of the centrum. The centrum is like a pipe bowl, fifteen-sixteenths of an inch in diameter. The lower curve of this centrum is about three-eighths of an inch from the curvilinear line forming the outward circumference of the specimen, but a notch has been cut in the base of the wings meeting the bottom of the bowl like centrum. It is not exactly in the center, which makes the wings appear unequal in length by almost one-fourth of an inch. Two tally marks appear at the top of each wing.

CONTRIBUTIONS TO THE PALEONTOLOGY OF NEW YORK

DEVONIAN GLASS SPONGES

BY JOHN M. CLARKE

I The Ontogeny of Hydnoceras

(Plate 1)

The interesting specimen here illustrated was recently sent to the State Museum by Mr L. D. Shoemaker of Elmira. It is a slab of sandy flagstone found near the village of Wellsburg, N. Y., 6 miles southeast of Elmira. One surface of this slab carries, as represented, two essentially entire and mature individuals of Hydnoceras, undoubtedly of an undescribed species, which lie side by side as they must have stood when they were growing erect on the sea bottom. The specimen is otherwise rather full of fossils characteristic of the Chemung fauna, principal among which is the little brachiopod Ambocoelia gregaria.

The genus Hydnoceras has been abundantly described and it would seem as though almost every variety of expression is manifested in the various species represented in the Monograph on the Fossil Reticulate Sponges.[1] In the preparation of that somewhat exhaustive treatise, very abundant material was available, and in the study of the representatives of this nodose and highly specialized genus Hydnoceras, it was desirable, at times to emphasize local variations in form and character of surface which might not have been so distinguished had the specimens been found in the same place or colony. In other words, it became very evident in the study of the various local colonies of this genus of sponges, in some of which the individuals grew by hundreds and thousands, that there was in many cases a distinct local impress which probably, on careful weighing of the evidence, would be found not to equal species values.

We there also indicated that morphologically, the simplest type of expression in these sponges is the obconical, smooth tube or reticulum; that is a skeleton without any division into nodes, rings, tufts or other surface modifications. This type is maintained in the greatest abundance throughout the climacteric development of these

[1] Hall, James & Clarke, J. M., 1898.

glass sponges in the Chemung fauna, and the genus Dictyospongia, which expresses it, is not only freely developed in species but its individuals are often of commanding size and graceful form.

It was also indicated in the study of these fossils that the smooth, obconical shape being primitive, the nodose structures of the surface appeared as a secondary character. Such evidence, however, was not, at the time of the preparation of the work cited, regarded as altogether conclusive.

It was further observed in connection with the study of the interrelations of these sponges, that the large series of annulated forms known as Ceratodictya stood in somewhat similar relationships ontogenetically to the smooth cones, as did the nodose species; that is to say, the secondary conformation of the surface begins to express itself either as nodes, or as rings, or as a combination of both together. We must here note a third consideration, and that is the series of prismatic or banana-shaped sponges, Prismodictya; a large tribe of very effective, compact and graceful appearance, in which the prismatic sides are developed with rarely any indication of nodosity or annulation. These prismatic sponges also, are found to develop their prismatic faces as a secondary feature, the incipient part of the sponge or its infantile condition being still of the smooth, obconical pattern.

We have then three different secondary modifications superimposed upon the primary expression of these sponges, all of which, in combination or independently, are competent to produce and have produced a very extraordinary variety of generic and specific expressions. The exact order of succession in these features should be established, if this is possible. Inspection of a very large amount of material does positively indicate the development of the prismatic form of the skeleton before the appearance of either rings or nodes, and of the other two it is reasonably safe to say in a general way, that the tendency to nodes manifests itself earlier than the transverse constrictions which produce the annulations. The normal order of time and succession therefore, in the development of these three characteristics from the simple, smooth obcone, is first the prisms, second the nodes, third the rings. In terms of this ontogenetic succession it is therefore possible to estimate any species of these various types of the prismatic, nodose and ringed Dictyosponges and their combinations, in terms of stationary, arrested, or accelerated development referable to the standard type of the simple, smooth skeleton.

These ontogenetic traits are brought out emphatically and beautifully in the specimens now under consideration. Here is a very strongly nodose and a very deeply annulate species in which the slightly modified, early and infantile expression of growth is continued for a long period, the lower obcones being smooth or faintly prismatic. In one of these this infantile condition is maintained for fully half the length of the completed skeleton, while in the other it covers a less proportion — one-third of the full length of the sponge. Thereupon follows, at the upper end of the obcone, the primary development into nodes, and directly thereafter, the constrictions which are to produce the annulations. Over these annulations, constrictions and nodes run the prism lines in the usual manner characteristic of all the nodose species of this genus Hydnoçeras.

The smaller of the two specimens under consideration (that at the left of the drawing) is actually complete so far as its length is concerned and the distal or upper extremity is the entire margin of the osculum of the sponge itself. The specimen presents other features of maturity and decline which are highly instructive. The first three of the annulations, counting from the bottom, are broad, their nodes are blunt; but therewith onward the constrictions become deeper, the annulations narrower and sharper, the nodes relatively smaller. The gradual decline in the prominence of the nodes is obvious, and in the seventh and eighth rings the nodes show distinct signs of suppression; in the eighth or terminal ring a suppression which indicates a tendency to complete extinction in further growth, had such further growth continued. This condition is likewise true of the rings themselves, and accompanying all this general decline after the adult development of the skeleton midway of its length, is its loss of diameter, approximating again in this respect the infantile condition. The specimen thus quite emphatically and unusually shows the unfolding of the general morphological characters of the genus and species in regular order through the nepionic stages into the mature, and then their equally gradual decline from the mature ontogeny into the gerontic or senile stage.

This evidence thus ties together a good many outstanding scattering data, regarding the structure of these sponges and the true relations of their individual development. The special interest of this specimen is that it helps to interpret the morphologic value of the sponges of this class; that is to say, here is a sponge, obviously of the genus Hydnoceras, which bears in itself the characters of the typical genera; Dictyospongia, the smooth sponges; Prismodictya, the prismatic sponges; and Ceratodictya, the annulated sponges; and upon these characters assumed in succession, are imposed the nodes which, generally speaking, are later than the other features (although they may appear at times on the prism-angles without the intervention or presence of the annulations); all of which indicates the fact that the nodose sponges of this type are the extreme terminus, the final term of development along these lines. They are the most advanced, the most highly accelerated, the most extravagant in ornament, and carry most conspicuously in themselves the evidence of the path they have followed in their development. Whether or not the nodose sponges are the last to survive in this peculiar group is quite another matter; upon that we are not prepared to speak positively. They are certainly the most abundant of all the known representatives of the stock, but logically the last to survive would be the stronger type, and theoretically the stronger type is the simplest.

The species under consideration has no outstanding specific name. It can not be brought into specific relationship with any other form now described, and for this reason it is herewith given the designation, Hydnoceras walcotti, in honor of the distinguished secretary of the Smithsonian Institution.

2 Chemung Sponges from the Vicinity of Erie, Pa.

Through the courtesy of Mr E. J. Armstrong of Erie, Pa., I have received interesting indications of heretofore undescribed species of Dictyosponges from the neighborhood of his city. Both of the species are represented by more than one specimen, and each is of very exceptional interest as presenting a type of structure, broader than specific, which has not heretofore been recognized from the great sponge fauna of the later Devonian Period.

The first of these may be designated and described as:

CERATODICTYA ORYX sp. nov.

(Plate 2)

The term Ceratodictya was introduced by Hall and Clarke for the purpose of embracing a series of rather commanding species characterized by simple or duplicate annulations but without retaining either the prismatic or the nodose features of the surface.

Ceratodictya, in its ontogeny, may properly be construed as elementary rather than senile; that is to say, the constrictions of the surface do not, in the ontogeny of the sponge, appear to be preceded by any other conformation of the skeleton.

The specimens in hand are long, slender, twiglike skeletons, with very prominent horizontal rings, all of which, in the best preserved of the two examples, appear to be duplicate on the periphery; that is to say, these rings stand out prominently and abruptly; they are compressed, and the surface is grooved in such a way medially, as to make each ring a duplicate one. On the second and longer specimen this duplication is not obvious, or at least is no more than suggested, but the preservation of this individual is bad and the absence of the crown groove may be due entirely to this fact. These annulations are separated by smooth and subcylindrical surfaces, which are rather long, as they have fully twice the width of the annulations themselves, and this is rather more than the interval in the other species of the genus. As preserved, the specimens show a sinuous or gracefully curved stock or twig, very slender and scarcely tapering from one end to the other, so that the original sponge must have been of extraordinary length in proportion to its diameter. The shortest specimen measures 100 mm, and carries 12 annulations; the longer specimen is 180 mm, and carries 23 more or less recognizable annulations. The average diameter of the shorter and better preserved specimen is 15 mm.

The matrix of this specimen is Chemung sandstone of somewhat coarse grain, and no trace is left of the reticulum. The larger specimen is buried in the sand, but the smaller is represented only by an external mold. The block which carries this smaller specimen has also a very indistinct trace of either another individual or the continuation of the first, bent at a very sharp angle. The locality of these specimens is given by Mr Armstrong as "about 6 miles southeast of Erie, Pa."

HYDNOCERINA gen. nov.

It seems necessary, for purposes of reasonably precise definition, to introduce a new generic term here for species of these sponges which combine the characters of Hydnoceras and Ceratodictya in such a way that they can be safely referred to neither. I think the group which is represented by the species herewith described, must be looked upon as a departure from the normal development of the elementary types of these sponges. The variability in their expression and the easy flexibility in the development or suppression of their surface characters, may make the group a convenient receptacle, even though the characters can not be very strictly delimited. Hydnocerina, then, is characterized by a reticulum bearing more or less prominent rings crested by one, two or even three rows of nodes, the nodes being often of irregular size; sometimes long and simple, sometimes low and duplicate, frequently fusing together and thus losing their distinctness.

HYDNOCERINA ARMSTRONGI sp. nov.

(Plates 3 and 5)

This species is represented by two specimens which present a fairly complete conception of the entire reticulum, the larger being almost the entire horn; the smaller, the initial end of a specimen which might well have been of the same dimensions as the larger. The aspect of the initial part of the reticulum is interesting as displaying very clearly the development of the exterior features. Prism-faces are almost wholly undeveloped, although suggested; annulations appear at once and these are quite simple. This small specimen carries six of these annulations, on the summit of which, at the crossing of the prism-lines, are intimations of nodes. At once thereafter, apparently, the nodes spring into greater prominence and the annulations at first become more upstanding through deeper constriction of the intervals. Growth appears to have been regular for a matter of three or four additional annulations, the nodes developing in such fashion that up to this point the species would be safely placed with the genus Hydnoceras. Then commence the irregularities which take it outside the boundaries of that genus. The annulations become broader, grooved on top; the nodes appear first small and then large, or small and large together, some of the rings being made up of a single row of large nodes as below, and other rings being broad, duplicate, or triplicate, grooved, with the nodes quite low and confluent. The larger of the specimens shows eleven annulations in which the character of the nodosity may be indicated from below upward as follows:

1 Large and simple
2 Large, some of the nodes fused laterally
3 Large, some of the nodes fused laterally
4 Double row of low nodes

5 Single row of low nodes
6 Triple row of low nodes, more or less fused vertically
7 Large, simple nodes, obviously fused vertically
8 Large, simple nodes
9 Low, triple, grooved nodes
10 Low, triple, grooved nodes
11 Low, duplicate, grooved nodes

The above details give a fairly adequate account of the characters of the species. The length of the specimen is 180 mm, and this length, if increased by the length of the smaller specimen, with a slight allowance for the break, would be 220 mm. The specific name is given as a recognition of Mr Armstrong's interest and his diligence in the study of the paleontology of his neighborhood. These specimens are from " about 8 miles east of Erie, Pa."

ELUCIDATION OF THE GENUS CRYPTODICTYA

(Plate 4)

In the Monograph of the Dictyosponges its authors described as Cryptodictya alleni, certain frond-shaped structures of large size which seemed to have been sponge masses with extremely thin, expanded reticulum and which, in being tossed together by the waves, had assumed irregularly infolded shapes. There was no evidence, from the study of these bodies, that the films had ever been inclosed into vases or other symmetrical forms. The sponge character of these organic structures was only presumptive, but their association in the Chemung rocks of Cattaraugus county, N. Y., was with other sponges and the occasional indications which they presented, of structures which might be interpreted as spicular, and also the fact that surfaces were irregularly marked by little monticules or acute papillae, sometimes symmetrical but often elongated and irregular elevated surfaces which might have served as bases for spicular tufts and did indeed, when protruding into the matrix, seem to be accompanied by evidences of such spicular sponges.

Mr Armstrong has recently discovered a series of small disks which have the same general surface appearance as those of C. alleni, but which are distinctly outlined, and I have little hesitancy in comparing the latter with the type species of the genus. These smaller disks are all of about the same size and average about

2 inches in diameter; are approximately circular, with some irregularities in outline, and the upper surface is broadly convex. Many of them show the effects of compression in a rifting of the surface, and so we are obliged to infer that these biscuit-shaped bodies were originally nearly as convex as the bell of a jelly fish. The surface is marked by monticules or acute elevations, distributed with apparent irregularity and varying very much in number. There are some in which these conicles are hardly apparent; others may have ten or twelve, while still others twice this number. In the slab which Mr Armstrong has sent me, there are at least eleven individuals, and he speaks of there having been more in the rock from which these were taken. The accompanying illustrations will elucidate the character of these specimens better than any further description, but it may be added that there is no clearly defined indication of spicular structure on these surfaces; further, that the surfaces of the organism must have been very thin, for the space between the outer and under casts is tenuous. Several of the specimens show the peculiarity of a scar or a broken, disordered spot at or about the center of the convexity, but as this is not shown by all, it does not now seem possible to regard this as a structural feature.

Whatever may have been the full form of these sponge bodies, there seems no evidence now that they were attached to the bottom by any other means than their spreading growth or by the margins of their reticulum. No specimen shows any evidence of an upright or vertical stem or other form of support. As the species is very sharply defined from C. alleni and occurs in a different horizon, it is here distinguished by the name Cryptodictya tylea. Mr Armstrong reports that his specimens were found loose in the gorge of Six Mile creek, 7 miles east of Erie, Pa., and he is of the opinion that they must have come from something less than one hundred feet above the base of the Chemung.

3 A Branching Form of Silicious Sponge

This sponge expresses a peculiar type of growth so unusual to this reticulate group that its silicious character may be held in some degree of reserve. The quadrate skeleton structure, however, seems to be evident on various parts of the surface, and the probability is that in the predominant silicious character of the great sponge fauna of the Upper Devonian period, this species partakes of the nature of the rest.

The specimens on which the genus and species are founded occur in a slab of hard silicious Chemung sandstone found loose at Hinsdale, Cattaraugus county, N. Y., and sent to the Museum by John S. Johnston of Wellsville. On the weathered surface of this slab is the deep impression of the large, branched specimen, (plate 6), taken as the type of the genus and species. In the substance of the slab several others, smaller in size, have been found preserved as external and internal casts.

OZOSPONGIA gen. nov.

Ozospongia johnstoni sp. nov.

(Plates 5 and 6)

Obconic, anodose, nonprismatic; generally expanding from the base up and rather abruptly constricted to well-defined ostia; extended below into short or long, subcylindrical stems which join at various intervals, uniting in or branching from a common stalk. This stalk or stem tapers so slowly that it must at times have reached very considerable length. The best expression of this compound form is shown in the typical colony, where it will be observed that two individuals divide the common stem equally, the branching stems having about the same caliber as the parent. One of these sponge cups has grown to larger size than the other, and from the stem of the lesser has apparently branched off a third cup attached by a much shorter stalk. The true position of this third individual may quite possibly be concealed by the compression of the colony. Over the surface of these bodies, particularly about the base and stems, there is a perfectly evident cross-lining, indicating a network, but the greater part of the surface bears irregular, low ridges running longitudinally and in some measure evidently due to lateral compression, though some such roughened surface might well be quite normal to the sponge.

The other specimens here shown indicate variations from this individual expression. Figure 2 shows a young offshoot of small size, branching from the parent cup by a very short stem. In these specimens the network of the reticulum is much more clearly indicated. The stem here does not terminate so abruptly as indicated, but is further represented by a stain in the rock. It is not thought that this structure can be construed as a basal spicular tuft.

Figure 1 is a single individual broken at the basal end but indicating an extending stem, while figure 3 is the basal end and very much compressed stalk of another individual.

EXPLANATION OF PLATES

Plate 1

Hydnoceras walcotti sp. nov.

(Page 180)

The original specimen; two individuals lie side by side as they may have grown on the sea bottom. The drawing has been made from a plaster counterpart of the original natural mold.

Chemung group near Wellsburg, N. Y.

Plate I

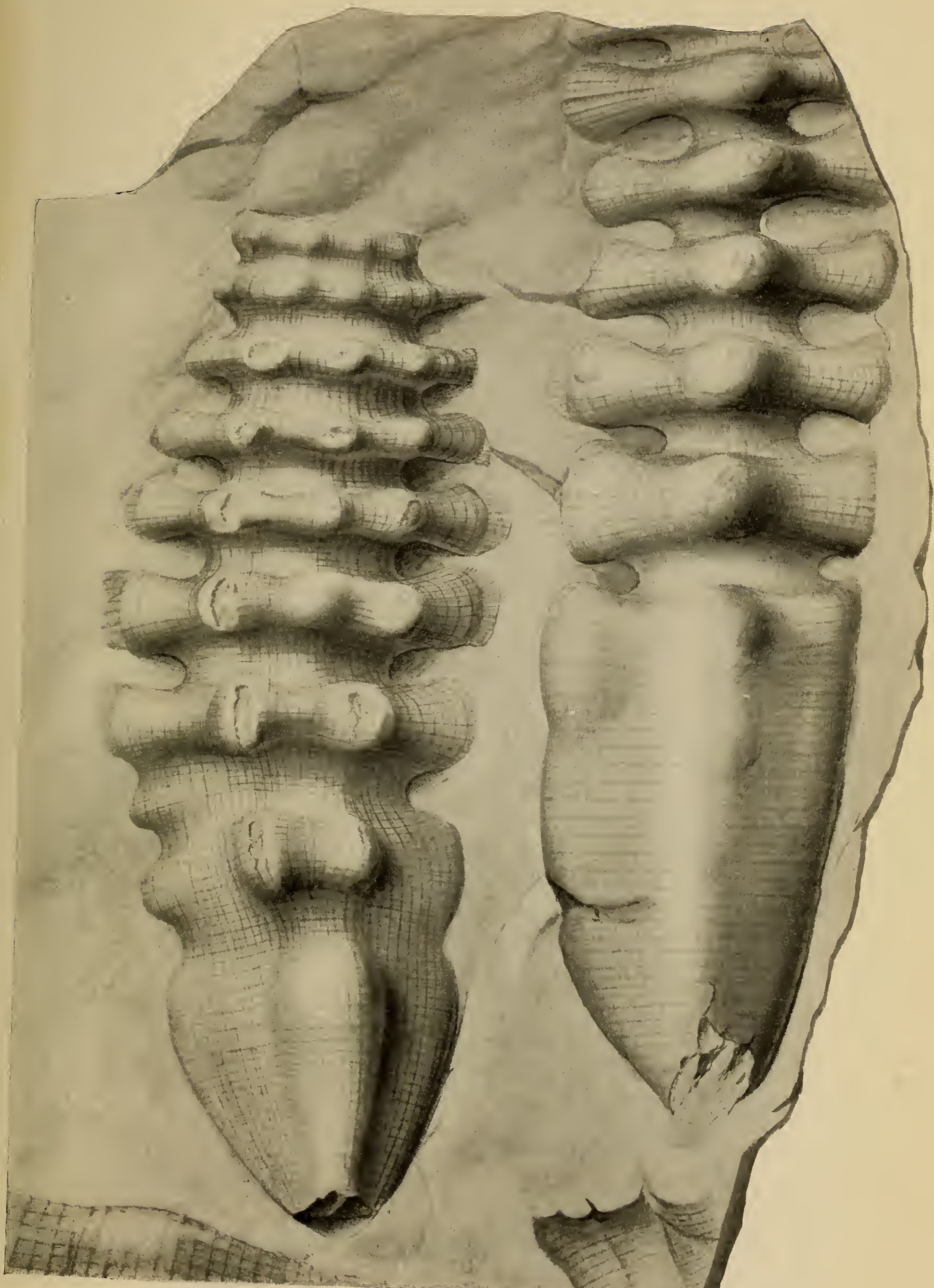


Plate 2

Ceratodictya oryx sp. nov.

(Page 180)

Figure 1. The shorter but better preserved specimen of this genus, showing the grooved annulations which are generally characteristic of Ceratodictya.

Figure 2. The longer of the specimens, but poorly preserved.

Both are casts from natural molds.

Chemung group, 6 miles southeast of Erie, Pa.

Plate 2

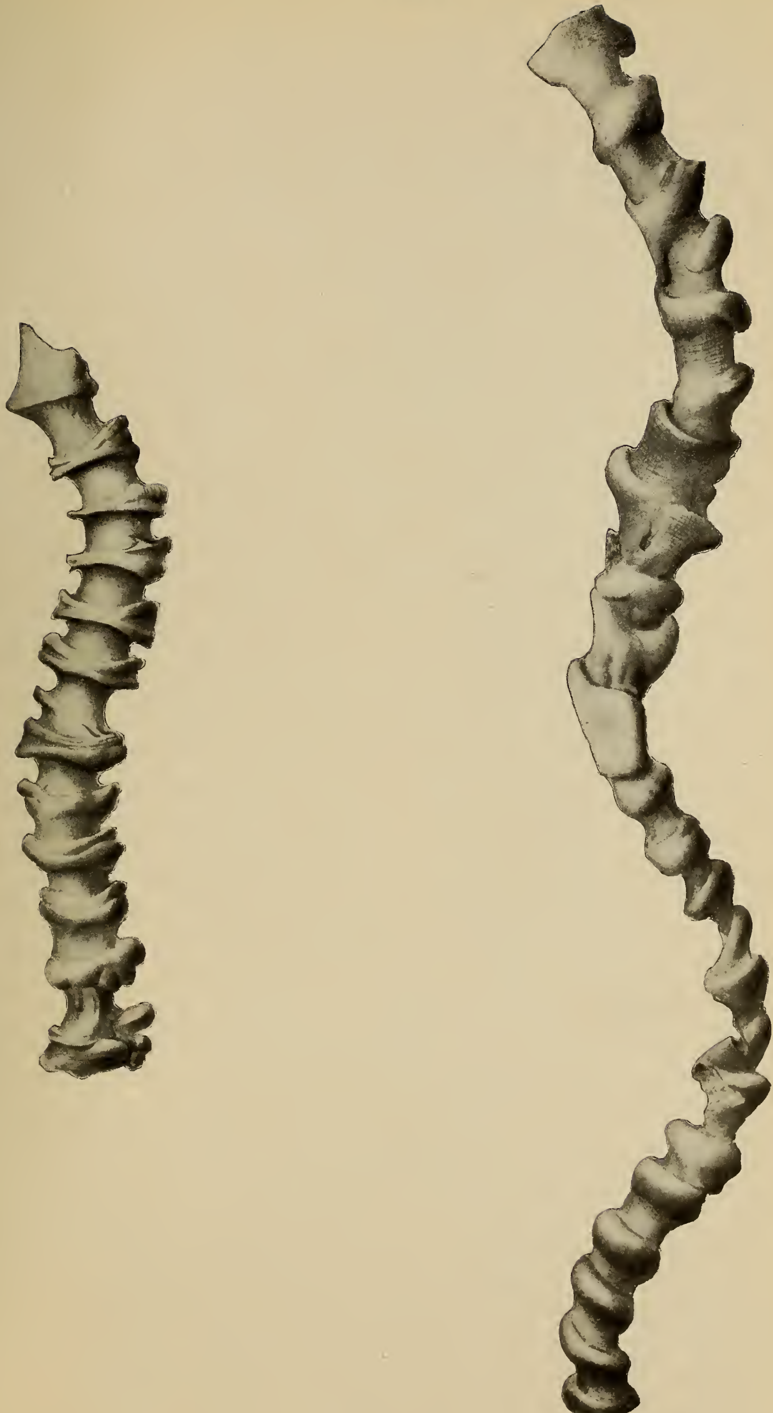


Plate 3

Hydnocerina armstrongi sp. nov.

(Page 182)

This is the best preserved of the specimens and shows the characteristic variation in the nodes upon the annulations.

Plate 3

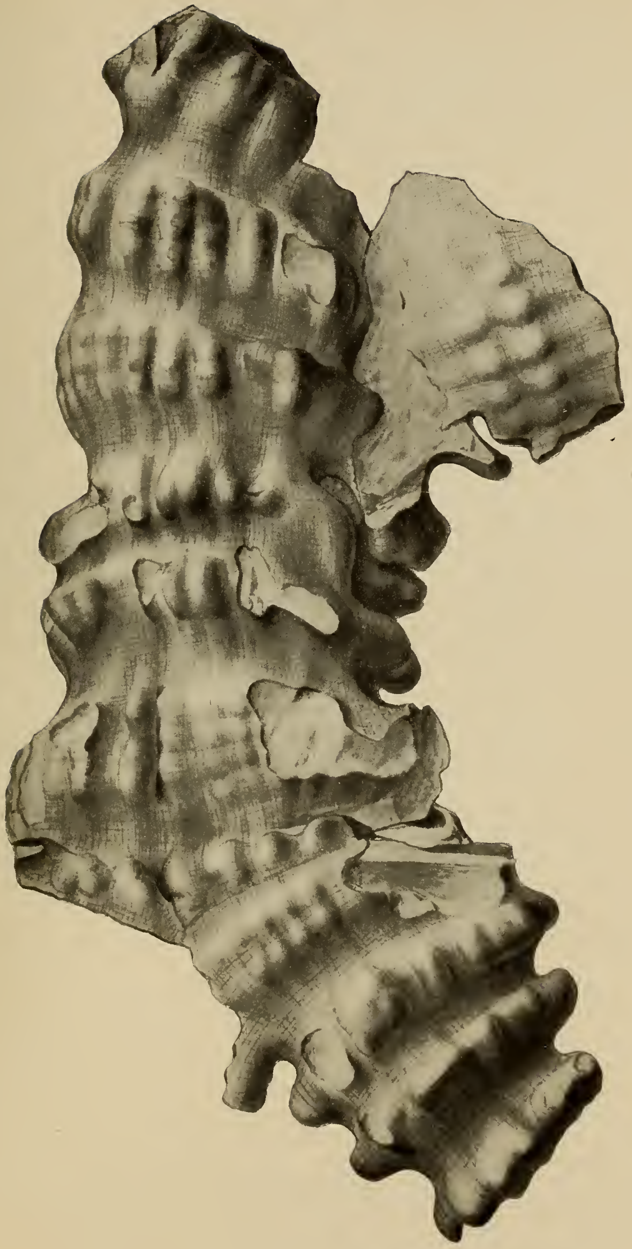


Plate 4

Cryptodictya tylea sp. nov.

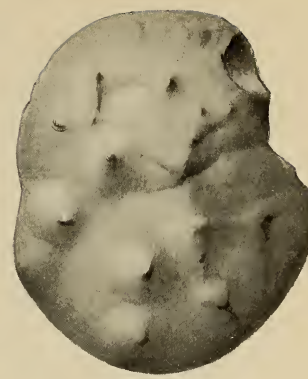
(Page 184)

Figures 1–5. This plate shows a series of these discoid sponge bodies as they occur somewhat flattened in the sandy shales of the Chemung group in the gorge of Six Mile creek, 7 miles east of Erie, Pa.

Plate 4

1

2



3

4

5

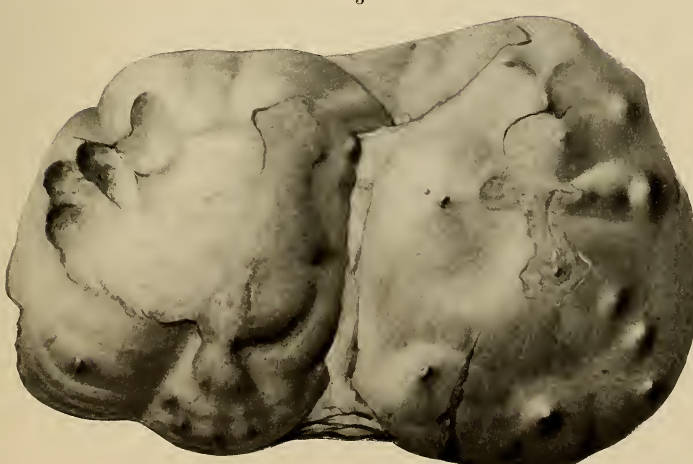


Plate 5

Ozospongia johnstoni sp. nov.

(Page 185)

Figure 1. A small single obcone of this species.

Figure 2. A specimen showing a single branching cone from the parent frond.

Figure 3. The base of an obcone retaining a part of the stem or pedicel.

Hydnocerina armstrongi sp. nov.

(Page 182)

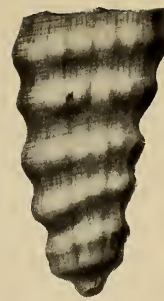
Figures 4 and 5. Opposite sides of the initial end of the individual which shows the incipient development of the nodes upon the rings.

Chemung group, 8 miles east of Erie, Pa.

Plate 5

1

4



5

2

3

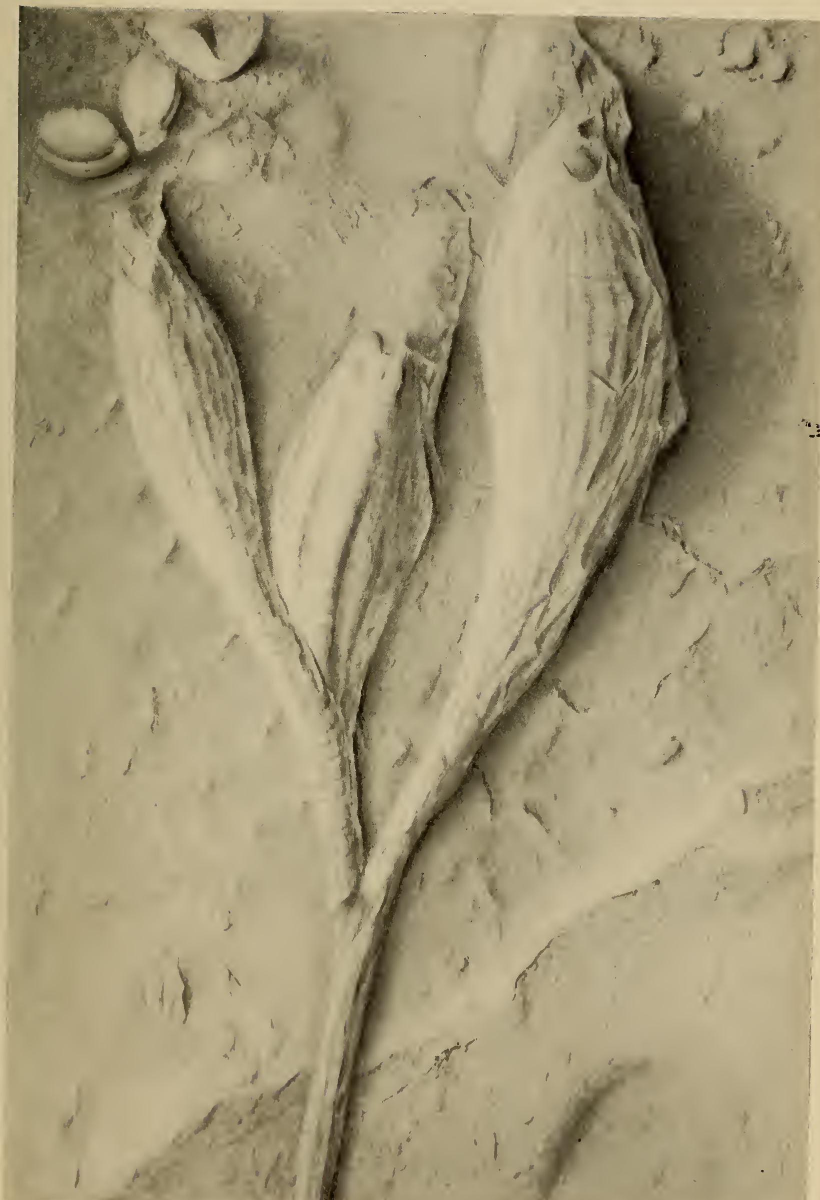
Plate 6

Ozospongia johnstoni sp. nov.

(Page 185)

The branching colony on which the description of the genus and species are based. This appears to represent three individuals or obcones derived from the same pedicel. All of the figures of this species have been made from plaster replicas of natural molds in the Chemung sandstone at Hinsdale, N. Y.

Plate 6



STRAND AND UNDERTOW MARKINGS OF UPPER DEVONIAN TIME AS INDICATIONS OF THE PREVAILING CLIMATE

BY JOHN M. CLARKE

The most conspicuous features on the surfaces of the sandy strata of the Portage group in the Upper Devonian of New York, are markings which have commonly been assigned to the moving of the waters over the strand. Wherever the beds of this important formational term of the Devonian become preponderantly sandy, these phenomena are observable. They have long been known; indeed, while they have commanded very little attention in the literature, and have been generally passed over as almost self-explanatory, the best outstanding descriptions of them are those given by the first official geologist reporting upon the region where these developments are most manifest. Reference is made to the descriptions of them given by James Hall, in the Geology of the Fourth District of New York, 1843, pages 232–37. These and the very striking illustrations he presented of them, have passed current as final, and even though occasionally his figures have been reproduced, there has been, so far as the writer knows, no published modification of his explanation of their origin.

During the many years which have elapsed since the date of that report, and especially since the writer's attention has been particularly directed to the phenomena, mechanical and biological, of the Portage formation, there has grown up in the Museum a very extensive collection representing the various expressions of these strand phenomena, from the study of which it has become perfectly obvious that we have not had a proper understanding of their origin. It is thought that the present paper may suggest a truer conception of them.

Preliminary observations. The phenomena which we have to discuss or to debate, are conformations in strong relief, invariably on the under side of the strata as they lie in normal position. The beds which bear these surface figures are slabs and flags of thin, hard sandstone; in other words, flagstones in which lamination beds are obvious but cleavage only potentially developed. In every case, also, the relief figures on these slabs in normal position fit into corresponding grooves and depressions in the underlying and intervening sandy shales. Emphasis is here to be laid upon the expression *sandy* shales, for when the shales are predominantly of clay, no such marks seem to have been made.[1] This is a fact and an observation which is in accordance with the interesting propositions recently set forth by Kindle,[2] who finds that the muddy bottom or muddy shore in which the sand is not predominant, is not competent to take such current marks as the commonly known ripple marks. The phenomena under consideration are not invariably those which can be interpreted by any action of moving water alone, so far as known to the writer, and it is necessary, therefore, to supplement the previous condition by stating that the shales of the Portage formation are prevailingly sandy, and in the upper measures of this formation, wherein these phenomena are most conspicuously shown, are quite inevitably sandy and therefore competent to take and preserve impressions that have been made by water in motion.

As a preliminary necessary to the understanding of this paper, reference is made at once to the accompanying illustrations. An effort has been here made to present these strand surfaces in their normal position and therefore counterparts in plaster of paris have been photographed to place alongside the pictures of the original rock specimens. If the observer's eye is quick to grasp these contrasting reliefs and intaglios, part and counterpart will help to remove risk from deceptive appearances. I say deceptive appearances, because even Professor Hall, in pointing out the fact that these marked sandstones occur with their relief surfaces downward in the strata, nevertheless so far forgot his statement as to illustrate one of the commonest varieties as a " cast of flowing mud," and such " mud flows " have been repeatedly referred to by geologists, as though their convex relief were the true one. " Mud flows " are in reality the natural casts of deeply marked strand slopes rilled and eddied by the ebbing tide.

In order, now, to present practically all the outstanding data regarding the particular phenomena with which we have to deal, I shall first quote from Professor Hall's very lucid description.

Casts of Mud Furrows and Striae

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

[1] Markings similar to some of those here noticed occur in great variety in other rock media and in many formations. Notice is incidentally taken here in the illustrations of such records on certain Silurian argillaceous limestones.

[2] E. M. Kindle. Recent and Fossil Ripple-mark. Mus. Bul. 25, p. 4, Canada Geological Surv. 1917.

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.

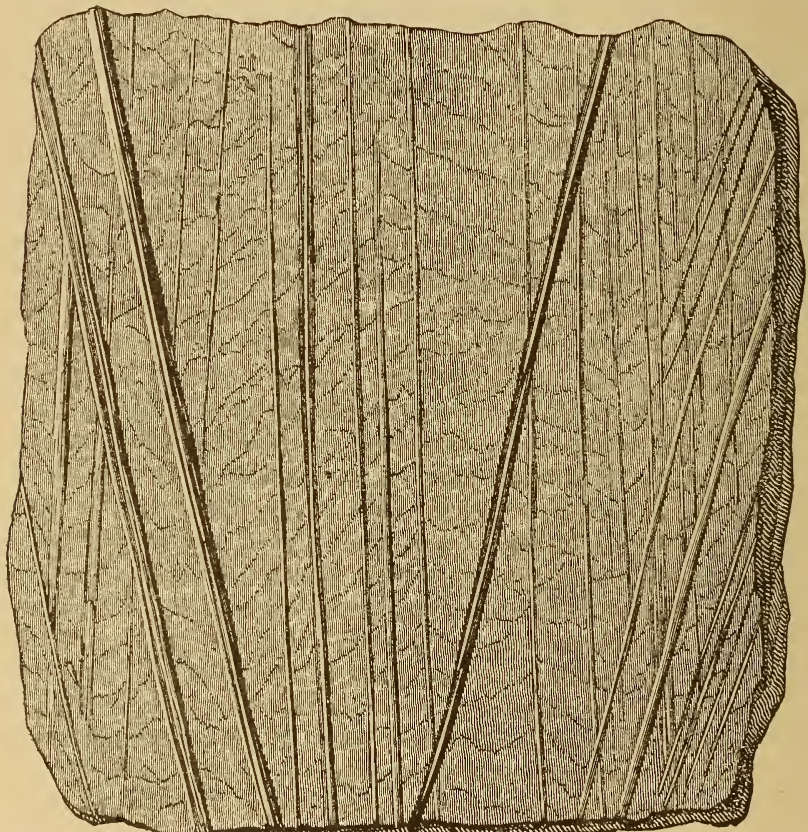
From the frequent occurrence of these, and their continuation through a great thickness of strata, we can hardly suppose the furrows to have been made upon hard surfaces; and if we suppose the mud in which they were made to have been soft, it seems almost impossible to conceive how they should be preserved. 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[1] the delicate wave lines and the minute 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 to 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.

This account is wise and safe; indeed may well be regarded competent so far as it goes. This phrase in the quotation may be emphasized, " they should be seen to be fully appreciated " — a characterization which in part justifies and leads to the present presentation.

[1] Pages 52 and 54 of the Geology of the Fourth District of New York.

Professor Hall in the above gave special attention to the remarkable casts of ridges and striae, and the specimen of these which he chose for his illustration is of such fine quality that the figure is here reproduced. It is no wonder that he compared them to glacial scratches upon subsoil rock surfaces, and little wonder, either, that later observers have looked somewhat suspiciously upon these scored



and grooved slabs as remarkably suggestive of ice work. In a paragraph directly following that quoted, Hall mentioned the fact that in two instances he had noted the direction of these ridges and found that it was nearly east and west. He also calls attention to the fact, which one occasionally sees, of the ragged surface of the furrow which was due, he intimates, to a tremulous motion in the body making it; just as one finds not infrequently among the glacial grooves. Furthermore, Professor Hall distinctly states his belief that he had detected on the same sandstone stratum in outcrops twenty miles apart, striations that ran in the same direction and suggested to him a uniform cause efficient over this entire stretch of strand or sea bottom. I regret very much not being able to verify so important an intimation. "Thus it appears," says Hall, "that, whatever may have been the cause, it operated very uniformly over large surfaces."

It is important for me to premise, in seeking the interpretation of these phenomena, that, in my experience, ripple marks in the Portage strata are of rather rare association with these other strand marks. If this statement is even approximately true, then the rhythmic factors producing ripple marks are measurably excluded from the formation of the strand marks under consideration. Doctor Kindle's perspicacious and faithful analysis of the causes to which ripple marks are due, finds, as we have intimated, that whether laid under water or under air, a sandy medium is essential; that ripple marks are of two kinds, symmetrical and asymmetrical; that the former are due wholly to oscillatory action of the water and occur, in his conclusion, entirely in fresh-water deposits, that is, in water bodies presumably free of tidal currents; while the other or asymmetrical type characterizes the salt water ripples. Disturbance in the currents, interfering waves or tidal flows, obstructions to regular flow, projections of rocky points between sandy beaches and over seething bottoms, are all influential in modifying the form of the ripple ridge and furrow, and the amplitude of the sand wave is in a definite though not determined relation to the force of the tidal ebb. Therefore, in the opinion of Doctor Kindle, which has been supported by the observations of others, principally those of Dr G. K. Gilbert, the ripple mark may be of any reasonable amplitude, often attaining a width of many feet.

The objects which we have under direct consideration, divide themselves into two groups; those which seem readily to explain themselves and those which obviously do not.

To the former we may reckon the characteristic "mud flows," as shown on our plates 7–14. These, it will be observed, are obviously the markings made by rills following the fall of the tide, or possibly the retreat of heavy storm waves on a strand of low pitch. These phenomena have various expressions and are often accompanied by collateral contemporary markings showing the dragging, scratching or otherwise indenting of the surface, presumably by objects dragged down by the ebb and following the same general direction as the surface rills. Tidal rills are produced by the downrush of considerable masses of water lagging behind the retreating and broken surge, and it is easily conceivable that larger amounts or continuous sheets of water, flowing down the strand, might produce series of unbroken water channels, rather than discontinuous rill channels. This is put forward as a possible explanation of the latter phenomenon, and as these and allied appearances seem to be intelligible by such explanations, they are included among those which are readily and deductively interpreted.

The other class of these strand markings includes those we are especially trying to interpret. Of this large class there are first the striated surfaces, which are here illustrated by specimens which are really less effective than that given by Professor Hall, but at the same time of more variant character. Various observers, speaking casually, have thought that these markings might have been due, in some part at least, to more or less compressed trunks of wood buried in the sand and fossilized. One might see a reason for such suggestions upon consulting our plates 16–19, but in my judgment this interpretation is absolutely excluded. There is seldom any straight tree-tissue associated with these beach marks, and whenever the opinion referred to has been expressed, it has generally been based upon the contemplation of the wrong side of the specimen. These slabs are actually grooved and furrowed in parallel lines, and these groovings are of various degrees of magnitude, from coarse to exceedingly fine. The surfaces of the larger grooves are not only sometimes, but usually striated finely by lines parallel to them. Even in our greatly reduced figures these details are very obvious and the fact stands out without reasonable challenge that these markings have been made by the dragging or shoving of irregular objects over the surface of the wet sand; not necessarily above water, but if not, then within the moderate water depths. One can conceive, for example, a heavy kelp attached at its root to a stone loosened from its moorings, thrown upon the strand and dragged down by the suck of the undertow, producing if moving with sufficient rapidity and without interruption, some such channelings as are indicated on our plate 16, or on plate 18, which is a single deep, sharply angular groove. But my observation leads me to doubt if anyone ever saw such an effect produced by the suggested cause. We may, however, for the moment, assume that heavy objects dragged by the undertow of storm waves might create such channeled strand and substrand surfaces as are here indicated.

Granting that the whole class of these parallel channelings and striations are of the mechanical origin suggested, I must say that my experience and observation do not justify the interpretation suggested above. I must therefore briefly refer to my field of observation in order to verify the conclusion which I am, by elimination, forced to reach with reference to these markings, and also to leave room specifically, for the wider or different experience of others in the observation of strand phenomena. In order to find some reasonable interpretation for these Devonian strand marks, many different kinds of coast have come under my examination — the broad and sandy shores and dune strands of bays and gulfs; mud flats a mile or more across, exposed and covered with every change in the tide; the short, steep, gravelly strands of rocky promontory fronts; capes and bays, retreats and endroits where the tidal interval may be slight or the tide waves rush in upon the coast like an army of white horses; tide-swept channels and broad, flat seabars of the islands, covering scores of square miles, among whose sands the sea breaks its way by inlets and gullies. I believe my experience has been variant and illuminating, much of it coming from intimate examination along several hundred miles of coast line on the shores and the islands of the Gulf of St Lawrence. I should remark further, that in this Gulf of St Lawrence region the tides are, as a rule, heavy; and heavy tides on strands of sharp angle would have the power, the other conditions being favorable, of producing such strand markings as those under discussion, if such markings could have been made this way. I am not convinced, either from my observation or from the considerable literature which I have been able to consult on the present action of the tides, that these things could have had the indicated origin under the action of such tides as exist today. It may be granted that heavier tides with more powerful undertow might have produced some of these effects. No such tides are now effective or at least no such tidal effects are, so far as observation and reading indicate, recorded. The world's tides may, it has been strongly contended, have been heavier in such ancient ages of the earth and so herein may lie a partial, in at least an alternative explanation of these channeled strands.

Let us now pass to the consideration of the so-called Fucoides graphica, the object early illustrated under this name by Vanuxem and by Hall, and which has long been known as eminently characteristic of these sandy Upper Devonian slabs, but whose vegetable nature was never contended for even at the time the name was applied to it. These things are short, straight, rodlike relief figures usually single but often crossed and in radiating fasces. They are large and small and lie at all angles with reference to the slope of the strand or of the bottom. If they are accompanied by parallel channelings or grooves, the " Fucoides " may lie between them or even upon them at every angle. They therefore can have nothing to do with any tidal flow or other mechanical movement of the waters which would have the power to arrange loose material lying on the bottom or on the beach. I have troubled a great many of my colleagues by asking of them an opinion as to the nature of these objects, and I have profited very much by a suggestion made to me by Prof. J. B. Woodworth. Professor Woodworth has intimated that these rodlike grooves might well have been produced at the bottom of the shallow water through the formation of ground ice; that the rods, independently or in mass, crossing and radiating, are directly comparable to ground-ice formation, and as a result of further study of ground-ice phenomena, I am confirmed in my belief that his intimations are sound. If this is a fair deduction, we may be confronted here with preliminary proof of seasonal or climatic freezing in the Portage ocean. The inference is confirmed by the character of the longitudinal strand channelings. The presence of ice and the moving of shore ice along the strand, its shoving up or its dragging down, are clearly indicated by these phenomena and may well be called upon and account for all the parallel striated surface to which we have referred, and very particularly to that illustrated on plates 21 and 22, where two striated grooves lie in the mud, commingled with the crystals of ground-ice.

The competency of ground or anchor-ice to produce such rodlike crystallizations, would seem reasonably evident from the discussions which have been given by various authors, and I shall take this occasion to quote somewhat from the volume by Doctor Barnes on "Ice Formation," with special reference to anchor-ice and frazil.[1] This spicular ice, in the opinion of not only the author cited but of other writers, forms at the bottom under varying physical conditions, and the fact that it may vary in respect to the size of the crystals or crystal groups formed, is emphasized at various points in this work. It is frankly to be admitted that no writer has had occasion to record observations on this spicular structure in which the crystallizing rods attain the size that are indicated for *Fucoides,* usually the spicules being fine and massed together in anchor-ice

[1] John Wiley & Sons, New York. 1906.

in spongy condition. Doctor Barnes cites remarks made by Sir William Dawson from his observations on the formation of such ice needles in the St Lawrence and elsewhere:

The spicular ice may further grow on the bottom in the manner in which crystalline needles form in some saturated saline solutions. The fact that it forms most readily in open water, without any covering of ice, and in clear cold weather, indicates that radiation from the bottom has an important influence in its formation, but where the water is sufficiently cold it may crystallize on any nucleus presented to it, and more especially, it would seem, on metallic bodies and stones which are good conductors of heat. Hind states that on the coast of Newfoundland anchor-ice forms in large masses in the sea at depths of 60 or 70 feet, and it has been known to raise stones and anchors from the bottom and to freeze round fish caught in nets. These are merely desultory observations from the point of view of a geologist, but they may serve to show that there are different kinds of spicular ice and that they may be formed in various ways. It seems certain that several of these modes of formation are concerned in the production of the spicular ice so troublesome in our river, so that it is not prudent to limit ourselves merely to one theory of formation any farther than the general principle that they all depend on the same rapid crystallization of water under circumstances in which it tends to form groups of spicular crystals rather than solid sheets.

The suggestions above given can not be regarded as conclusive of the ice crystal character of *Fucoides,* for they deal with objects of different magnitudes. Professor Woodworth, in his study of the Boston clay beds, has illustrated crystallizations of ice lying between the laminae of the clay, such frost marks as one might expect on surfaces where a small amount of moisture has been free to take on crystal form under proper conditions of cold. Such occurrences are frequently observed.[1]

While then the ice origin of these markings may not be conclusive in itself, these suggestive similarities to ground-ice and spicular bundles of ice crystallization, corroborated by the other evidences here brought together of the work of the ice upon these ancient strands, give good reason for the deduction that all these phenomena together are to be referred to the glacious conditions of the Portage sea.

As a corroboration of the foregoing interpretation, there is an interesting reference to the grooving action of the ice foot when well loaded with stones, in the account of the travels of Lyell in North America on his first visit, 1841–42. This is referred to because at

[1] The Glacial Brick of Rhode Island and Southeastern Massachusetts, by N. S. Shaler., J. B. Woodworth and C. F. Marbut. 17th Annual Report, Director U. S. Geological Survey, 1896, p. 951.

the time Mr Lyell was here, he and his colleagues were struggling for an interpretation of what were then commonly known as "glacial" phenomena; but the glacier itself, as a factor in producing such phenomena, had not yet arrived. Both Lyell and Hall used the word "glacial" in their writings with reference simply to the action of ice, and in most every application thereof at this time, to the action of moving berg or floe ice carried southward over the surface of the continent. Mr Lyell was always searching the beaches for an evidence of rock grooving caused by the movement of such ice, and on this first trip it was not until he had practically made his entire tour, that he happened to find what he sought on the rock beds of the beach at Cape Blomidon, Nova Scotia. I quote his memorandum regarding this occurrence[1] without reproducing his illustrations and for the purpose of indicating here the effectiveness of such a grinding by the ice, not only of such soft beaches as we have been considering, but even on the rocky slopes of the strand:

As I was strolling along the beach at the base of these basaltic cliffs, collecting minerals, and occasionally recent shells at low tide, I stopped short at the sight of an unexpected phenomenon. The solitary inhabitant of a desert island could scarcely have been more started by a human footprint in the sand, than I was on beholding some recent furrows on a ledge of sandstone under my feet, the exact counterpart of those grooves of ancient date which I have so often described in this work, and attributed to glacial action. After having searched in vain at Quebec for such indications of a modern date, I had despaired of witnessing any in this part of the world. I was now satisfied that, whatever might be their origin, those before me were quite recent.

The inferior beds of soft sandstone, which are exposed at low water at the base of the cliff at Cape Blomidon, form a broad ledge of bare rock, to the surface of which no sea weed or barnacles can attach themselves, as the stone is always wearing away slowly by the continual passage of sand and gravel, washed over it from the talus of fallen fragments, which lies at the foot of the cliff on the beach above. The slow but constant undermining of the perpendicular cliff forming this promontory, round which the powerful currents caused by the tide sweep backwards and forwards with prodigious velocity, must satisfy every geologist that the denudation by which the ledge in question has been exposed to view is of modern date. Whether the rocks forming the cliff extended so far as the points [indicated] 10, 50, or 100 years ago, I have no means of estimating; but the exact date and rate of destruction are immaterial. On this recently formed ledge, I saw several straight furrows half an inch broad, some of them very nearly parallel, others diverging, the direction being N. 35° E., or corresponding to that of the shore at this point. After walking about a quarter of a mile, I found

[1] Charles Lyell. Travels in North America, 2: 144. 1845.

another set of similar furrows, having the same general direction within 5 degrees; and I made up my mind that if these grooves could not be referred to the modern instrumentality of ice, it would throw no small doubt on the glacial hypothesis. When I asked my guide, a peasant of the neighborhood, whether he had ever seen much ice on the spot where we stood, the heat was so excessive (for we were in the latitude of the south of France, 45° N.) that I seemed to be putting a strange question. He replied that in the preceding winter of 1841 he had seen the ice, in spite of the tide, which ran at the rate of 10 miles an hour, extending in one uninterrupted mass from the shore where we stood to the opposite coast at Parrsborough, and that the icy blocks, heaped on each other, and frozen together or "packed," at the foot of Cape Blomidon, were often 15 feet thick, and were pushed along when the tide rose, over the sandstone ledges. He also stated that fragments of the "black stone" which fell from the summit of the cliff, a pile of which lay at its base, were often frozen into the ice, and moved along with it. I then examined these fallen blocks of amygdaloid scattered round me, and observed in them numerous geodes coated with quartz crystals. I have no doubt that the hardness of these gravers, firmly fixed in masses of ice, which, although only 15 feet thick, are often of considerable horizontal extent, have furnished sufficient pressure and mechanical power to groove the ledge of soft sandstone.

In Nova Scotia the term "loaded ice" is in common use for large sheets of ice several acres in area, which are sometimes floated off from the rivers as the tide rises, with sedge and other salt-marsh plants frozen into their lower surfaces; also with mud adhering plentifully to their roots. In our speculations, therefore, on the carrying power of ice, we ought always to remember that, besides gravel and large fragments of rock, it transports with it the finest mud.

Doctor Harding informed me that the surface of mudbanks along the estuaries near Wolfville are often furrowed with long, straight and parallel ruts, as if large wagons had passed over them. These conform in their general direction to the shore, and are produced by the projecting edges of irregular masses of packed ice, borne along by the tidal current.

Essentially good and well-established reasons otherwise exist for believing that in the Gaspé peninsula at least, the period of the Middle Devonian was followed by a general coating of land ice. I have written somewhat at length upon this theme and it is not necessary to enter here into detail, but the premises are, first, the absence in the Gaspé succession, of any true late Middle or early Upper Devonian deposits; second, positive evidence of the ice-worn, ice-scratched morainic material outwashed and heaped together in beds beneath the Upper Devonian fish deposits of Migousha on the Bay of Chaleur. There is then reason for inferring that the late Devonian was a period of cold which brought the land ice down to what is now the edge of the sea at the northeast, and may well have created conditions, regardless of the alternation of the seasons, which would give plenty of means for channeling the Devonian strands of New York, by the movement of land ice toward the sea or by the landward thrust of the sea ice back from the water.

References to Literature Consulted

Ridpath, J. W. High Tides of the Bay of Fundy. Franklin Inst. Jour. v. 167. 1909.

Kruger, Gustav. Ueber Sturmfluthen an den deutschen. Kusten d. westl. Ostsee. 1904.

Seebach, K. v. Ueber die Wellen des Meeres u. ihre geolog. Bedeutung (Virchow Samml. 7 ser. heft 153) 1872.

Walther, P. Land u. See. 1907.

Hunter, H. W. Rivers and Estuaries or Streams and Tides. 1913.

Mitchell, H. Tides and Tidal Phenomena; Navy Scientific Papers No. 2. 1868.

Davis, C. H. Law of Deposit of the Flood-tide. Smithson. Contrib. to Knowledge, v. 3. 1851.

Greenwood, W. N. Phenomena of the Tides. Shipmasters Soc. London, No. 30. 1893.

Carr. Tide-lands of California. 1869.

Bourdelles. Etude du régime de la marée dans la Manche. Ann. d. Ponts et Chaussees, v. 9. 1899.

Darwin, G. H. The Tide and Kindred Phenomena in the Solar System. 1898.

Brocklehurst, G. The Trent "Aegír." Wide World, London 1914, v. 32.

Parsons, H. de B. Tidal Phenomena in the Harbor of New York. Amer. Soc. Civil Eng. Proc. 1913, v. 39.

EXPLANATION OF PLATES

(All illustrations, unless otherwise stated, are from Portage slabs and all are much reduced in size.)

Plates 7 and 8

7 is the original, 8 the plaster counterpart showing the true surface. For the purpose of reversing the relief, figure 8 is placed so that the depressions expand upward or toward the top of the plate. This is " mud flow "— 7, as it is found in natural cast; 8, as it was made by rills flowing down the beach (from bottom to top of plate).

Plate 7

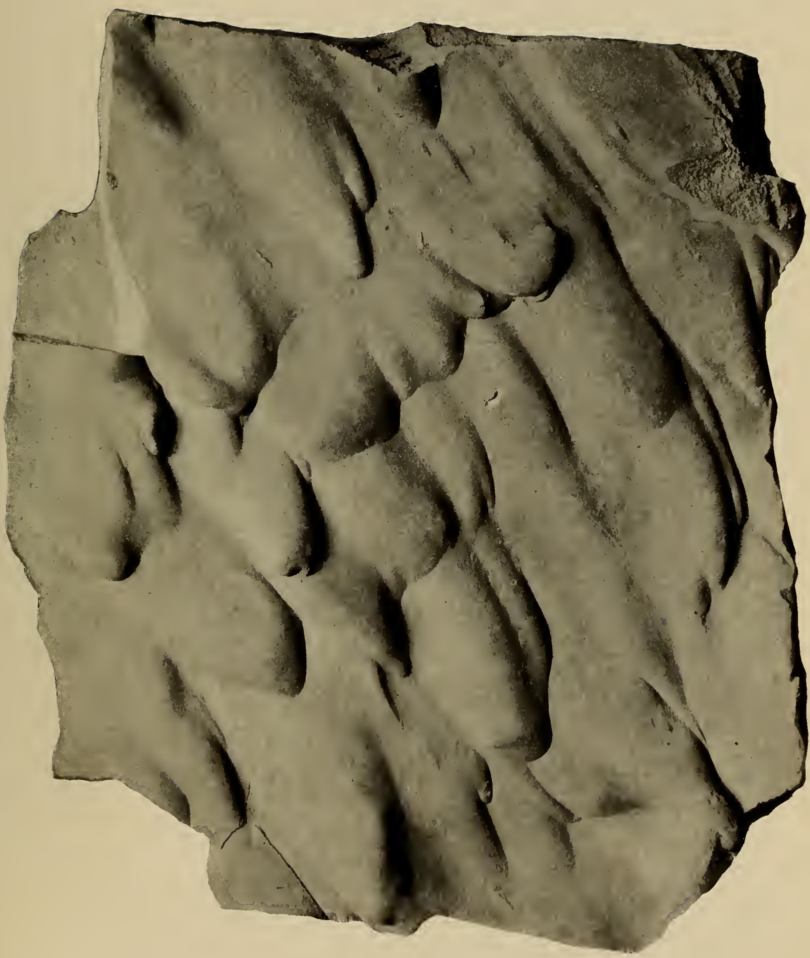
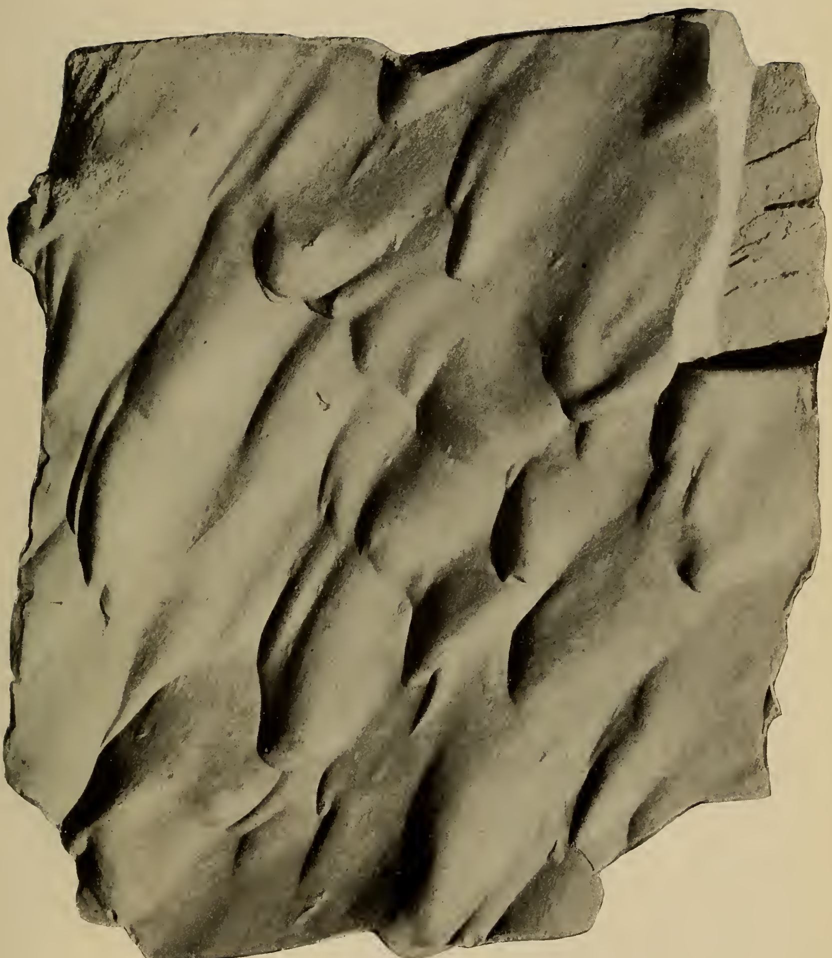


Plate 8



Plates 9 and 10

9 original; 10 counterpart; the latter placed so that the rill discharge is toward the bottom of the page. One may note here as on the preceding figures the flanges at the side of the rilled channels which indicate a stronger followed by a weaker flow of water; that is, the gradual running off of the wave or tide. At the sides of the slab are continuous channels and accessory markings; scratches and bruises of the sand are also evident.

Plate 9

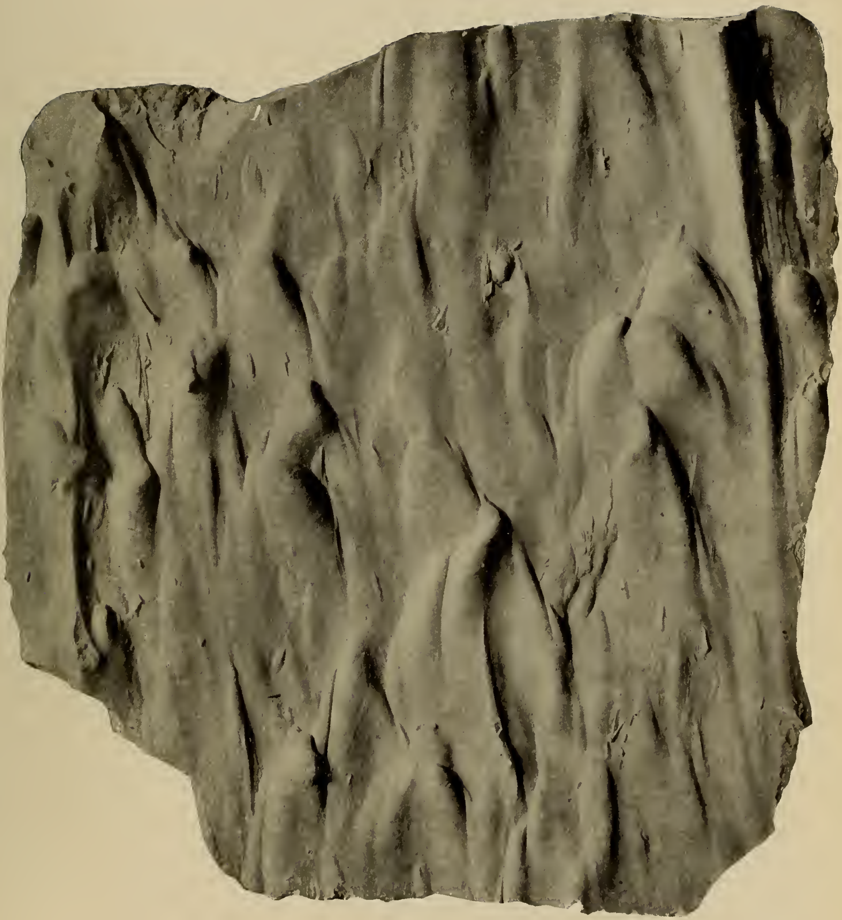


Plate 10

Plates 11 and 12

11 original; 12 counterpart. This "mud flow" is interesting as showing straight surface scratches made by objects carried down with such celerity and directness as to touch only the upper surfaces of the rilled channels. They are obviously later than rills. The flow is here downward to the right.

Plate 11

Plate 12

Plates 13 and 14

13 original; 14 counterpart. A very fine illustration of this sort of configuration.

Plate 13

Plate 14

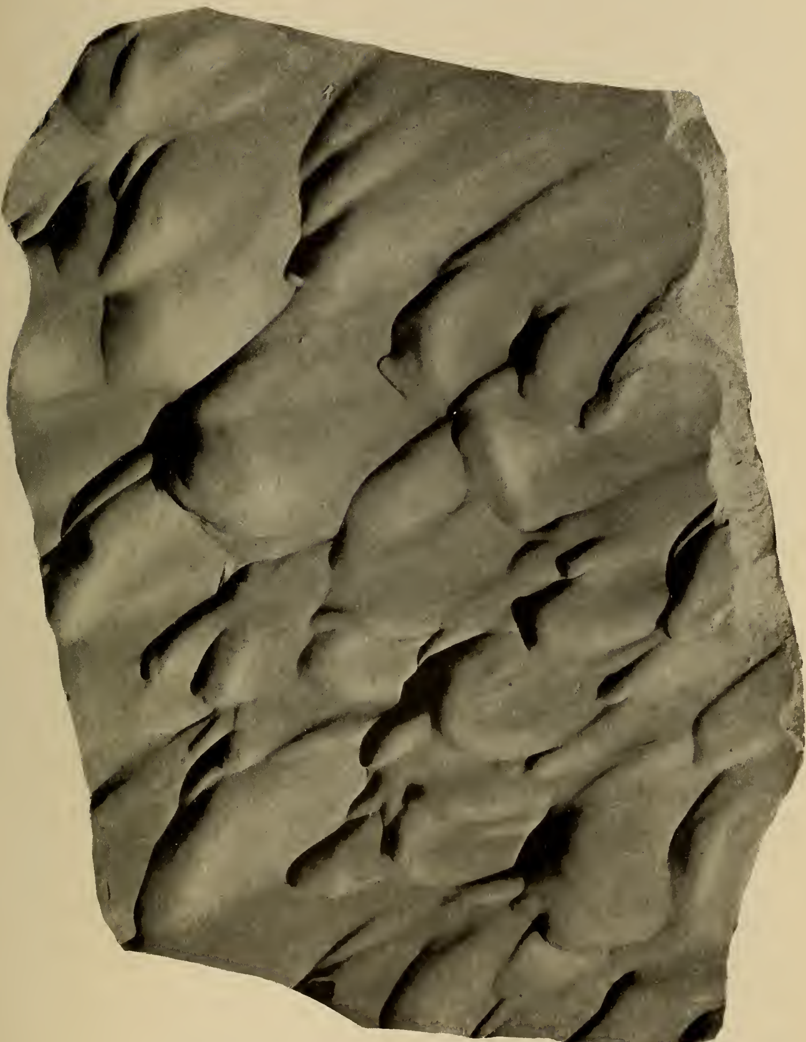
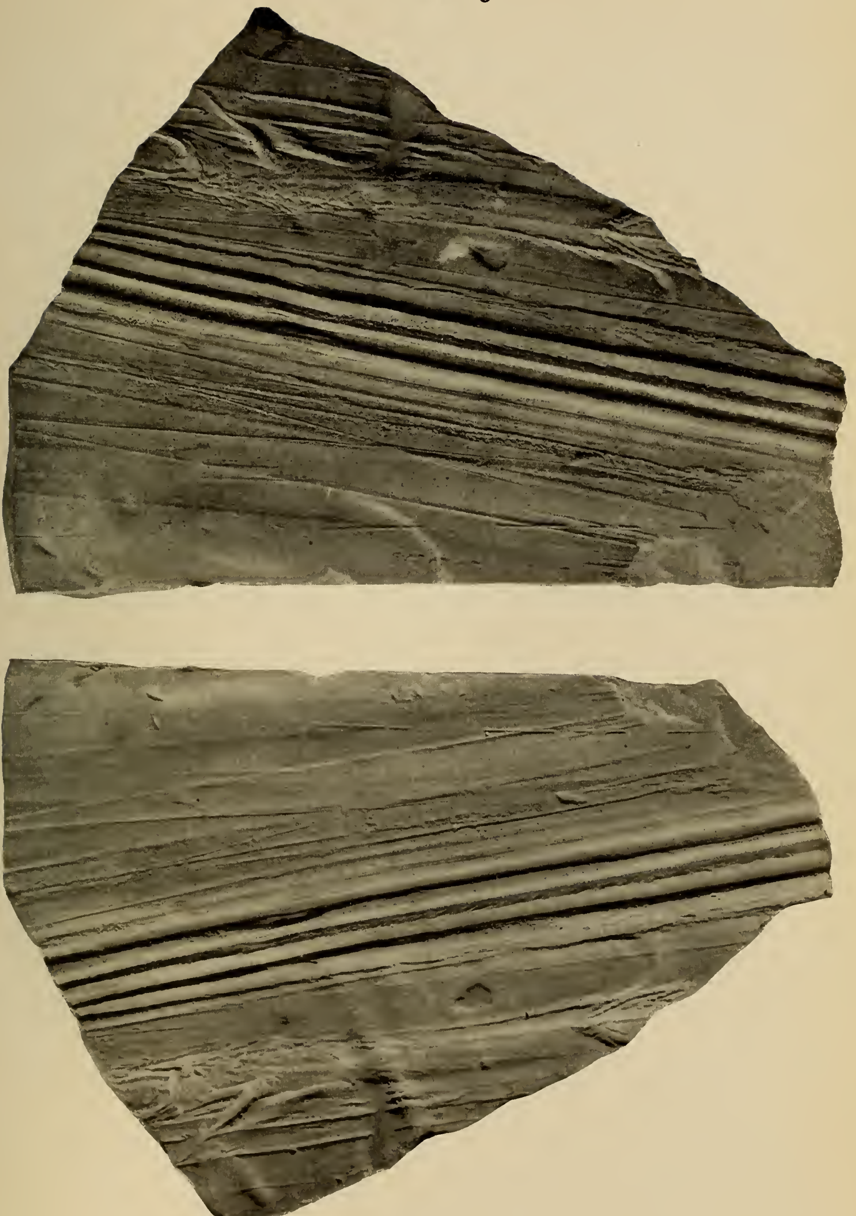


Plate 15

Original and counterpart. Grooved and striated surfaces. These two are so much alike because close reading with the eye does not readily catch the difference between them. General parallelism in the striae is accompanied by crossing lines and vibratory "chattering" is indicated. Striation as shown on the original is carried out with extreme delicacy.

Plate 15



Plates 16 and 17

16 original; 17 counterpart. Deeply channeled (ridged) and finely striated slab.

Plate 16

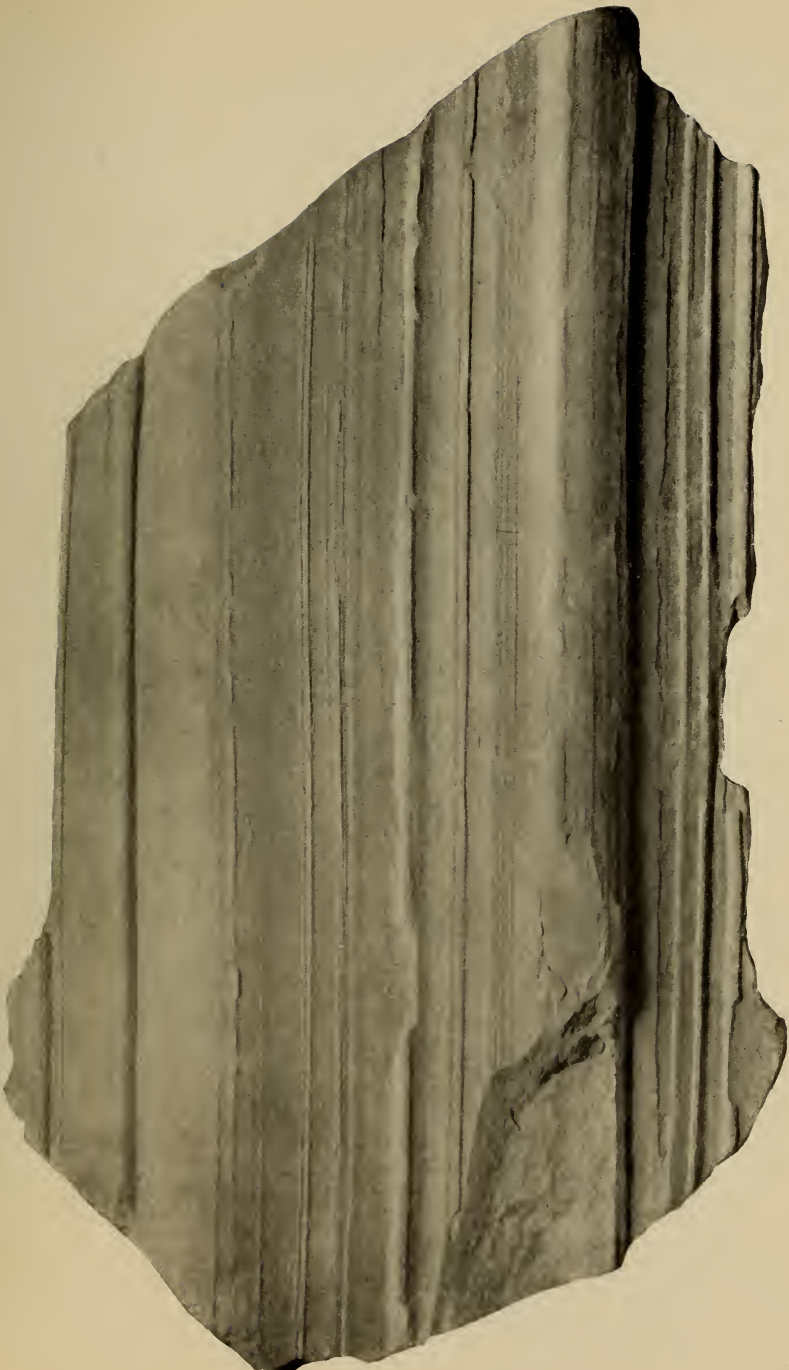
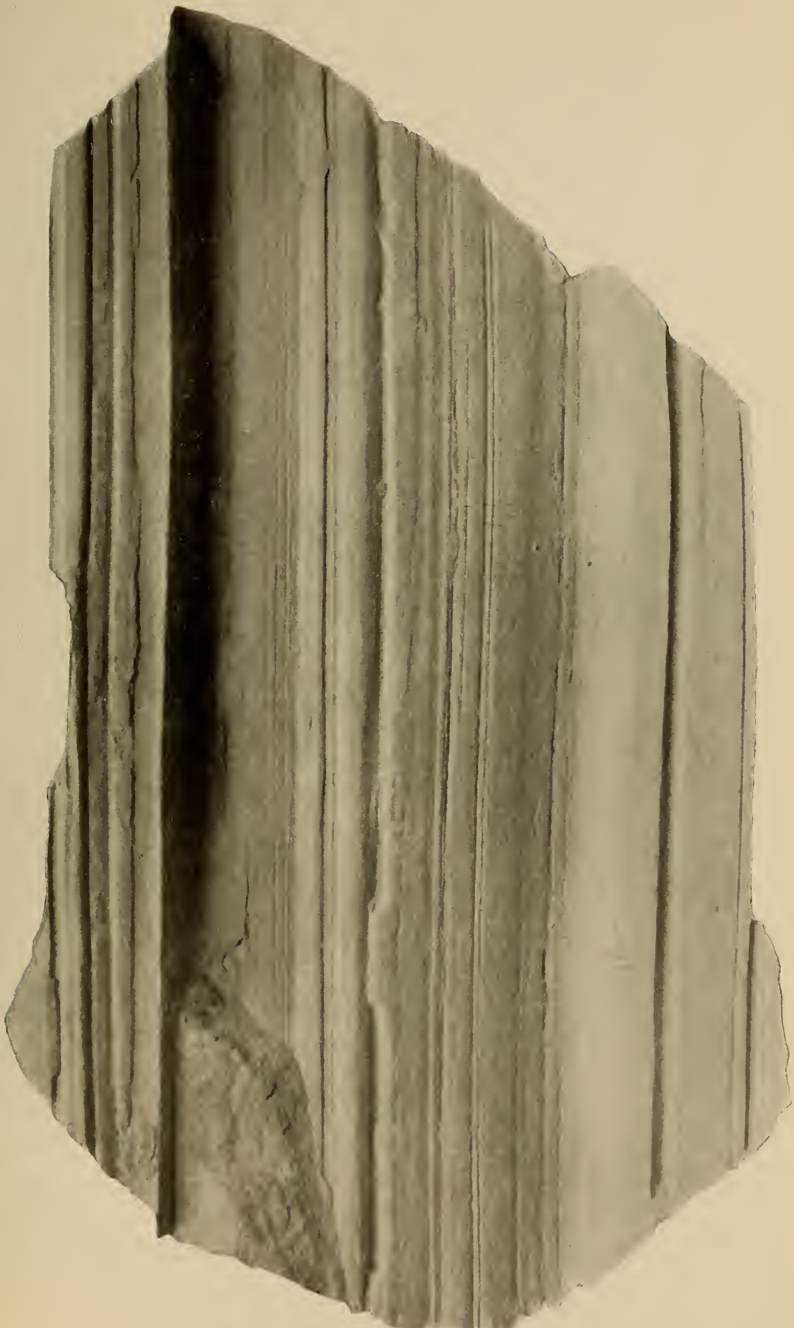


Plate 17

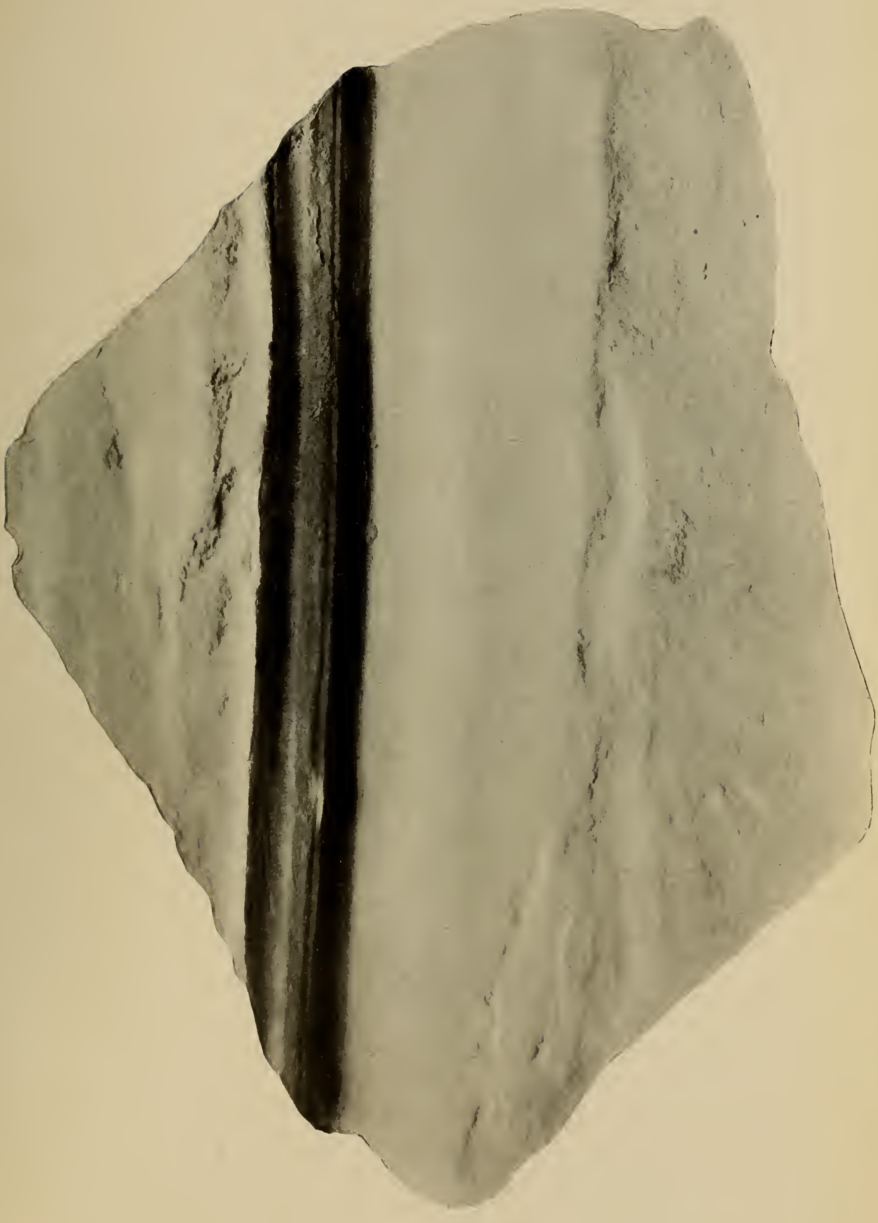


Plates 18 and 19

18 original; 19 counterpart. A single sharply angular and striated groove. The attempt to show the depth of the groove on the sand has not been very successful.

Plate 18

Plate 19



Plates 20 and 21

20 original; 21 counterpart. A typical slab of "Fucoides graphica"; short straight rods (depressions) with tapering and squared ends lying at various angles with reference to each other and to the bottom. Some of these angles are approximate to or suggestive of ice angles and there is observable a tendency to radiation from several centers.

Plate 20

Plate 21

Plates 22 and 23

22 original; 23 counterpart. This slab shows the ice crystals, "Fucoides," lying on a surface of the sand in which is buried a goniatite shell (Manticoceras) and over which have been dragged two objects, presumably rough-edged stones set in ice, which have made deep and clearly striated channels. The interspaces show a fine parallel striation. It is seen that the ice crystals of the "Fucoides" formed on the sand after the grooves were made.

Plate 22

Plate 23

Plates 24 and 25

24 original; 25 counterpart. This is an illustration of the winnows or wave ridges of sand pushed together on the beach by successive overriding and retreating waves or wavelets. 24, the original, presents them as shallow, narrow, oblique grooves; 25, the true aspect of the surface, is placed so as to bring out the delicate relief as effectively as possible.

Plate 24

Plate 25

Plate 26

Vertical Silurian limestones in the cliff of Mt Joli, Percé, showing ripple and other strand markings on the under surface of the thin limestone plates.

Plate 26

Plate 27

A closer view of the same, showing on various surfaces the casts of snail tracks or worm meanderings over the wet sand of the beach.

Plate 27

Plate 28

Another part of the same section of jointed thin limestones with snail-tracked and polygonal ripple-marked layers.

Plate 28

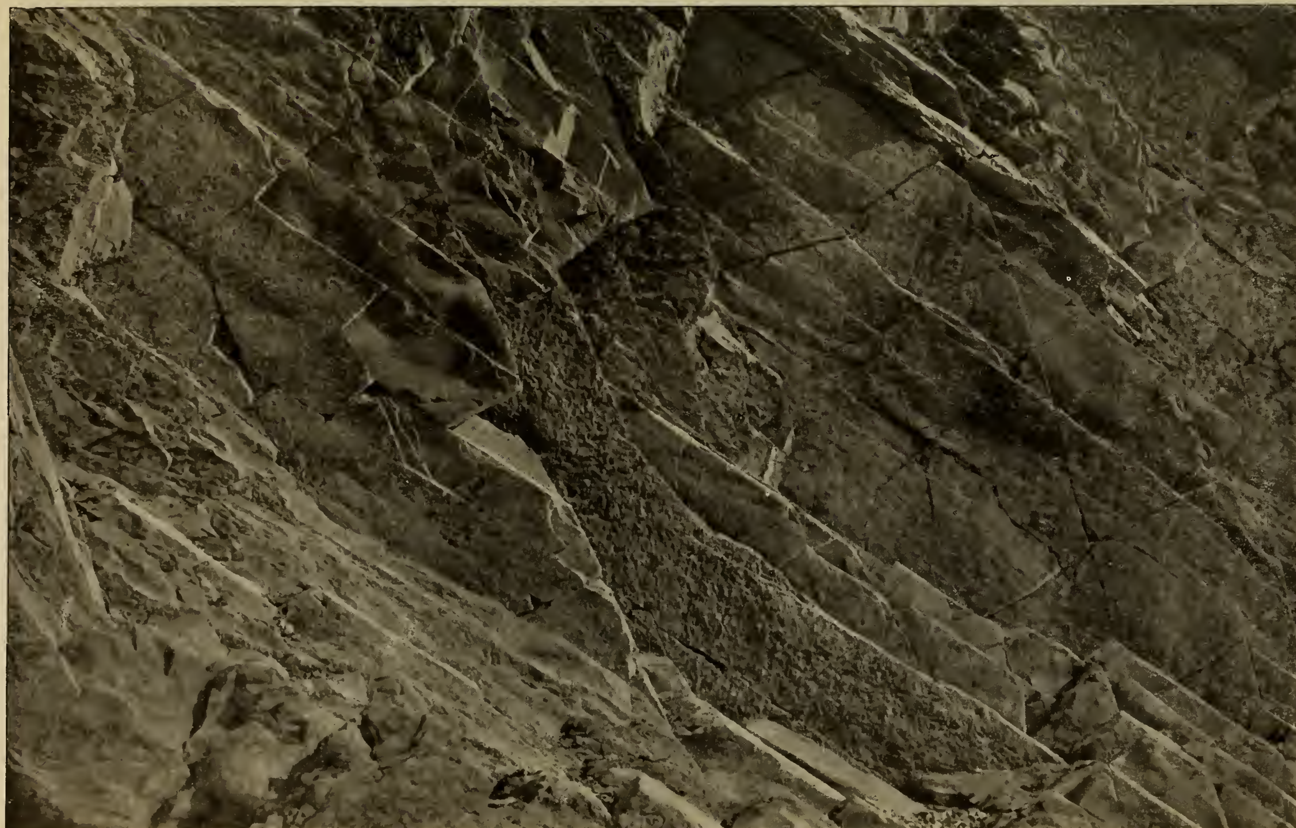


Plate 29

This view of the same cliff shows, on a limestone surface, the relief impressions of rill marks; the characteristic "mud flows" of the sandy strata elsewhere described.

Plate 29

PRIMARY AND SECONDARY STRESSES

RECORDED BY THE VEIN SYSTEMS IN THE PERCÉ ROCK

BY JOHN M. CLARKE

(Plates 30–32)

The Percé rock in Gaspé, P. Que., to which reference has frequently been made in these publications, is a block of lower Devonian limestones standing almost on end. An isolated mass out of the flank of a great anticline of Appalachian type, it is a part of the mountain folds of the Gaspé peninsula. The strains to which it has been subjected through upturning of its strata were naturally manifold and as some part of these were torsional the rock mass has been considerably cross-checked by fissures now filled out of calcite veins.

There is, however, a very evident record of successive strains which, when closely read, gives an interesting clue to the history of the deformations; and this record is illustrated in plan by the accompanying sketch made by the writer. Doubtless there are like evidences of other disruptions which may point to later stages in the development of the rock mass.

In studying the figure on plate 30 the observer is looking down on the vertical strike edges of the strata, which are made up of limestones largely composed of fine sand grains stained brilliantly by red and yellow iron oxides, the former, a bright brick red, predominating. Of the two vein series crossing these strata, the older is an anastomosing network in which the main strands have a generally parallel direction. These veins are all solid white calcite, filling the fissures entirely and streaked lengthwise by black deposits of impurities. The veins of this series are of prevailingly larger size than the others and may be several feet across. Generally they contain no inclusions of wall rock or other material and are thoroughly healed wounds of the rock mass.

The secondary series crosses the primary at a bold angle; in one place, however, a branch of this fissure series has opened along the middle of one of the primary veins. These veins are red in general cast of color, brighter even than the mother rock; carry well-defined wallbands of crystalline calcite and later bands upon these; they are filled with a breccia of small horses which are partly fragments of the mother rock and partly pieces of the crystalline wall lining or a continuous laminated deposit of the calcareous red sand which composes the rock itself. Where broad, the veins are still open and lined with calcite crystals.

It is very obvious that these secondary fissures have been built in a different way than the primary. Torn-off parts of old fissure linings and bits of the rock itself may have got into them with the process of rending the strata, but the laminated sand deposits which completely fill the veins over a considerable extent can have come only from the washing into the open fissure of the sand resulting from the meteoric decomposition of the rock itself. It is to be conceived that these secondary fissures opening across the strata when exposed to weathering agencies, received from the wash of the rain, etc., the red limestone sand which now fills them.

The inference, therefore, is that however ancient the primary series of fissures may be, the secondary series is of relatively late origin.

The torsion stresses in these rocks are indicated by the photograph on plate 31.

Plate 30

Sketch of primary and secondary series of veins in the Percé rock. The observer is looking down upon the strike edges of thin Devonian limestones.

[242]

Plate 30

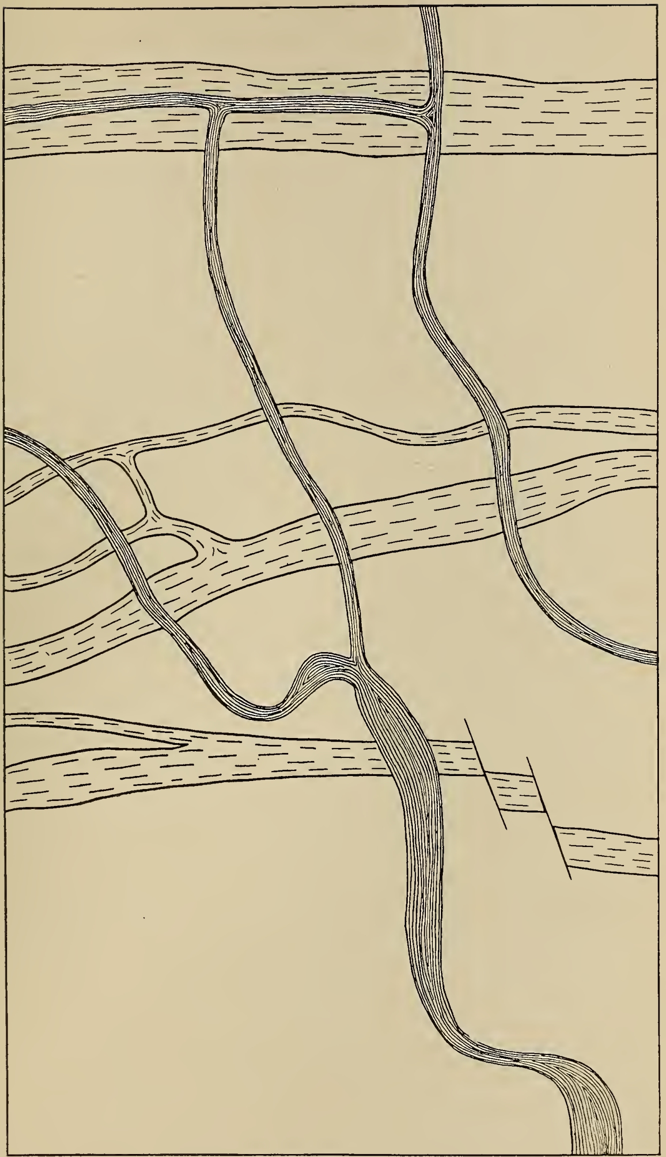


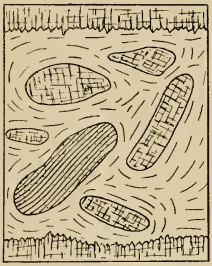
Plate 31

Figure 1. Sketch of a section of part of the secondary vein illustrated on plate 30. This shows the filling of the vein by solid calcite-carrying fragments which are parts of the crystalline wall of an earlier vein of the same series, and also a fragment of the red lime-sand filling of which this secondary vein is now largely composed.

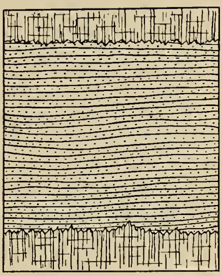
Figure 2. A similar section of the secondary series of veins in which the entire vein-space is filled, with the exception of the crystalline wall lining, with red lime-sand derived by influx into the fissure from above.

Figure 3. A fragment of the limestone showing a major vein at the bottom and the series of torsion veinlets departing therefrom.

Plate 31



1



2

3

Plate 32

Front view of the Silurian limestone pit at Mt Joli, showing a horizontal displacement of the beds, definitely bounded by undisturbed upper and lower surfaces. At X the vertical layer is not displaced but the fault that starts there and travels across the section shows actual displacement. This displacement is terminated by the layer which is shown at the left of the plate; unfortunately not fully shown in this photograph.

Plate 32

THE MINING AND QUARRY INDUSTRY OF NEW YORK STATE

REPORT OF OPERATIONS AND PRODUCTION DURING 1916

BY D. H. NEWLAND

INTRODUCTION

The mineral industries of the State made a good record in 1916, and more than restored the losses that were experienced during the slump of the preceding year or two. Prices were more favorable than they had been for a long time, and the demand in many branches, particularly those related to metallurgical and chemical manufacturing, readily absorbed all the supplies that had accumulated as well as the year's production. It was a period of great activity and high prices.

An exception to the general prosperity obtained in the branches dependent upon the building trades, such as stone and clay wares, in which the conditions were not altogether favorable. Although prices were better than for some time, the scarcity of labor and the higher scale of wages served to restrain production and diminish profits. The cement manufacturers, however, had a good season.

A new item in the list of mineral products of the State, which helped to expand the total for the year, was zinc ore from the mines near Edwards, St Lawrence county. The initial market shipments were made in 1915, but the past year was the first in which operations were continuous throughout a twelvemonth. Owing to the fact that so far only a single company has been engaged in production of the ore for the furnace, the output is not listed separately in the table. Preparations were under way during the year to revive operations in some of the old zinc-lead mines in southeastern New York.

The statistics of production incorporated in the present report have been collected by the United States Geological Survey and the New York State Survey in cooperation; this plan was adopted by the two offices so as to diminish the task of collecting and compiling the information and to give uniformity to the results.

The summary of the various industries active in the State, as presented in the accompanying table, shows that the value of the year's production reached the sum of $45,947,947, which established a new record. The best previous year was 1913 when the corresponding figures were $41,598,399. As compared with the total for 1915, there was an increase in the value of $9,667,508, or about 27 per cent. It is to be noted in connection with the statistics that they are based for the most part upon materials in crude and first marketable forms, as they are shipped from the mine or quarry, rather than finished products, and consequently represent only a fraction of the total which are contributed annually by the mineral industries in the more general sense. If such materials as iron and steel, coke, sulphuric acid, carborundum, aluminum, alkali products, artificial graphite, etc., manufactured in the State were included, the total would amount to several times the aggregate returned by the particular industries covered in this report.

Mineral production of New York in 1916

PRODUCT	UNIT OF MEASUREMENT	QUANTITY	VALUE
Portland cement	Barrels	5 603 477	$5 752 809
Natural cement	Barrels	104 415	51 635
Building brick	Thousands	982 942	6 497 270
Pottery	....	....	3 344 672
Other clay products	....	....	1 913 070
Crude clay	Short tons	11 158	36 413
Emery	Short tons	15 282	123 901
Feldspar and quartz	Short tons	20 379	115 311
Garnet	Short tons	5 840	198 200
Graphite	Pounds	*a*	*a*
Gypsum	Short tons	579 827	1 459 587
Iron ore	Long tons	1 464 917	5 571 429
Millstones	....	....	10 287
Metallic paint *b*	Short tons	14 572	34 296
Mineral waters	Gallons	7 746 490	697 650
Natural gas	1000 cubic feet	8 594 187	2 524 115
Petroleum	Barrels	874 087	2 190 195
Pyrite	Long tons	*a*	*a*
Salt	Barrels	14 087 750	3 698 798
Molding sand	Short tons	661 673	570 898
Other sand and gravel	Short tons	7 436 424	2 073 931
Sand-lime brick	Thousands	15 851	109 337
Slate	Squares	2 727	21 345
Granite	....	....	368 119
Limestone	....	....	3 672 454
Marble	....	....	268 391
Sandstone	....	....	714 558
Trap	....	....	956 100
Talc	Short tons	93 236	961 510
Zinc ore	Short tons	*a*	*a*
Other materials *c*	....	....	2 011 666
Total value	....	....	$45 947 947

a The output is reported under "Other materials" in last item of table.
b Iron ore sold for paint manufacture.
c Includes zinc ore, apatite, diatomaceous earth, graphite, marl, mica and pyrite. The value of the zinc ore is based on that of the metallic zinc recovered from the mine product.

CEMENT

BY ROBERT W. JONES

With the great increase in building construction which opened with the year 1916 there came a steady demand for the output of the portland cement plants in the State. Nine plants were in operation during the year as compared with 7 in 1915. One plant was temporarily out of commission due to destruction of a portion of the plant by fire. One new company began to produce. This plant is operated by the Acme Cement Corporation, in the Catskill district, having taken over the property of the Seaboard Portland Cement Company. The old plant of the Cayuga Cement Company, Portland Point, Tompkins county, after being extensively reconstructed is again in operation under the management of the Cayuga Cement Corporation. Properties at Phelps, Ontario county, were under examination for the production of portland cement.

There was during 1916 a total of 5195 feet of rotary cement kilns in operation as compared with 4019 feet in 1915 and 4499 feet in 1914. Of the total number of feet in operation during 1916, only 1750 feet were operating under the wet system. The total number of feet represents the combined length of 37 kilns varying in diameter from 5 feet to 12 feet and with a combined daily available output under normal conditions of 26,000 barrels.

After allowing 7½ cents a bag and four bags to a barrel, the price of portland cement f. o. b. New York, opened in January at $1.37 and continued at this figure until May when it rose to $1.42, where it remained until December, the year closing at $1.62. This was a considerable increase over the selling price of the preceding year, when a maximum and minimum were $1.32 and 92 cents respectively.

The factory shipments of portland cement in the State amounted to 5,603,477 barrels with a value of $5,752,809 as compared with a production of 5,219,460 barrels and a value of $4,175,528 for 1915. There were on hand at the mills on January 1, 1916, a total of 729,436 barrels, and at the end of the season on December 31, 1916 a total of 776,856 barrels. A little trouble occurred during the summer months in securing barge capacity for the Hudson River plants.

The Alpha Portland Cement Company has entered upon the production of potash for agricultural purposes, making a product in the form of a calcium salt carrying a minimum of 2¼ per cent soluble potash. This country before the war imported annually potash-bearing materials which if reduced to pure potassium oxide would amount to practically 360,000 tons, with a value of $20,000,000. The flue dusts and gases produced during the manufacture of portland cement generally carry a considerable percentage of the alkalies. It has been estimated that if all the cement plants carrying available potash in the United States could be equipped to produce this material, there would be an annual production equivalent to approximately 80,000 tons of potassium oxide.

Materials grouped under the heading of natural cement were produced to the extent of 104,415 barrels, with a value of $51,635. The decline in production of natural cement was very great during 1916. In the previous year there was a production of 223,564 barrels with a value of $134,138. There were 4 plants in operation with a combined total of 18 kilns. Of this number, 12 were of the continuous type of vertical kiln, having a daily available capacity, under normal conditions, of 90 barrels each; the others belong to the old style of intermittent vertical kiln of variable capacity.

The following table gives the statistics of cement production in the State for the period 1897–1916. The figures prior to 1904 have been taken from the annual reports of the *Mineral Resources*. It will be noted that the amounts given for the year 1916 represent shipment rather than production, but the difference is not important.

Production of cement in New York

YEAR	PORTLAND CEMENT		NATURAL CEMENT	
	Barrels	Value	Barrels	Value
1897	394 398	$690 179	4 259 186	$2 123 771
1898	554 358	970 126	4 157 917	2 065 658
1899	472 386	708 579	4 689 167	2 813 500
1900	465 832	582 290	3 409 085	2 045 451
1901	617 228	617 228	2 234 131	1 117 066
1902	1 156 807	1 521 553	3 577 340	2 135 036
1903	1 602 946	2 031 310	2 417 137	1 510 529
1904	1 377 302	1 245 778	1 881 630	1 207 883
1905	2 117 822	2 046 864	2 257 698	1 590 689
1906	2 423 374	2 766 488	1 691 565	1 184 211
1907	2 108 450	2 214 090	1 137 279	757 730
1908	1 988 874	1 813 622	623 588	441 136
1909	2 061 019	1 761 297	549 364	361 605
1910	3 364 255	2 939 818	292 760	147 202
1911	3 416 400	2 930 434	274 973	134 900
1912	4 495 842	3 488 931	287 693	142 165
1913	5 146 782	4 873 807	193 975	95 565
1914	5 667 728	5 088 677	232 076	115 117
1915	5 219 460	4 175 528	223 564	134 138
1916	5 603 477	5 752 809	104 415	51 635

CLAY

BY ROBERT W. JONES

The building trade industry for 1916 was affected by a variety of conditions. In general, construction was carried on at a higher rate than in the preceding year, although held back to a considerable extent by labor and transportation difficulties, both in regard to construction and production. A certain portion of this increase in construction is the result of a sudden demand due to war conditions and may not be considered as being permanent. There is, however, a heavier demand growing up for burned clay materials in construction, especially where fireproof conditions are concerned.

The following table gives the value of the output of clay materials in the State, exclusive of crude clay, for the last three years:

Production of clay materials

MATERIAL	1914	1915	1916
Common brick	$4 597 856	$4 886 734	$6 433 266
Front brick	105 439	153 572	64 004
Paving brick	680 226	382 502	204 209
Hollow brick	38 119	59 683	*b*
Fireproofing	245 034	177 844	174 786
Terra cotta	892 630	647 815	714 041
Fire brick and stove lining	331 671	502 478	498 410
Drain tile	92 938	91 221	63 756
Sewer pipe	81 000	*a*	*a*
Pottery	2 405 676	3 064 274	3 344 672
Miscellaneous	4 630	36 250	257 868
Total	$9 475 219	$10 002 373	$11 755 012

a Included under miscellaneous.
b Included under fireproofing.

During 1916 there were 216 plants in the State which were in a condition to produce clay products of various grades. Thirty-four of these plants were idle and 19 reported a production of pottery, for which the crude materials, except that used for red ware, were imported. Five plants producing miscellaneous burned products also secured their crude materials from sources outside the State.

Sales of burned clay material during the season had a value of $11,755,012. Onondaga county led with a production of $1,630,587, most of which is represented by sales of pottery. Ulster county occupied second place with sales amounting to $1,444,275 made entirely of common soft mud building brick. Erie county was third with sales of $994,994, followed by Rockland county with $809,019. Thirty-four counties of the State were productive, of which 32 reported a production of common soft mud brick, 8 reported a production of drain tile, 3 of paving brick and 7 of fireproofing.

The sales of common building brick for 1916 amounted to 977,085,000, with a value of $6,433,266. The actual production during the same period was 945,348,000, with a value of $6,196,284, as compared with 934,726,000 and a value of $4,886,734 for 1915. Of this number during 1916, 59,414,000, were made by the stiff mud wire-cut process, with a value of $445,112 as compared with 41,896,000 and a value of $290,003 for 1915.

Production of clay materials by counties

COUNTIES	1914	1915	1916
Albany	$369 312	$447 344	$459 665
Broome	*a*	*a*	*a*
Cattaraugus	334 557	180 290	157 676
Cayuga	8 765	9 800	8 100
Chautauqua	168 134	128 798	106 937
Chemung	*a*	*a*	*a*
Clinton	*a*	....	....
Columbia	198 866	271 672	350 771
Dutchess	430 269	491 156	552 271
Erie	819 427	710 101	994 994
Greene	196 889	130 093	188 032
Kings	449 839	489 264	719 963
Livingston	73 775	724 267	170 982
Monroe	168 463	98 863	169 856
Montgomery	*a*	*a*	*a*
Nassau	96 534	92 559	135 931
Niagara	38 213	44 188	67 999
Oneida	45 000	159 400	80 100
Onondaga	1 556 093	1 293 022	1 630 587
Ontario	68 762	232 149	369 068
Orange	319 500	461 233	577 829
Queens	472 616	333 904	356 399
Rensselaer	124 152	233 332	116 994
Richmond	454 646	515 600	527 903
Rockland	747 026	446 583	809 019
St Lawrence	*a*	*a*	*a*
Saratoga	255 562	270 950	552 294
Schenectady	354 872	411 018	572 792
Steuben	*a*	*a*	*a*
Suffolk	69 300	66 600	96 097
Tompkins	*a*	*a*	*a*
Ulster	895 126	1 059 377	1 444 275
Warren	*a*	*a*	*a*
Washington	10 186	59 300	7 800
Westchester	321 826	303 558	170 547
Other counties	427 509	337 952	360 131
Total	$9 475 219	$10 002 373	$11 755 012

a Included under other counties.

COMMON BUILDING BRICK

The year 1916 opened with great activity along the lines of building construction. Owing to this increase the supply of burned clay building material in stock had been drawn on to such an extent that very early shipments were necessary from the Hudson River yards. The productive season, of the Hudson valley, closed with approximately 60,000,000 bricks in the yards. During January common brick were selling in the New York market as high as $10 a thousand with an average of $9. This was the highest selling price for common brick since May 1906. During January 1915, there was sold in this market 8,400,000 Hudson river common as compared with 20,650,000 for the same period of 1916. Many of the larger yards produced throughout the winter months, bringing the stock in the yards to 135,000,000 at the opening of navigation. At the beginning of March common brick were selling at $8.50 a thousand with a slightly smaller demand. In April the price dropped to $8.25 and in May to $8, with a final reduction at the end of the month to $7.50. In June the price rose to $8.25, resulting from a shortage due to labor difficulties. In July the price fell to a minimum of $7 with an average of $7.50. Clean brick from demolished buildings began to be a factor in the trade with a selling price of $3 a thousand. In September building construction received a setback and combined with labor troubles on construction managed to hold the price at $7.25. In October orders for future delivery began to be called and the price rose to $7.75 with a further increase to $8.25 for the first two weeks of November, the month closing at $9.25. Transportation and labor troubles again affected the market. In December 6,000,000 bricks were unexpectedly placed on the market, but due to the heavy demand had no effect on the price which closed for the year at $10 with a minimum of $9.50.

Production of common building brick by counties

COUNTY	1915 NUMBER	1915 VALUE	1916 NUMBER	1916 VALUE
Albany	68 112 000	$392 344	71 183 000	$442 640
Cayuga	1 100 000	6 100	*a*	*a*
Chautauqua	3 905 000	31 187	*a*	*a*
Columbia	57 766 000	271 672	59 415 000	350 771
Dutchess	108 459 000	491 156	87 779 000	552 271
Erie	28 807 000	176 010	43 639 000	323 006
Greene	27 555 000	130 093	29 683 000	182 524
Monroe	7 738 000	38 690	*a*	*a*
Nassau	13 783 000	86 747	*a*	*a*
Oneida	22 200 000	154 200	10 320 000	78 100
Onondaga	22 635 000	155 376	22 486 000	166 260
Orange	84 997 000	461 233	80 450 000	577 829
Richmond	38 341 000	176 657	*a*	*a*
Rockland	87 917 000	446 583	121 967 000	809 019
Saratoga	53 390 000	267 950	92 010 000	549 894
Suffolk	11 100 000	66 600	*a*	*a*
Ulster	211 230 000	1 059 377	222 651 000	1 444 275
Westchester	47 619 000	278 955	18 357 000	126 197
Other counties	38 072 000	195 804	117 145 000	830 480
Total	934 726 000	$4 886 734	977 085 000	$6 433 266

a Included under other counties.

Hudson River region. The total production from this district was slightly less than the preceding year with an output of 691,485,000 and a value of $4,485,526. The following table gives the production of the Hudson River region for the last two years:

Output of common brick in the Hudson River region in 1915

COUNTY	NUMBER OF OPERATORS	OUTPUT	VALUE	PRICE PER THOUSAND
Albany	11	68 112 000	$392 344	$5 68
Columbia	4	57 766 000	271 672	4 70
Dutchess	14	108 459 000	491 156	4 62
Greene	5	27 555 000	130 093	4 70
Orange	6	84 997 000	461 233	5 42
Rensselaer *a*	1	....	....	....
Rockland	18	87 917 000	446 583	5 07
Ulster	21	211 230 000	1 059 377	5 01
Westchester	5	47 619 000	278 955	5 85
Total	85	693 655 000	$3 531 413	$5 09

a The output of Rensselaer county is included with that of Albany county.

Output of common brick in the Hudson River region for 1916

COUNTY	NUMBER OF OPERATORS	OUTPUT	VALUE	PRICE PER THOUSAND
Albany	11	71 183 000	$442 640	$6 21
Columbia	4	59 415 000	350 771	5 90
Dutchess	14	87 779 000	552 271	6 29
Greene	5	29 683 000	182 524	6 14
Orange	7	80 450 000	577 829	7 18
Rensselaer *a*	....	....	....	....
Rockland	19	121 967 000	809 019	6 63
Ulster	22	222 651 000	1 444 275	6 43
Westchester	3	18 357 000	126 197	6 87
Total	85	691 485 000	$4 485 526	$6 48

a The output of Rensselaer county is not included with that of the Hudson river counties, having tidewater transportation.

CRUDE CLAY

Sales of crude clay as reported had a value of $36,413. Of this amount, slip clays reported a total of over 50 per cent of all the crude clays shipped. The amount reported in excess of the slip clays was entirely for the production of red burned ware and coke oven use. This clay came almost entirely from Onondaga county.

FELDSPAR

The discussion as to the use of feldspar for the extraction of potash, noted in the previous issue of this report, was continued during the past year, but so far as known no definite steps were taken toward the establishment of an active industry. While it is generally agreed among chemical technologists that there is no special obstacle to the extraction of potash, so far as the methods are concerned, opinion seems to be divided in regard to the commercial outcome of the undertaking, in view of the probable reduction of market values with the close of the war. An establishment on a commercial basis would have to be of large capacity and would entail a correspondingly large initial outlay. The matter thus becomes mainly of financial nature.

Some difficulty would likely be encountered, however, in finding a suitable location for such an establishment. Most of the large feldspar deposits are situated in rather remote districts, where fuel and other needed supplies are not readily to be had. Another matter which has not been adequately considered in the discussion hitherto is the amount of waste which would have to be dealt with in the working of most feldspar deposits. These are in the nature of coarse granites and carry quartz and other minerals besides the feldspar. Furthermore, very few occurrences contain the potash varieties alone (microcline and orthoclase) but usually they have considerable, if not important, amounts of the soda-lime varieties or the plagioclases. In nearly all the New York State occurrences the common variety of potash spar is microcline. Orthoclase is a rarity. The microcline often is intergrown with the soda variety (albite) in such manner that the two can not be mechanically separated, and thereby the potash content is brought down very considerably below the amount required by the chemical formula for microcline.

There were no important developments in the production of feldspar for pottery and other established uses, and the output, as reported, of 16,240 long tons valued at $82,461 showed no material change from the total of the preceding year. The figures are inclusive of unsorted pegmatite, which is shipped by two quarries in the Adirondacks for roofing and other purposes. The active quarries included two in Essex county, one in Fulton and one in Westchester county.

A detailed account of the feldspar resources of the State was incorporated in the report of the New York State Museum, entitled "The Quarry Materials of New York," published in 1916. There is an abundance of the mineral among the crystalline formations of the Adirondacks and the Highlands, where it occurs in "giant granites" or pegmatite intrusions, some of which attain large size. Only a few of the large occurrences have so far been developed. The market for feldspar and the prices obtainable do not encourage extensive exploitation of the resources, and only under favorable conditions can deposits be profitably worked.

Among the factors that have to be taken into consideration in determine the possibilities of a particular occurrence, some relate to the intrinsic characters of the deposit which require more or less expert knowledge to determine. The geological features are important in relation to the form and probable extent of the body, since there is almost every variation in these respects to be met with among pegmatites. Tabular bodies or dikes, with parallel walls and of indefinite continuity downward, are rather the exception than the rule in the large workable occurrences. More commonly these have a rounded, lenticular or irregular shape as seen on the surface, while the concealed portion is likely to be variable as well. Some pegmatites occur in normal granites as local differentiation phases and show gradation by imperceptible stages on the borders, but such rarely exhibit so coarse crystallization as the separate intrusions. The size of the crystal individuals is a factor of practical importance, since it affects more or less the work of sorting and cobbing. In all quarry operations, except those connected with the production of roofing material, there is considerable waste in the preparation of the shipping product, the proportion varying with each separate occurrence. In some the loss may amount to fully one-half of the rock broken down, represented by quartz, lime-soda feldspar, and the less important silicates like mica, hornblende, tourmaline etc., the presence of which is detrimental to the use of the spar for pottery manufacture.

The other factors that need to be considered are the situation with respect to shipping facilities and the distance to market. The selling prices, which in recent years have ranged between $3 and $5 a long ton for selected crude spar of pottery grade, impose narrow limits upon the costs of haulage and freights. The market centers are Trenton, N. J., and East Liverpool, Ohio, where are situated the largest pottery manufacturers. The local pottery industry, though important, does not afford a sufficient outlet for the quarry product of the State.

GARNET

The production of abrasive garnet last year was stimulated by the widespread industrial activity and by the curtailment of supplies of foreign abrasives owing to the high ocean freight rates. The Adirondack mines, which yield the larger part of the domestic supply, reported a gain of about 50 per cent in the year's shipments, a very encouraging increase after the general dulness which has obtained in the industry in recent years. The output has averaged around 4000 tons, and only a few times has it exceeded 5000 tons. The output for 1916, however, established a new record.

The largest operations in the Adirondack region were carried on by the North River Garnet Co., at Thirteenth Lake, near North River, Warren county. This company has a large, open quarry in a great body of garnetiferous gneiss that consists of acid feldspar and hornblende, with garnet crystals rather plentifully distributed through the mass. The gneiss has the appearance of a metamorphosed igneous rock allied to the syenitic class which is so abundant in the eastern and northern Adirondacks. The garnet crystals range from a fraction of an inch up to 4 or 5 inches in diameter. It is only occasionally that they possess crystal boundaries and then show dodecahedral development with a parting parallel to the crystal faces. They are of dark red color, translucent on thin edges. The garnet is extracted by mechanical means, the rock being crushed and passed through jigs of special design which effect a good separation although there is only half of a unit difference in the gravity of the garnet and the hornblende. The product has a bright, fresh appearance of typical garnet color. It is shipped unsorted, the sizing being done by the manufacturers.

The Rogers quarry on Gore mountain in the same vicinity has been operated for many years by H. H. Barton & Son Co. and is the oldest of the Adirondack workings. It is based on a long, narrow band of hornblende schist or amphibolite, which may represent either an altered dike of gabbro or an inclusion of Grenville gneiss in the country syenite. The garnet occurs in roundish masses and aggregates which are probably crystal individuals, though not regularly bounded. It shows the effects of deformation and crushing, so much so that the masses shell or break down readily when they are exposed, yielding small fragments which are bounded by one or more smooth surfaces that represent the dodecahedral parting, characteristic of the crystal garnet. The individual crystals attain very large sizes, some of them yielding many hundred pounds of broken garnet. The extraction of the garnet is by cobbing and hand picking.

The Wevertown quarry of the Warren County Garnet Mills turns out a product that is rather different from the others, the garnet being less distinctly of crystalline habit and of lighter color. It is associated with pyroxene, the two minerals constituting the rock which is undoubtedly a metamorphosed limestone. In some parts of the workings the garnet occurs in nearly solid masses. A very similar occurrence was worked for a time near Keeseville. The product when crushed is of granular rather than platy character.

The total shipments from the Adirondacks last year amounted to 5840 short tons with a value of $198,200. The figures are not strictly comparable with the statistics of previous years, which represented production and not sales. The output in 1915 was reported as 3900 short tons valued at $134,064.

In recent years small amounts of garnet have been imported from Spain for manufacture, in competition with the domestic product. The quantity so imported in 1915 was 1343 short tons with a declared value of $24,472. No figures of the amount imported in 1916 have been obtainable, as no record was made of the tonnage that passed through the customs office, although the value was given as $43,481.

GRAPHITE

Trade conditions in the graphite industry last year were quite unprecedented. The demands for crucible grades far exceeded the supply and there was a marked advance in consequence in the prices of crystalline graphite, both domestic and foreign. Since the outbreak of the present war the consumption has increased greatly on account of the requirements for crucible steel and for brass manufacture, both of which industries have experienced a tremendous expansion in connection with the making of ammunitions. The shortage of supply has been in part an artificial condition, resulting from the scarcity and high costs of shipping and also from the embargo which the British and French governments put upon the importation of graphite from Ceylon and Madagascar in the first year of the war. This embargo was later removed, so that importations could be made under certain guaranties and restrictions; but still the imports, which last year exceeded all records, supplemented by a large domestic production, did not meet the needs.

The imports of crystalline graphite for the last five years have been as follows: In 1916, 64,120,000 pounds valued at $6,933,731; in 1915, 45,064,000 pounds valued at $2,049,792; in 1914, 22,166,000 pounds valued at $1,107,192; in 1913, 38,756,000 pounds valued at $1,835,530; and in 1912, 39,220,000 pounds valued at $1,506,934. Of the quantities given, all but a small proportion each year has come from Ceylon, the remainder having been supplied by Madagascar, Korea, Canada and other countries. The domestic production, as given by the United States Geological Survey, for the same period has been as follows: 1916, 10,931,989 pounds worth $914,748; 1915, 7,074,370 pounds, $417,273; 1914, 5,220,539 pounds, $285,368; 1913, 5,064,727 pounds, $254,328; 1912, 3,543,771 pounds, $187,689.

The highest market prices are commanded by the Ceylon graphite in lump form, for which as much as 25 to 30 cents a pound was paid in 1916. The domestic flake graphite of the best quality was sold at 12 to 15 cents a pound. A reduction on these prices should be made of course for the lower grades, which in regard to domestic graphite include the smaller and more impure flake, but no regular scale of prices can be given. The commercial grades of the domestic crystalline graphite show wide variations in respect to purity, the best carrying 90 to 95 per cent carbon.

There is some doubt as to the ability of Ceylon to meet the increasing demands for its product. According to expert testimony the mines on the island are worked at about their full capacity under the present system of operations, which is quite primitive. This seems to be borne out by the record of exports, which have shown no decided tendency toward expansion during the last decade. On the other hand, Madagascar is likely to forge ahead and become a very important factor in the world's markets, judging from the progress it has made within the last year or two. The industry there was started less than 10 years ago, and the product for the current season promises to reach 40,000,000 pounds, according to a recent article in "The Engineering and Mining Journal,"[1] which is about two-thirds of the average quota of Ceylon.

The active general market conditions were reflected in the year's developments in the local mining industry which reported a good gain in the output, with an outlook for a still further enlargement of the production during the current season. This will undoubtedly follow, inasmuch as two new companies have already started productive operations and should make a considerable increment to the previous year's total. The list of producers for 1916 included the American mine of the Joseph Dixon Crucible Co. at Graphite, the Graphite Products Corporation of Saratoga Springs, and the Popes Mills Graphite Co. of Popes Mills, St Lawrence county. The recent mining developments in the Adirondack region are covered in the following notes.

American mine. This is the oldest of the Adirondack mines now active, having been continuously in operation for about 40 years, and probably is the most productive mine of its kind in the country. It is based on layers of graphitic quartzite, interbedded with Grenville limestones and garnet-sillmanite gneiss, that outcrop some 6 miles west of Hague on Lake George. There are two principal deposits, which outcrop with an interval of a few hundred feet between but follow the same northeasterly course and southeasterly dip. The two are probably the broken faulted members of one series, inasmuch as both are characterized by similar geological relations. Most of the mining hitherto has been done in the north-

[1] July 7, 1917.

western or main deposit, which extends from near the present mill where the incline shaft is situated southwest to the limits of the property, a distance of fully one-half of a mile. This has been worked almost entirely underground, the bed which ranges up to 30 to 35 feet thick being stoped in drifts which run off from the incline to the southwest. The dip is low, 20° to 25° ordinarily, but may change suddenly to 45° or 50°; the bed varies greatly in thickness, as it has been squeezed into a succession of bulges and constrictions so that it is in places really a series of lenses separated by varying intervals in which the quartzite is reduced to a thin seam. Occasionally a subsidiary graphite deposit occurs in the foot or hanging of the main deposit. In the last year considerable attention has been given to the Summer bed, which for a long time has lain idle. It was opened in the early nineties, mostly by pits situated along the outcrop and following only short distances down the dip. The length of outcrop is around 700 feet. On the northeast end it begins on the surface as a thin band only a foot or so thick, but widens rapidly to the southwest to 6 to 8 feet and has recently been mined down to 150 feet on the dip. After another interval it pinches again to a foot or less, only to open out once more, showing that the deposit here also consists of a succession of lenses. The bed has been explored on the dip onto the adjoining Wheeler property, of which the mining rights are held separately. The relations of the two beds have importance in regard to the future mining operations, since the reserves of ore would be likely to be much greater in case there were two distinct beds. The circumstances in evidence, however, point to a repetition by faulting of a single ore zone.

Graphite Products Corporation. This company with mines and mill near Kings station, 4 miles north of Saratoga Springs, was engaged in active production during the year, after having carried out an extensive program of construction and development on the property. The company succeeded to the ownership of the holdings of the Saratoga Graphite Co., which had performed little more than experimental work on the property. The mines were enlarged and equipped for economical operation, and a new mill with 15 stamps and approved devices for separating the graphite was erected by the company. The year's record of operations was reported as very satisfactory. The graphite appears in two main series of outcrops, which may be displaced parts of a single zone as is the condition on the Dixon property, and the beds have been intruded by amphibolite and pegmatite so that their structures are rather difficult to determine. In the main workings which lie near the summit of the ridge to the southwest of the mill the bed ranges up to 25 feet or more thick and is worked partly under cover and partly as an open cut.

The matrix of the graphite is a thin-bedded schist, carrying a good deal of feldspar and sporadically more or less mica, in addition to quartz. It is rather heavily charged with pyrite and the exposed edges of the beds have been decomposed into an iron-stained clayey material which is relatively enriched with graphite. The flake varies in size, a good proportion being fairly coarse. Plans have been considered for increasing the output, which will necessitate an addition to the milling plant but little change in the mine equipment.

Hooper Brothers' mine. This is a new property, situated in the vicinity of South bay, west of Whitehall, Washington county. The first development work was undertaken in the late summer of 1916 by the present owners, Messrs F. C. and George Hooper, and so rapidly was the development and construction work carried forward that the property was ready for commercial operations in the early part of 1917. The deposit combines many advantages for economic production, and it seems remarkable in view of its size and exposed situation — lying within the narrow peninsula between Lake George and Lake Champlain — that the deposit should not have been brought to attention long ago. The outcrop of the graphite bed is on the northern flank of the ridge called the "Diameter" which rises from the western shore of South bay, about 4 miles due west from Whitehall, which is the shipping point. The old Burgoyne road, built by the British general of that name, crosses the property.

On the south side of Diameter, next the bay, is the mine of the Champlain Graphite Co., now inoperative, no doubt located on the same bedded series but under much disturbed conditions, due to faulting and igneous intrusion. The deposit on the Hooper Brothers' property outcrops along a low ridge facing north with a continuous exposure for over 3000 feet; for much of the distance the exposed edge forms a steep wall, of which the base is formed by garnet gneiss conformable with the graphite schist, while the ridge is capped by a sheet of gabbro that apparently was intruded along the bedding planes of the schist overlying the graphite and later uncovered by erosion. The whole series dips to the south at an angle of 20° or so. The layer of graphite schist measures 40 feet or more in maximum thickness. Samples have returned up to 15 per cent graphite, but the average of course is less by several per cent. The flake is medium to coarse, some of it unusually large and thick for this type of occurrence. There is little mica in evidence.

The mill stands near the eastern end of the ridge where a favorable slope of the ground provides ample storage for the tailings. The ore is broken in a preliminary crusher and reduced by stamps, after which the separation of the graphite is effected by tables and buddles according to the general plan employed in the Adirondack mills. The mill product is now shipped without refining, but it is the plan of the owners to provide facilities for turning out refined flake graphite and to market the product in that form.

GYPSUM

Market conditions in the gypsum industry which had been rather unfavorable to the producers during the preceding year or two showed distinct improvement in 1916. There was a better demand for calcined plasters, the principal products made from gypsum, and also a slightly increased demand for crude gypsum in portland cement manufacture. As a result the local mines extended their operations wherever this was possible and attained a new level of output, well above that of the most prosperous year of previous record.

The market for calcined plasters, in keeping with conditions in nearly all the building trades, was upset by the war, and furthermore suffered for a time from an excess of productive capacity which conduced to extreme rivalry for trade among the individual producers. It would appear that this feature has been removed from the situation, at least for the present. In fact last year the local concerns were unable to keep pace with the market demands, which were somewhat abnormal owing to the curtailment of imports that ordinarily enter the New York and New England markets in large quantities. Most of the imported gypsum comes into the country in crude form to be converted into plasters by calcining plants situated along the seaboard. Nova Scotia is the principal source of the material, and the falling off in supply has been owing to high freights and not to any impairment of the productive resources of that country.

The production of gypsum and its products in New York State for 1915 and 1916 is shown in the accompanying table. The figures given for wall plasters in the last item of the table cover only the amounts that were made from local rock by plants operated in connection with the mines. The actual output of such plasters is much greater than is indicated by the table, since large quantities in addition are made by local plants from imported materials. Of the total product of crude gypsum last year, about two-thirds was converted into calcined plasters (plaster of paris, stucco and wall plasters) by the companies who operated the mines, and the remaining third was sold in crude form, principally to portland cement mills, or ground to land plaster.

Production of gypsum in New York

MATERIAL	1915		1916	
	SHORT TONS	VALUE	SHORT TONS	VALUE
Total output, crude	516 002	....	579 827	....
Sold crude	162 686	$241 511	188 077	$273 322
Ground for land plaster	6 536	13 486	7 169	18 710
Wall plaster, etc., made	292 344	1 006 203	311 264	1 167 555
Total	....	$1 261 200	....	$1 459 587

The production in 1916 was reported from five counties (Onondaga, Cayuga, Monroe, Genesee and Erie) situated in central and western New York along the belt of Salina strata which hold the gypsum. The Salina beds are mostly shales, with limestones near the top, inclosing beds of rock salt and massive gypsum. The greatest thickness of the formation is in Onondaga and Cayuga counties where the beds altogether measure 1000 feet or more from the base to the top. Here also occur the heaviest layers of gypsum, ranging from 20 to 60 feet, the latter thickness being attained in the vicinity of Fayetteville and Jamesville, Onondaga county. The gypsum in the western section seldom exceeds 6 or 8 feet in thickness.

There is a great difference in the grade of the gypsum that is obtainable in the different deposits. The percentage of hydrated calcium sulphate, or gypsum substance, ranges from 65 to 70 per cent in the more impure sorts to 95 per cent in the best rock. The impurities consist of clayey matter and the carbonates of lime and magnesia. The variation is not altogether without rule, for it can be stated in general that the grade improves progressively from east to west, the best quality of rock being found in Genesee and Erie counties on the extreme west end of the belt, while on the east end in Madison, Onondaga and Cayuga counties the average material does not carry much above 75 per cent in gypsum. It is for this reason that the bulk of the output now comes from the western section, despite the advantages that the eastern deposits have in regard to size and accessibility.

All the mines are situated on the outcrop of the deposits and are opened usually by adits or tunnels on the level of the beds, although in one or two mines access to the workings is through shallow shafts. There are no mines now operated under more than 100 feet of cover. With the exhaustion of the resources in the outcrop mines the workings will have to be extended in depth, to the south of the outcrop, where it would appear that deposits of similar character to those now worked are to be found.

Very little exploration has been carried on of late years in the gypsum belt. The period of greatest development was from 1900 to 1907, when the mines in the western section, that is Genesee and Erie counties, were opened and rapidly gained the lead which they have since maintained. In the last year the testing of deposits near Victor, Ontario county, has been under way, but it is not known just what results were obtained.

IRON ORE

The unprecedented conditions in the iron trade which obtained during the year 1916, when production and consumption proceeded at rates that are absolutely without parallel in the history of the industry, showed their influence upon the local mining developments and the statistics of output as returned by the active companies. The shipments of lump ore and concentrates by New York mines amounted altogether to 1,464,917 long tons, valued at $5,571,429, a new record and representing a gain of over 50 per cent in the total for the year.

The details of the record will be found in the accompanying table, which gives also the figures for the past two decades. In comparing the statistics of the table it should be noted that those for 1916 represent shipments, while in previous years the mine output has been the basis of compilation. As a matter of fact, however, there is rarely any wide variation between the quantity of ore mined in any one year and the shipments for the same period, since little of the product is held in stock at the mines but is sold on yearly contracts.

The shipments consisted of magnetite, hematite and limonite in the order of their importance. A total of 1,402,859 long tons consisted of magnetite in the form of lump ore and concentrates from the Adirondacks and the southeastern Highlands. The hematite amounted to 61,712 long tons, all of it from the Clinton district; while the remainder consisted of a few hundred tons of limonite from Columbia county. The magnetite was made up of 802,241 long tons of mill concentrates and 600,618 long tons of lump ore. The concentrates averaged over 60 per cent in iron, the bulk of the shipments carrying 63 to 65 per cent. The lump ore contained 58 to 60 per cent iron. In the concentration of magnetite as practised in the Adirondacks, each ton of finished product represents from a little over 1 to nearly 3 tons of crude ore, the ratio varying with each deposit. Improvements in the methods of mining and milling have made it possible to handle ore running as low as 25 per cent on a profitable basis.

The amount of ore hoisted exceeded the shipments by several hundred thousand tons, the difference being accounted for by the shrinkage due to the concentration of the magnetite ores. The actual mine output in 1917 was a little over 2,000,000 tons, considerable more than the total for any preceding year.

Production of iron ore in New York State

YEAR	MAGNETITE	HEMATITE	LIMONITE	CARBONATE	TOTAL	TOTAL VALUE	VALUE A TON
	Long tons	Long tons	Long tons	Long tons	Long tons		
1897	296 722	7 664	20 059	11 280	335 725	$642 838	$1 91
1898	155 551	6 400	14 000	4 000	179 951	350 999	1 95
1899	344 159	45 503	31 975	22 153	443 790	1 241 985	2 80
1900	345 714	44 467	44 891	6 413	441 485	1 103 817	2 50
1901	329 467	66 389	23 362	1 000	420 218	1 006 231	2 39
1902	451 570	91 075	12 676	Nil	555 321	1 362 987	2 45
1903	451 481	83 820	5 159	Nil	540 460	1 209 899	2 24
1904	559 575	54 128	5 000	Nil	619 103	1 328 894	2 15
1905	739 736	79 313	8 000	Nil	827 049	2 576 123	3 11
1906	717 365	187 002	1 000	Nil	905 367	3 393 609	3 75
1907	853 579	164 434	Nil	Nil	1 018 013	3 750 493	3 68
1908	663 648	33 825	Nil	Nil	697 473	2 098 247	3 01
1909	934 274	56 734	Nil	Nil	991 008	3 179 358	3 21
1910	1 075 026	79 206	4 835	Nil	1 159 067	3 906 478	3 37
1911	909 359	38 005	5 000	Nil	952 364	3 184 057	3 34
1912	954 320	103 382	Nil	Nil	1 057 702	3 349 095	3 17
1913	1 097 208	120 691	Nil	Nil	1 217 899	3 870 841	3 18
1914	703 670	47 705	341	Nil	751 716	2 356 517	3 13
1915	873 422	70 147	834	Nil	944 403	2 970 526	3 15
1916	1 402 859	61 712	346	Nil	1 464 917	5 571 429	3 80

The list of active mining companies for the year included the following in the Adirondack region: Witherbee, Sherman & Co. and Port Henry Iron Ore Co., Mineville; Chateaugay Ore & Iron Co., Lyon Mountain; Cheever Iron Ore Co., Port Henry; Benson Mines Co., Benson Mines. The last two companies were active only for part of the year, the Benson mines operating only for a short period in an experimental way to test the new process of mill treatment that had been installed on the property. In southeastern New York the Hudson Iron Co., Fort Montgomery, and the Sterling Iron & Railway Co., Lakeville, maintained operations on the usual scale. The hematite mines included those of C. H. Borst, Clinton; Furnaceville Iron Co., Ontario Center; and Ontario Iron Co., Ontario Center. The single limonite mine near Boston Corners, Columbia county, was worked by Barnum, Richardson & Co., of Salisbury, Conn.

Mineville. The most active year in the history of this district was indicated by the reports of the mining companies, whose combined output was nearly 1,500,000 tons of crude ore. The more productive properties were the Old Bed, Harmony and Barton Hill of Witherbee, Sherman & Co. and "21" mine of the Port Henry Iron Ore Co. The former company also worked the Sherman and Smith mines on a small scale. The principal feature in the recent history of the district, perhaps, is the increased exploitation of the low-grade or concentrating ores, which are rapidly superseding the richer ores in importance. This has been made possible by the extensive additions to mine equipment that enable a large tonnage to be handled economically and by the erection of large milling plants, of which three are employed at present in the beneficiation of the different mine products. The available ore resources have been greatly increased by these developments and a long life assured for the district.

To facilitate ore shipments from the district, extensive ore docks and loading machinery have been erected at the lakeside at Port Henry, which through the New Champlain and Barge canals has direct water connection with the important furnace centers on the Great Lakes and with the Atlantic seaboard. A fleet of barges is in course of construction by Witherbee, Sherman & Co. and will be employed in transporting the ore to market and in carrying coal or other freight on the return trip.

Cheever mine. This property was again placed in operation, after a shutdown of about two years, and since has been working to the capacity of the plant. The mine holds the record among the New York magnetite mines in the handling of low-grade ore, as its product for some time has run considerably under 30 per cent in iron, requiring nearly 3 tons crude for a ton of 60 per cent concentrates. Much of the ore treated has come from the floor and roof of the old workings, but there is still available a large area of unworked ground on the northern and southern borders of the exploited territory, enough to assure a supply for many years to come. An increase in the capacity of the plant which now is rated at about 500 tons of crude a day seems justified economically in view of the available tonnage.

Lyon Mountain. The low-phosphorus concentrates from this group of mines find a ready market at a premium over the usual prices and of late have been in special demand. The Chateaugay Ore & Iron Co. is the operator. Plans are being put into effect to enlarge the production. A new shaft with a hoisting capacity of 3000 tons daily has been constructed to take the place of the several small, inconvenient openings that have been used in the past. The principal addition to the surface plant is the mill, on which construction was started during the current season and which when completed will affect considerable economies, as well as provide for a larger outturn, in comparison with the old plant.

Benson Mines. A renewal of operations in these extensive deposits is in prospect for the current season. During 1916 only test runs were made, but it was planned to inaugurate a steady campaign during the present year. The milling plant has been rebuilt, with a change in the method from the dry magnetic concentration practised elsewhere in the Adirondacks to the wet magnetic system similar to that employed largely by the mines of central Sweden. The ore is very dense and close textured, necessitating finer crushing and more careful handling than the common ores of the eastern Adirondacks. Owing to the presence of considerable sulphur, the concentrates also require a roast, which is further beneficial on account of the accompanying agglomeration that takes place. The success of the undertaking will mean a great deal to the iron-mining industry of the State, as the resources in this class of ore are very large.

Jayville. The mines at this place, 14 miles west of Benson Mines, on the Carthage & Adirondack Railroad, were under examination in 1916, with a view to their reopening. They are based on a group of shoots and lenses of magnetite, some of which yield a merchantable ore, while others consist of an intergrowth of magnetite with hornblende, biotite and other minerals, forming a lean ore suitable only for concentration. Unlike the Benson Mines deposit they carry little pyrite. The mines were worked last in 1888 by the Magnetic Iron Ore Co., which mined about 25,000 tons in the period of two years in which they were active. The recent work has been undertaken by W. J. Hughes.

Palmer Hill. The exploration of the magnetite bodies at this place near Ausable Forks, Clinton county, has been in progress. The property, as well as many others in this region, was acquired a few years ago by Witherbee, Sherman & Co. with a view to their eventual reopening.

Sterling Lake. A good record was made last year by the two active mines in southeastern New York operated by the Hudson Iron Co. (near West Point) and by the Sterling Iron & Railway Co. at Sterling Lake, just north of the New Jersey state line. Both companies ship their product in lump form, having no concentrating mills on their properties.

The output at Sterling Lake is now taken from a single deposit, known as the Lake, one of the numerous bodies that occur in the vicinity and that together have supported a mining industry for the last 150 years and more. The different deposits vary greatly in their physical features as related to form and content, although situated in the same general geological surroundings, so far as cursory examination shows. Some are thin sheets lying flat, or slightly inclined, others are attenuated lenses with a moderate to steep dip and usually with a pitch to the north, and still others are developed as narrow, elongated shoots with the long axis on the pitch which likewise is to the north. More complex forms result from differential compression and folding of these simpler types.

The principal deposits lie within a belt that begins near the New Jersey line and extends some 5 or 6 miles to and beyond Sterling Lake. It is part of a much larger ore zone that reaches into New Jersey on the south and extends in a general northeasterly direction across Orange county to the Hudson river. Beginning at the south, within a short distance of the state line, the series includes the Steel mine which outcrops on a ridge at about 800 feet A. T. and is based on a band of ore striking N. 20° E. It is opened by a few pits on the south end. The same band of ore extends north beyond the hill under the adjoining valley. The next deposit is the Crawford, located on a lens which begins near the base of the succeeding ridge and pitches northward under it; it is opened as a pit and underground drift for a distance of 500 feet on the strike. It measures 20 to 50 feet in width from wall to wall, but includes bands of lean or barren gneiss intercalated with the magnetite. An interesting feature of its geology is the presence of massive granite on the eastern or hanging side (the dip is about 75° E.) whereas the foot wall consists of the usual hornblende gneiss. The granite on the north end also caps the ore body.

The California mines are about 7000 feet farther north, on the opposite side of the ridge on which the Sterling and Lake deposits outcrop, and about one-half of a mile distant from these. They are based on a thin but persistent band of magnetite that lies nearly flat and outcrops on the southern and southwestern sides of the hill. The ore is of Bessemer grade, whereas the Lake and Crawford mines contain too much phosphorus to come in that class.

The Sterling and Lake mines, of which the latter is now the only active producer on the property, are opened on two long lenses or shoots which outcrop on the side hill at the foot of the lake and extend north under the latter at an angle of 28° for the Sterling and 23° for the Lake body, measured on the average inclination of the respective slopes. Both dip to the east, although rolls occur which locally reverse the normal dip. The Sterling mine is down 1000 feet and has not been worked since 1902. The Lake slope is over 3200 feet in depth. The two slopes are 500 feet apart at the surface and pursue a slightly divergent course. From the presence of numerous pinches and minor rolls in the Lake mine, it might be reasonably maintained that the two bodies are parts of one original deposit which has been squeezed out into the present form. It seems to be the prevalent opinion locally, however, that they are separate and distinct deposits and the Lake, if it were continued on the dip, would lie above the Sterling deposit. For a distance of 2300 feet on the slope, granite forms the hanging wall of the Lake slope, but at that depth gives way to hornblende gneiss. The Lake mine has yielded 1,500,000 tons of shipping ore up to the present time. The ore runs about 57 or 58 per cent iron and 1 per cent or so of phosphorus.

To the east of Sterling lake about 3000 feet are a series of lenses that lie along a nearly north-south axis, on which are located the Causeway, Mountain and Smith mines. About 800 feet farther east a second series, with openings known as the Augusta, Cook, Scott, Oregon and Long mines, occurs along a parallel axis measuring

6500 feet from south to north. They all have an easterly dip and northerly pitch and have been worked by open cutting or by drifting under cover. The Cook mine, however, was worked through a vertical shaft and had underground connections with the Scott deposit, which also was tapped by a slope. There is little of the early workings in this part now accessible, but the ore as seen in place near the outcrop measures up to 25 feet thick. Altogether the resources still remaining in the various mines are undoubtedly very large since they were worked in early times for the rich ore alone that could be used directly in the furnace, and as a rule all the material that could not be so employed was left in the walls. There is no evidence also that the mines have been bottomed. The ore supply would maintain a large mill for many years.

MINERAL WATERS

The production of mineral and potable spring waters for public sale constitutes an important branch of the mineral industry of the State, though perhaps seldom considered in that light. Not only is a large revenue derived from the bottling and shipment of such waters, but some of the spring localities by virtue of their waters have become favorite resorts for tourists and health-seekers and thus become indirect sources of income of large importance. Saratoga Springs, Ballston Springs, Richfield Springs, Sharon Springs and Lebanon Springs are among the number that will be first called to mind in such connection. They illustrate also the variety of waters which are to be found within the state limits. Saratoga and Ballston yield waters of alkaline-saline character, of wide range of composition. They are further characterized by the presence of carbon dioxid in free state to the extent often of two or three times the volume of the water. The waters are mostly drunk, both for table use and for therapeutic purposes. The application of the highly carbonated waters to bathing has become an important feature of the cure at Saratoga. At Richfield and Sharon the waters are sulphurous and charged with alkalies and alkaline earths. They are employed mainly for bathing. Waters that contain important quantities of sulphur as sulphureted hydrogen, are obtained at Clifton Springs, Massena Springs, and many other localities. Lebanon in Columbia county is the only example of a thermal spring in the State, its water issuing at a temperature of 75°, winter and summer, indicative of a deep source. It is only slightly mineralized, among the ingredients being small amounts of carbon dioxid and nitrogen.

The sale of potable waters that are not mineralized in the usual sense has become a prominent factor in the industry of late years. Suitable waters for the purpose are obtainable in almost every section of the State, but the industry is mainly centered in the vicinity of the larger towns or points convenient to shipping facilities. The main requirement of such waters is that they be free from contamination and any injurious impurities, in which respect they are usually superior perhaps to the ordinary public supplies. Their sale is extensive in some communities, and altogether the commerce in such waters is greatly in excess of that of the medicinal class.

In 1916 the total sales of mineral waters, as reported by the springs listed below, amounted to 7,746,490 gallons valued at $697,650. To the total value the table waters contributed $610,937 and the medicinal waters $86,713. The returns in 1916 indicated sales of 8,636,920 gallons with a value of $745,530.

List of springs. The following list includes the names and localities of most of the springs in the State that are employed commercially, as shown by a canvass of the industry:

NAME	LOCALITY
Baldwin Mineral Spring	Cayuga, Cayuga county
Coyle & Caywood (Arrowhead Spring)	Weedsport, Cayuga county
Diamond Rock Spring	Cherry Creek, Chautauqua county
Cassadaga	Stockton, Chautauqua county
Breesport Oxygenated Spring	Breesport, Chemung county
Breesport Deep Rock Water Co	Breesport, Chemung county
Chemung Valley	Elmira, Chemung county
Deep Rock	Breesport, Chemung county
Chemung Spring Water Co	Chemung, Chemung county
Whiter	Norwich, Chenango county
Dietade	Keeseville, Clinton county
Keeseville Mineral Spring	Keeseville, Clinton county
Lebanon Mineral Springs	Lebanon, Columbia county
Greendale Crystal Springs	Livingston, Columbia county
Mount Washington Spring	Hillsdale, Columbia county
Trespur Spring	McGraw, Cortland county
Arlington Spring	Arlington, Dutchess county
Mount Beacon Spring	Mount Beacon, Dutchess county
Mount View Spring	Poughkeepsie, Dutchess county
Monarch Spring Water Co	Beacon, Dutchess county
Elk Spring Water Co	Lancaster, Erie county
Aldena Park	Alden, Erie county
Collins	....
Diamond Rock	Lancaster, Erie county

Sparkling	Buffalo, Erie county
Oak Mountain	Dolgeville, Fulton county
W. A. A. Heek	Tupper Lake, Franklin county
Eagle Spring	Edgewood, Greene county
White Bear	Batavia, Genesee county
Oasis Cold Spring	.........., Genesee county
McManus	............, Jefferson county
Red Rock	Fine View, Jefferson county
Swan	Alexandria Bay, Jefferson county
Valley	Omar, Jefferson county
Crystaldale	Crystaldale, Lewis county
Nunda Mineral Springs	Nunda, Livingston county
Mohawk Spring	Amsterdam, Montgomery county
Table Rock Mineral	Honeoye Falls, Monroe county
Garden City Well	Garden City, Nassau county
Sagamore	Oyster Bay, Nassau county
Clinton Lithia Springs, Inc	Franklin Springs, Oneida county
Glen Alix Spring	Washington Mills, Oneida county
Lithia Polaris Spring	Boonville, Oneida county
F. H. Suppe (Franklin Lithia Spring)	Franklin Springs, Oneida county
Orville Risley	New York Mills, Oneida county
Cold	Utica, Oneida county
Paris	Sauquoit, Oneida county
Split Rock Lithia	Franklin Springs, Oneida county
Warner Artesian Well	Franklin Springs, Oneida county
Westmoreland Mineral	Westmoreland, Oneida county
Geneva Mineral Water Springs	Geneva, Ontario county
Orange Great Rock	Middletown, Orange county
Crystal Spring	Oswego, Oswego county
Deep Rock Spring	Oswego, Oswego county
Great Bear Spring	Fulton, Oswego county
Richland	Richland, Oswego county
White Sulphur Spring	Richfield Springs, Otsego county
Black Rock Spring	Rensselaer, Rensselaer county
Mammoth Spring	North Greenbush, Rensselaer county
Shell Rock Spring	East Greenbush, Rensselaer county
Flint	West Sand Lake, Rensselaer county
Ideal	Troy, Rensselaer county
Plymouth	North Greenbush, Rensselaer county
Standard	Troy, Rensselaer county
Carrier	Potsdam, St Lawrence county
Madrid Indian Spring	Madrid, St Lawrence county
Massena Springs	Massena, St Lawrence county
Artesian Lithia Spring	Ballston Spa, Saratoga county
Comstock Mineral Spring	Ballston Spa, Saratoga county
Mohican Spring	Ballston Spa, Saratoga county
Arondack Spring	Saratoga Springs, Saratoga county
Hathorn Nos. 1 and 2 Springs	Saratoga Springs, Saratoga county
Coesa Spring	Saratoga Springs, Saratoga county

Geyser Spring	Saratoga Springs, Saratoga county
Minnonebe Spring	Saratoga Springs, Saratoga county
Orenda Spring	Saratoga Springs, Saratoga county
Saratoga Gurn Spring	Saratoga Springs, Saratoga county
Saratoga Vichy Spring	Saratoga Springs, Saratoga county
Old Iron	Ballston Spa, Saratoga county
Congress No. 2	Saratoga Springs, Saratoga county
Ferndale	Saratoga Springs, Saratoga county
Chalybeate Spring	Sharon Springs, Schoharie county
Eye Water Spring	Sharon Springs, Schoharie county
Sulphur-Magnesia Spring	Sharon Springs, Schoharie county
White Sulphur Spring	Sharon Springs, Schoharie county
Red Jacket Spring	Seneca Falls, Seneca county
Pine Hill Crystal	Pine Hill, Steuben county
Pleasant Valley	Rheims, Steuben county
Setauket Spring	Setauket, Suffolk county
Ithaca	Ithaca, Tompkins county
Elixir Spring	Clintondale, Ulster county
Sun Ray Spring	Ellenville, Ulster county
Vita Spring	Fort Edward, Washington county
Vermont Mineral Spring	Granville, Washington county
Briarcliff Lodge Association	Briarcliff Manor, Westchester county
Gramatan Spring Water Co	Bronxville, Westchester county
Granite	Granite Springs, Westchester county
Orchard Spring	Yorktown Heights, Westchester county
Mokoho	Mount Kisco, Westchester county
Skenorock	Baldwin Place, Westchester county

MOLYBDENUM

The rare metal molybdenum has for its principal ore the sulphide MoS_2, which is known as molybdenite. This mineral is found in several places in New York State. The recent extraordinary demand that has developed for the metal in consequence of its application in the manufacture of heavy ordnance, lends interest to every occurrence of molybdenite that has not been inspected and reported upon with reference to its economic possibilities. It is for this reason the accompanying notes upon some New York molybdenite localities have been prepared.

Whitlock[1] lists the following occurrences for molybdenite in his "New York Mineral Localities":

Manhattan Island, between 43d and 44th street and First and Third avenues, found in mica schist; West Point, Orange county, in gneiss; Constitution island (Hudson river off West

[1] N. Y. State Mus. Bul. 70, 1903.

Point), in gneiss; Warwick, Orange county, in limestone; Tilly Foster mine, near Brewster, Putnam county, in serpentine; North Russel, St Lawrence county, gneiss-limestone contact. To this list may be added a locality in the town of New Bremen, Lewis county, reported to the writer by A. F. Buddington; and one north of Peekskill, in Phillipstown, Putnam county, discovered by the writer a few years ago.

Of the above occurrences the one in New York City is no longer accessible. From what has been learned indirectly, it is evident that the West Point, Constitution island, and Warwick occurrences have little or no interest except purely from a collector's standpoint. At the Tilly Foster mine molybdenite occurs sparingly as a contact mineral in the metamorphosed limestone and is no longer to be found except in the waste dumps of the old workings.

The Russel locality, about which little has been made known, was visited during the past summer by A. F. Buddington who contributes the following account of it. The mineral is found in association with a green pyroxene rock, or coccolite, that has been prospected in several places, but rather for copper than molybdenite, according to local accounts. There are few indications of copper, although the rock carries considerable pyrite in thin, lenticular bands. Molybdenite occurs in disseminated flakes and aggregates of flakes, some of which attain a size of an inch or so in diameter and an eighth of an inch thick, but mostly much smaller. The mineral seems to be rather sporadic, and at best too sparsely represented to warrant its mining. The occurrence apparently belongs to the contact type, as the pyroxene wall rock is the result of alteration of limestone and is included in a mass of granite gneiss which undoubtedly has produced the change and introduced the metal. The wall rock is traversed by veins of a coarser pyroxene-phlogopite material which seems to be free of molybdenite. The property on which the prospecting has been done lies just south of Boyd pond, near Russel. It is owned by Martin Leary.

The occurrence in the town of New Bremen, Lewis county, belongs to a different type in that the sulphide is distributed through the mass of a granite intrusion, or rather within indefinitely bordered veins of pegmatite that are found in the granite. The granite has a gneissic appearance and weathers to a reddish color, but is green and pink on fresh surfaces. It may represent a phase of the green syenite found to the northwest of the locality. This occurrence is on the farm of William J. Aucter, three-quarters of a mile southeast of Bushes Corners, and is reached most conveniently from Croghan, the terminus of a branch railroad from Lowville. Altogether four narrow pegmatite bands were noted, each scarcely more than 1 inch wide, exposed on the face of a sloping ridge for a distance of 25 feet. The flakes are relatively coarse and will average from one-quarter of an inch to one inch in diameter. Traces of the mineral are found at other points along the same ridge. A hill of coarse red gneiss, one-half of a mile south of Stifts schoolhouse, west of the highway, also shows its occurrence. The locality is one that seems to warrant more careful search and possibly some exploration in the hope of uncovering some larger pegmatite veins than those now exposed, which are on the whole fairly rich.

Perhaps the most promising locality of all in respect to actual content of molybdenite in the ore is that on the Owens farm about 5 miles north of Peekskill. The place is just south of the Catskill aqueduct on the west side of Sprout Brook valley. It is now a part of the Stuyvesant Fish estate. The occurrence consists of rusty gneiss which forms a hard ledge traceable for several hundred feet and is made up largely of pyroxene of green color in fresh fracture. The rusty color results from the presence of pyrrhotite that occurs in scattered grains. The rock is of contact nature, an altered limestone undoubtedly, but neither limestone nor granite was noted in the immediate vicinity. It carries disseminated flakes of molybdenite, and in one place so abundantly as to constitute a fairly rich ore, that is containing 2 or 3 per cent of the sulphide. The flakes are small and average scarcely more than one-eighth of an inch in diameter. It would appear that the richly impregnated zone that is now exposed is of small compass, probably only a few feet in diameter. If a considerable body of the ore like that now exposed in the ledge could be found, it would undoubtedly be of commercial importance.

NATURAL GAS

The decline in the production of natural gas that had been under way in the preceding two or three years was checked in 1916 when a campaign of active exploration succeeded in bringing in some new supplies large enough to counteract the material falling off in the older wells. Although a considerable addition to the flow was made, no very important discovery occurred that could be considered as promising a material enlargement of the productive territory. The last event of this kind was in 1912, when the Orchard Park field of Erie county was opened and brought about the large gain in the yield for that year.

The total flow of natural gas in 1916, according to the reports received from the producers and distributors, was 8,594,187,000 cubic feet, as compared with 7,110,040,000 cubic feet in 1915 and 8,714,681,000 cubic feet in 1914. The figures represented a gain of 21 per cent in the output in the year and put the industry back in nearly the same place it held in 1914. The leading counties on the basis of their output were Erie, Chautauqua, Allegany, Cattaraugus and Genesee.

The value of the production last year was reported as $2,524,115, against $2,085,324 in 1915. This is based on the prices received for the gas in the different centers of consumption. The mean for the whole State was 29.4 cents a thousand, the same as in 1915. Actually the prices at which the gas was sold ranged from 20 cents as a minimum to over 50 cents, according to locality. The lowest selling rates were reported in Allegany and Cattaraugus counties, where the local product finds close competition with the Pennsylvania output. The isolated districts of Central New York reported the highest prices which as an extreme, however, were only about one-half those obtained for artificial gas elsewhere.

Production of natural gas

YEAR	OUTPUT 1000 CU. FT.	VALUE	NUMBER OF WELLS
1904	2 399 987	$552 197	....
1905	2 639 130	607 000	....
1906	3 007 086	766 579	....
1907	3 052 145	800 014	925
1908	3 860 000	987 775	1 100
1909	3 825 215	1 045 693	1 280
1910	4 815 643	1 411 699	1 340
1911	5 127 571	1 547 077	1 403
1912	6 564 659	1 882 297	1 660
1913	9 055 429	2 549 227	1 750
1914	8 714 681	2 570 165	1 797
1915	7 110 040	2 085 324	2 051
1916	8 594 187	2 524 115	2 068

For several years it was the practice to report the production according to the counties and leading districts from which the output came. This is no longer possible, as the greater part of the supply is now handled by a few distributing companies who operate over a large area, often taking in widely separated districts, and who are not always able or willing to distribute their receipts according to locality.

The field reports indicated a total of 2046 wells used for gas on January 1, 1916. A total of 141 new wells were drilled, of which 35 were dry, and 84 old wells were abandoned, so that the number of producing wells at the close of the year was 2068.

Altogether natural gas is produced in 15 counties, situated in the central and western sections between Lake Erie and the east end of Lake Ontario. The most productive fields are in Erie county and include the area east of Buffalo and also many pools in the southern part in the towns of East Hamburg, Aurora, Collins and others. Chautauqua county has over 100 separate producers, most of them small, but with a few large companies which supply their product to local communities. Cattaraugus and Allegany counties contribute considerable quantities of gas, obtained from the same general area as the oil, which is found in several pools along the Pennsylvania boundary. Genesee county has come into prominence in recent years through the Pavilion field in the southeastern corner. Ontario county contains a number of wells, mainly in the towns of East and West Bloomfield. Among the smaller factors in the industry are Livingston, Monroe, Niagara, Onondaga, Oswego, Schuyler, Steuben, Wyoming and Yates. A test well was drilled in 1917 near Belleville, Jefferson county, which found some gas in the Trenton limestone at 600 feet depth. Similar discoveries are reported from time to time in the limestones and shales along the Mohawk valley as far east as Albany county, but there have never been any commercial pools developed anywhere east of Oswego county, which contains some small but persistent and paying wells in the vicinity of Pulaski and Lacona.

The business of distributing the output among the cities and towns within the different districts is controlled by a relatively small number of concerns, some of whom are engaged also in productive operations. The Iroquois Natural Gas Co. of Buffalo, the largest single distributor in the State, operates pipe lines to the principal fields in Allegany, Cattaraugus, Erie and Genesee counties. The Alden-Batavia Natural Gas Co. and the Pavilion Natural Gas Co. are important producers and distributors in the Erie-Genesee county districts. In Chautauqua county the larger operators are the Frost Gas Co. and the Silver Creek Gas & Improvement Co. In Allegany and Cattaraugus counties the Gowanda Natural Gas Co., the Empire Gas & Fuel Co. and the Producers Gas Co. are important. In Ontario county the main producer and distributor is the Ontario Gas Co. Among the smaller companies engaged in the business are the Consumers Natural Gas Co. with wells in the town of Darien, Schuyler county, the Baldwinsville Light & Power Co. of Baldwinsville, Onondaga county, the Pulaski Gas & Oil Co. of Pulaski, Oswego county, and the Sandy Creek Oil & Gas Co. of Sandy Creek, Oswego county.

PETROLEUM

The production of petroleum in 1916 fell a little short of the usual average, for which the decline in prices in the previous season and the resulting discouragement of new drilling may be held partially responsible. The total pipe-line receipts were 874,087 barrels, as compared with 928,540 barrels in 1915 and 933,511 barrels in 1914. A gradual falling off in the production, furthermore, has to be expected; no new oil pools are being discovered to take the place of those now drained nearly dry after many years of steady output. There is still left some undrilled territory in the Allegany and Cattaraugus county fields and its development will keep the industry alive for some time to come.

The progress of drilling from year to year depends largely upon the encouragement that is received from the market. The new wells can be depended on for a yield of one or two barrels a day as a rule, but rarely more. Consequently it is unprofitable to carry on the work when prices are low, which for New York crude means considerably more than the general average of quotations. When prices fall below $2 a barrel for New York crude there is little profit in production. The trend of quotations in 1915 was downward during the first half, starting at $1.50, and then a gradual rise began, persisting to the end when the price reached $2.25 a barrel. In 1916 the course of the market was upward during most of the twelvemonth. At the start the price was $2.25, the same as in the preceding December, but in February an advance to $2.35 took place, to be followed in March by a further raise to $2.50 and in April by another to $2.60 a barrel. The market remained at this level during May and June. In July a decline to $2.35, with a further recession to $2.30 in August, brought an interruption to the usual trend. In September the price advanced to $2.50. A sharp rise to $2.75 came in November, followed by still another increase to $3.05 in December, the highest mark reached in recent years.

The number of new wells drilled during the year was larger than in 1915 but still fell below the average.

Production of petroleum in New York

YEAR	BARRELS	VALUE
1897	1 279 155	1 005 736
1898	1 205 250	1 098 284
1899	1 320 909	1 708 926
1900	1 300 925	1 759 501
1901	1 206 618	1 460 000
1902	1 119 730	1 530 852
1903	1 162 978	1 849 135
1904	1 036 179	1 709 770
1905	949 511	1 566 931
1906	1 043 088	1 721 095
1907	1 052 324	1 736 335
1908	1 160 128	2 071 533
1909	1 160 402	1 914 663
1910	1 073 650	1 458 194
1911	955 314	1 251 461
1912	782 661	1 338 350
1913	916 873	2 255 508
1914	933 511	1 773 671
1915	928 540	1 476 378
1916	874 087	2 190 195

The statistics of production for the 20-year period 1897–1916 are shown in the accompanying table. The figures up to the year 1903 are those published in the annual volumes of the *Mineral Resources* while for the remaining years the statistics have been collected directly from the pipe-line companies and shippers who operate in the New York fields. For 1916 a canvass of the individual producers was carried out by the United States Geological Survey and the New York State Survey in cooperation, which showed a total of 11,200 wells in production at the close of the year. The wells were distributed as follows: Allegany county, 7794; Cattaraugus county, 3183; Steuben county, 223.

From time to time efforts are made to extend the limits of the oil-bearing territory by drilling to the northward and eastward of the productive area. The results occasionally have seemed successful at first, as oil in some quantity has been encountered in such experiments. A few years ago a good deal of excitement was aroused by the bringing in of a well in the extreme northern part of Allegany county, near the Livingston county line, in the so-called Granger field. The oil at first flowed under natural pressure. In the boom that followed some 30 wells were drilled in the vicinity, but the supply was quickly exhausted and less than 3000 barrels in all were produced. Another discovery was made in the vicinity of Swain in the same county, with similar results. The attempt to develop oil in the region to the east of the proved territory has been scarcely more successful. So far no persistent pools have been tapped much east of the Allegany-Steuben county line. A well was recently drilled near Adrian, in the town of Canisteo, Steuben county, that is reported to have encountered oil at 625 feet in shale. The oil was of canary yellow color and high in the light distillates. At the start it produced 14 barrels a day, much better than the average in the old territory, and attracted wide attention. The flow soon ceased.

PYRITE

In its resources of sulphur ores, New York State has an asset which is not as yet fully appreciated. The deposits have been little exploited up to the present, although for a number of years they have shared with those of one or two other states the principal rôle in the domestic industry, which, it need scarcely be remarked, has never measured up to the needs of the home market. In sulphur content they are low grade, so that the ores have to be concentrated before shipment, but they are extensive, well located for convenience of mining and milling, and have the advantage of ready accessibility to the leading centers of acid manufacture on the Great Lakes and Atlantic seaboard.

In the present situation which portends a probable scarcity of pyrite in the immediate future, if not an actual dearth of material available for acid making, the resources of New York deserve consideration for the possibilities they hold of increased utilization.

The deposits that are of most importance, present and prospective, occur on the west side of the Adirondacks in St Lawrence and Jefferson counties. The region is underlain by the same Precambrian rocks as the Adirondacks, but has a moderate altitude, only 500 to 800 feet A. T., and low relief. In a way it bridges the gap between the Precambrian area of northern New York and the Laurentian province of Canada, here separated only by the width of the St Lawrence plain. The region is noted for its agricultural wealth, no less than for its varied mineral character.

The pyrite, associated with more or less pyrrhotite, occurs in certain well-defined belts of Grenville gneiss, of which the more important have been recently mapped by A. F. Buddington for the State Geological Survey. There are at least 9 or 10 individual belts, so far known, distributed over the region, but those of most interest from a mining standpoint are grouped within a single zone that stretches from the town of Canton in the central part of St Lawrence county southwest for some 40 miles to and beyond Antwerp in Jefferson county. The developed deposits all lie in this zone; they include the Pyrites and Stella mines near the northeastern extremity, both with abundant resources, the Cole mine opened in a large ore body near the center, and several others which are to be classed as prospects so far as exploration is concerned, but with the appearance of substantial deposits.

All the deposits possess a certain similarity in their physical surroundings and mineral character, however much they may differ in the details of form, size or content. They are associated with one of the characteristic Grenville rocks (a banded rusty gneiss) which varies in individual layers or beds from a quartz-feldspar-biotite gneiss to nearly pure quartzite and not infrequently contains intercalations of crystalline limestone. The rock occurs in belts that extend northeast and southwest, usually for distances of several miles, but of narrow width. Careful study of the field features has revealed that these belts are parts of a single series of beds repeated by folding, the strata having been tightly compressed and overturned so as to give a common inclination to all, the dip being almost invariably northwest and usually at a high angle. In outcrop the gneiss is distinguished by its rusty burnt look which shows the presence of sulphides, and where concealed its occurrence is denoted by the red color imparted to the soil. The gneiss with its disseminated pyrite is much like the " fahlbands " that are described in connection with metalliferous veins in the crystalline schists, whereas the concentrated pyrite that constitutes the deposits proper may be likened to the veins themselves.

The workable bodies partake of the tabular form of the gneiss, to the structure of which they conform very closely. Their parallelism with the foliation of the gneiss, the general similarity between the ore and wall rock so far as qualitative mineral composition is concerned, and the indefinite contacts seem at variance with the idea of a secondary derivation for the sulphides but rather argue for their primitive accumulation with the sedimentary wall rocks. On the other hand C. H. Smyth jr.[1] who has given most attention to the origin of the ores, shows that the pyrite in large part is undoubtedly of later crystallization than the gangue and that the only difference between the workable deposit and the country rock is the degree to which the metasomatic process has been carried. In evidence of such derivation may be pointed out the abundance of secondary minerals, chiefly chlorite, developed as an accompaniment of the process. It is noticeable also that graphite is always associated with the ores, in a manner suggestive of precipitating action upon the metallic ingredients.

In most examples of the ore the pyrite may be seen to occur in two forms: as finely divided particles more or less evenly distributed through the gangue and as aggregates of coarser grains and crystals in bunches, veinlets and stringers of quite irregular distribution. The relative abundance of the latter type determines to a great extent the relative richness of the ore. Pyrrhotite is not uncommon, but much less abundant than the pyrite. It forms independent bodies and also occurs in a few places in association with the pyrite. Its distribution seems entirely without rule.

Analyses of representative samples taken from various parts of the district show that the sulphur content ranges between the approximate limits of 20 and 30 per cent for the most part. The samples on which they were based were taken so as to give, so far as practicable, a fair average of the ore in a working face or exposure. The results are in agreement with mining experience in the district. Ore carrying around 30 per cent has been shipped in some quantity from the Cole property, and the average of that mine is probably over 25 per cent. The Stella and Pyrites deposits are lower grade, with an average of 20 per cent or a little more.

Experience has shown that the ores will concentrate readily to about 45 per cent sulphur, for which something over 2 tons crude will be required, depending on the individual deposit.

Of the three properties which have been exploited on a commercial scale, the Stella is the single one in present operation. It is worked by the St Lawrence Pyrite Co. and turns out 50,000 tons or more of concentrates a year. The Cole mine, which has been worked intermittently, shipping lump ore, was taken under option by the same company during the past summer and explored. It has an ore richer than the average. The third mine, known as the Pyrites or High Falls, is held on lease by the Oliver Iron Co., of

[1] N. Y. State Mus. Bul. 158, 1912.

Duluth, which has never worked it but apparently is holding the property as a possible future source of supply.

In addition to these developed mines there are many prospects and outcrops of the pyrite ores in southwestern St Lawrence and northern Jefferson counties. The beltlike development of the pyritous schists makes for a degree of continuity in the ore-bearing areas as they are traced on the strike that is quite remarkable, although of course there is no absolute uniformity in the enrichment of the material by sulphides. At the same time the work of prospecting is greatly facilitated by this characteristic.

The same belt in which the Cole mine is located extends northeast for 6 or 7 miles, paralleling the Rome, Watertown & Ogdensburg Railroad for the first 5 miles to a point a mile or so beyond Bigelow. The Hendricks, Styles and Farr shafts are located within this area.

Another belt extends through Hermon and has been prospected near Ore Bed school, 2 miles northeast of Hermon village.

A remarkably persistent outcrop of the pyrite schist is found in the towns of Hermon, Fowler and Gouverneur, St Lawrence county, and Antwerp, Jefferson county. It crosses the Oswegatchie river at Hailesboro, from which point it reaches northeast in a nearly straight course to the Barnum school, in the town of Hermon, and southwest to Keene station below Gouverneur and thence along the Rome, Watertown & Ogdensburg Railroad to near Antwerp. Its principal development is in the stretch from near the old Caledonia iron mines just north of Keene to the Dickson mines north of Antwerp. The pyrite schist is accompanied in this stretch by hematite which also occurs in sporadic bodies elsewhere and which is an indicator of pyrite throughout this section. Little or no prospecting for pyrite has been carried on in this belt, although the schist has been well exposed by the iron-mining operations or is found in natural outcrop. In several places, notably on the Keene, Morgan, Wight and Dickson properties, there is a good body of the ore shown which carries above 20 per cent in sulphur. The vein ranges from 10 to 25 feet or more in thickness. The deposit is so persistent on the surface that its continuity for a good distance on the dip may be regarded as assured. The ore is coarser in grain in the southwest part on the Wight and Dickson properties than elsewhere. With the railroad close at hand this section seems one of the most attractive in which to prosecute exploration for pyrite.

In the vicinity of Oxbow, Jefferson county, is another schist belt that has locally enriched bodies that carry around 25 per cent or more sulphur. The Laidlaw farm, 1 mile east of Oxbow, on the north end of the belt, has been prospected in a small way by trenching across the body in one or two places. The ore shown in the principal pit consists of 4 feet of pyrrhotite on the footwall with 15 to 20 feet of pyrite overlying it. A composite sample of the latter gave the following results on analysis: Sulphur, 29.06 per cent; arsenic, 0.22 per cent; iron, 33.77 per cent. A sample of the pyrrhotite from the same place yielded 27.78 per cent sulphur.

In the vicinity of Sylvia lake is a belt of pyrite schist on which some prospecting has been done. The Kilburn place is one of the localities that has been tested. In the average the ore is lower grade than that of the other belts described. The belt is also rather inaccessible, lying several miles distant from the nearest station on the Edwards branch railroad. A very similar grade of ore occurs, south of Talcville, near Pleasant Valley school.

Altogether the St Lawrence-Jefferson county region contains enormous resources of ore of low-grade character. All of the material requires concentration to bring it up to marketable standard. The ratio of concentration and tenor of the product obtainable under practical conditions can be determined of course only by actual tests conducted for each deposit. But the experience that has been obtained in the past at the several mines under operation may be taken as a useful guide in a general way. It would appear that the practical limit to which concentration may be carried with the ores is to produce a product with 45 to 47 per cent sulphur. This requires from 2.5 to 3 tons of the crude 20 to 25 per cent ore to each ton of concentrates. Mining conditions in the region on the whole are favorable. The costs for mining and milling may be taken as about on the same level as in the iron mines in the eastern Adirondacks, or a little below the latter if anything, due allowance being made for local conditions and surroundings of the ccurrences.

SALT

The salt industry experienced a remarkable expansion of activity in 1916. Although no new mines or evaporating plants entered the list of producers during the year, the output increased by about 27 per cent in quantity and 23 per cent in value as compared with the totals reported for 1915. This shows the great reserve of productive capacity available that was not hitherto brought into use.

The total product, inclusive of rock and evaporated salt and the salt contents of brine employed for the manufacture of soda products, amounted to 14,087,750 barrels, as compared with 11,095,301 barrels for the preceding year, also a record output. It is noticeable that the value placed upon the product, $3,698,798, represents a smaller average than the amount $3,011,932 returned for 1915, the value a barrel being 26 cents last year, against 27 cents in 1915. In spite of this the actual selling prices of marketed salt showed a considerable increase, as will be observed from the figures given in the accompanying tables. The explanation of the apparent anomaly lies in the proportionately larger output of salt in brine used for chemical manufacture without evaporation, on which a merely nominal value is placed and which in consequence of the size of the product has a very appreciable influence upon the average figure. The grades of evaporated salt, which naturally command the highest prices in the market, account for only about 25 per cent of the total product of the State. The prices for such grades ranged last year between 44 and 71 cents a barrel, as compared with an average of 16 cents for the combined output of rock salt and salt in brine.

Production of salt by grades in 1915

GRADE	BARRELS	VALUE	VALUE A BARREL
Common fine *a*	1 460 379	$598 193	$.40
Common coarse	126 193	59 077	.46
Table and dairy	1 274 743	829 581	.65
Solar	267 886	93 760	.35
Packers	165 179	83 890	.50
Other grades *b*	7 800 921	1 347 431	.17
Total	11 095 301	$3 011 932	$.27

Production of salt by grades in 1916

GRADE	BARRELS	VALUE	VALUE A BARREL
Common fine *a*	1 694 943	$828 617	$.48
Common coarse	267 421	153 844	.57
Table and dairy	1 308 529	940 969	.71
Solar	249 728	110 505	.44
Packers	*c*	....	....
Other grades *b*	10 567 129	1 664 863	.16
Total	14 087 750	$3 698 798	$.26

a Common fine includes a small amount of common coarse.
b Includes rock salt, salt in brine used for alkali manufacture, agricultural salt and small amounts of brine salt for which the uses were not specified in the returns.
c Included in other grades.

In respect to the separate items of the tables, it may be noted that common fine salt includes the commercial product of fine artificially evaporated salt, not specially prepared for use. Common coarse is the coarser product of similar quality. Table and dairy salt represents the highest grade, specially sorted or otherwise prepared for table and dairy use. Packers is the grade sold to meat packers and fish salters. Solar salt is a somewhat exceptional product, as it is made in no other state in the east, and it does not compete in the market with other grades of evaporated salt. It represents the output of solar evaporation of the natural brines that occur in Syracuse and vicinity. Its uses are much the same as those of rock salt.

The returns for 1916 showed a total of 25 active concerns in the business in the State, distributed among the following counties: Genesee 1, Livingston 3, Onondaga 15, Schuyler 1, Tompkins 2, Wyoming 3. Of the number, 14 were solar salt makers with a small individual output. Two produced rock salt and the other 9 were engaged in making various grades of evaporated salt. Livingston county has the largest output, followed closely by Onondaga, with Tompkins in third place.

Following the recent exploration at Portland Point, Cayuga county, announced in the report for 1915, which resulted in the location of a bed of rock salt 65 feet thick at a depth of 1484 feet from the surface, shaft sinking operations were begun with a view to working the salt deposit underground. Operations were held up during a part of the year by trouble with natural gas, which resulted in a serious explosion and incident loss of life. The flow of gas came mainly from the Marcellus shale, according to accounts, and there seemed to be no reason to anticipate that the difficulties from this source would increase with depth so as to endanger the final success of the undertaking.

The following table of production for the 20-year period 1897–1916 evidences the rapid strides that have been made in the development of the local resources. The figures for the years preceding 1904 are taken from the volumes of the *Mineral Resources,* published by the United States Geological Survey.

Production of salt in New York

YEAR	BARRELS	VALUE
1897	6 805 854	$1 948 759
1898	6 791 798	2 369 323
1899	7 489 105	2 540 426
1900	7 897 071	2 171 418
1901	7 286 320	2 089 834
1902	8 523 389	1 938 539
1903	8 170 648	2 007 807
1904	8 724 768	2 102 748
1905	8 575 649	2 303 067
1906	9 013 993	2 131 650
1907	9 657 543	2 449 178
1908	9 005 311	2 136 736
1909	9 880 618	2 298 652
1910	10 270 273	2 258 292
1911	10 082 656	2 191 485
1912	10 502 214	2 597 260
1913	10 819 521	2 856 664
1914	10 389 072	2 835 706
1915	11 095 301	3 011 932
1916	14 087 750	3 698 798

SAND AND GRAVEL

The sand and gravel industry is represented in every section and nearly every county of the State. The deposits of these materials are so widespread that usually the ordinary demands of each community, so far as building purposes are concerned, can be met from supplies close at hand.

The sand and gravel beds of the State belong mainly to the Pleistocene formations, accumulated as the result of the great ice invasion which moved from north to south and reached as far south as northern New Jersey and Pennsylvania. This ice sheet swept the rocks bare of their former mantle of disintegrated material and in its place left a covering of transported boulders, gravels, sands and clays. These deposits, when laid down directly by the ice as ground moraine, are so intermixed as to have little or no industrial value. Such unmodified drift covers a considerable portion of the area, especially of the hilly country; in the valleys and lowlands the ground moraine has been removed by stream action or concealed below beds of sorted gravels and sands that were laid down in bodies of standing water whose existence in most cases was incidental to the flooded waters of the Glacial period. In some of the larger valleys like the Hudson, Champlain and Genesee, as well as in numerous smaller ones, the glacial waters were held imprisoned for a time by dams so that they stood high above the present levels, and the sands and clays are revealed today in a series of terraces of great thickness and well-sorted arrangement.

Beach sands are found on the shores of many of the interior lakes and around Oneida lake in particular are of considerable economic importance. These are characterized by a degree of uniformity and purity which make them valuable for many purposes, like glass-making, molding, etc. The most valuable sand beaches, however, occur on Long Island where most of the supply of building sands for New York and vicinity is obtained.

The information as to the production of sand and gravel collected for this report gives probably a fairly close approximation of the business, and for certain branches is very reliable, but it is not claimed that it is complete. The figures for building sand and gravel are perhaps the least reliable, and understate the actual business perhaps as much as 15 per cent of the total output in any one year. The operations in building sand are so widely scattered and often of so fugitive nature that it is impossible to keep abreast of all the developments and changes in the industry that take place. On the other hand, the data on molding sand are measurably full and the statistics can be accepted as being as accurate as those in many other lines of the mineral industry. This branch of the trade has a stable basis and is restricted to a limited area, mostly in the Hudson River valley.

Production of sand and gravel

MATERIAL	1914	1915	1916
Building sand	$1 151 521	$1 185 812	$941 884
Molding sand	310 727	415 073	570 898
Fire and core sand	23 944	24 797	16 430*b*
Other sand *a*	75 000	75 000	134 638
Gravel	650 895	965 336	980 979
Total	$2 212 087	$2 666 018	$2 644 829

a Includes engine sand, paving, glass, railroad ballast and a small amount of miscellaneous sand.
b Represents fire sand alone.

The total quantity of building sand (for concrete and mortar) reported in 1916, for which the value alone is given in the above table, was 4,331,603 short tons. In the preceding year the compilation was based on cubic yards, of which the reported quantity was 4,127,508, equivalent to about 5,000,000 tons. The drop in the production thus shown was owing to the dulness of the building trade, a condition that obtained all over the State as the result of the general situation brought on by the war. Nassau county, from which the New York market derives its supply, produced 3,044,359 tons valued at $578,945. The industry there is controlled by a few corporations who dredge the sand from shallow waters or excavate it by steam shovels from the exposed beaches. The sand is screened and loaded onto barges for shipment.

The output of molding and core sand in 1916 was 661,673 short tons valued at $570,898, against 454,511 short tons worth $415,073 in the preceding year. The business experienced a decided improvement, compared with the conditions in 1915, from the extraordinary activity in the metal industries. Most of the molding sand comes from the Hudson valley, from Rensselaer and Saratoga counties on the north to Dutchess and Ulster counties on the south. The material represents a special form of the fine sands, which with the brick clays, were laid down in the expanded waters that occupied the valley at the close of the ice invasion. The molding sand layer consists of the uppermost weathered layer from a few inches to several feet thick.

Among other kinds of sand that were produced in the State may be mentioned abrasive and grinding sand, 169,737 short tons, valued at $46,900; fire or furnace sand, of which the output amounted to 38,144 short tons, valued at $16,430; engine sand, 66,497 short tons, valued at $30,144; paving sand, 83,671 short tons, valued at $29,282; and various other uses 17,862 short tons, valued at $5,325.

The production of gravel for roofing, concrete and other uses amounted to 2,728,910 short tons, of a total value of $1,003,966.

STONE

The stone industry has for many years occupied a prominent place among the branches of the mineral industry of the State. Its growth was particularly rapid in the decade from 1890 to 1900, which was a period of remarkable advancement in all kinds of engineering work. At about the latter date, however, certain changes began to be introduced in the methods of building and engineering construction that served to check the rapid development of the stone industry and partially to transform it. The use of cement and terra cotta first gained importance about that time and has steadily expanded in the subsequent interval, largely at the expense of cut stone. This branch of the trade, consequently, has declined to small proportions, whereas formerly it was one of the principal elements in the industry and probably the most profitable one. Similarly the market for flagstone and curbstone has fallen off, especially flagstone, as a result of the favor shown for cement in street work. As a partial counterbalance for these losses, a tremendous development has occurred in the crushed stone trade through the requirements of concrete construction and road improvement work; yet altogether the changes that have occurred have meant a loss industrially, since in place of the numbers of skilled workmen once employed in the business there is now a minimum of hand labor, and much of it untrained.

The year 1916 brought little change in the conditions of the stone trade from those of the preceding year which were regarded as unsatisfactory. In one or two branches some improvement was noted, sufficient to give a slight impetus to the productive activities which were on a little larger scale than in 1915. The aggregate value of the quarry materials for the year was $5,979,622 against $5,162,115 in 1915 and $5,741,137 in 1914. There was thus a gain of about 16 per cent in the output for the year, but an increase of only 4 per cent for the two years. It is not unlikely that the turning point in the downward trend has been passed and that conditions will hold the slight gain already made, if they do not actually show further improvement.

The record of the industry for the last three years is exhibited in detail in the accompanying tables.

The granite quarries have continued to operate at about the usual rate. A large share of the product is building stone and is supplied on contract. A considerable gain in the output in 1916 under the last item of the table is accounted for by the restarting of some paving block quarries.

Limestone accounted for considerably more than one-half of the total value last year. Its importance lies mainly in its extensive use for crushed stone, for which limestone is by far most extensively employed.

Marble showed a gain, contributed by the building and monumental branches, which more than made up for the falling off in 1915. There are only a few quarries active in this industry.

Sandstone is the one variety which has experienced an almost uninterrupted decline during the last decade. More than any other kind it has felt the competition of cement, since the principal branches in New York State are those supplying stone for street work — curbstone, flagstone and paving blocks.

A gain in the production of trap restored the loss registered in the preceding year. The industry is carried on chiefly in Rockland county, and the principal quarries are in process of condemnation as part of the plan for the conservation of the Palisades.

Production of stone in 1914

VARIETY	BUILDING STONE	MONUMENTAL	CURBING AND FLAGGING	CRUSHED STONE	ALL OTHER	TOTAL VALUE
Granite........	$79 903	$10 952	....	$259 750	$16 637	$367 242
Limestone.....	81 409	....	$3 877	2 156 503	1 074 274	3 316 063
Marble........	142 223	70 797	....	8 000	9 222	230 242
Sandstone.....	217 508	....	490 222	36 143	313 117	1 056 990
Trap..........	....	....	....	770 600	....	770 600
Total.....	$521 043	$81 749	$494 099	$3 230 996	$1 413 250	$5 741 137

Production of stone in 1915

VARIETY	BUILDING STONE	MONUMENTAL	CURBING AND FLAGGING	CRUSHED STONE	ALL OTHER	TOTAL VALUE
Granite.......	$261 091	$19 926	$1 165	$61 965	$78 450	$422 597
Limestone.....	63 121	....	1 627	2 072 852	1 040 100	3 177 700
Marble.......	61 601	37 074	....	....	21 772	120 447
Sandstone.....	198 743	....	317 986	77 368	296 314	890 411
Trap..........	....	....	....	497 660	53 300	550 960
Total......	$584 556	$57 000	$320 778	$2 709 845	$1 489 936	$5 162 115

Production of stone in 1916

VARIETY	BUILDING STONE	MONUMENTAL	CURBING AND FLAGGING	CRUSHED STONE	ALL OTHER	TOTAL VALUE
Granite........	$173 431	$9 293	....	$55 196	$130 199	$368 119
Limestone.....	59 492	*a*	$1 621	2 085 748	1 525 593	3 672 454
Marble........	133 238	75 587	....	....	59 566	268 391
Sandstone.....	184 971	....	259 047	124 555	145 985	714 558
Trap..........	4 000	....	....	952 100	....	956 100
Total.....	$555 132	$84 880	$260 668	$3 217 599	$1 861 243	$5 979 622

a Included under "all other."

GRANITE

The quarrying of granite for commercial purposes is carried on in the Adirondack and St Lawrence river regions in the north and the Highlands in the southeastern part. A detailed account of the resources in this material, which are much more important than one might infer from the statistics of production, will be found in Bulletin 181 of the New York State Museum, issued in 1916.

The granite employed for building stone is mainly quarried in southeastern New York. The Mohegan Granite Co., with quarries near Peekskill, and the firm of H. S. Kerbaugh, Inc., with quarries at Valhalla, are the principal factors in this industry. The Peekskill stone possesses an attractive appearance in the mass, being from light gray to deep yellow in color. The yellow variety has been much in demand for large structures.

In the Adirondacks, Essex and Clinton counties contribute most of the stone reported from that region. Included in the product is the green monumental stone from Ausable Forks, scarcely to be duplicated elsewhere. The material is really syenite and is very lustrous when polished, showing a dark green color.

In the St Lawrence River district the Wisconsin Granite Co. has recently acquired interests in quarry lands of the well-known red granite which outcrops on several islands in the river. Its main quarries are on Wellesley island, which were worked last year for paving blocks. J. Leopold & Co. have quarries at Alexandria Bay, where paving blocks are the main product. The output of this region is sold in the markets contiguous to the Great Lakes.

The output of granite in 1916 had a value of $368,119, as compared with $422,597 in 1915. The value of the building stone was $173,431, against $261,091 in the preceding year. Monumental stone accounted for a value of $9293 ($19,926 in 1915) and crushed stone for $55,196 ($61,965 in 1915). The output of paving blocks was valued at $44,437. Rubble and riprap represents a value of $81,412.

LIMESTONE

The stone classified under the heading of limestone consists for the most part of the common grades of limestone and dolomite, such as are characterized by a compact granular or finely crystalline texture and are lacking in ornamental qualities. A smaller part is represented by crystalline limestones and by the waste products of marble quarrying which are sometimes employed for crushed stone, lime-making or flux. Limestone used for the manufacture of portland and natural cement is, however, excluded from the tabulations so as to avoid any duplication of the statistics.

Limestones have a wide distribution in the State, the only region which is not well supplied being the southern part, where the prevailing formations are sandstones of upper Devonic age. The micro-crystalline varieties occur in regularly stratified order in the Cambric, Lower Siluric, Upper Siluric and the lower and middle parts of the Devonic system. In most sections they occupy considerable belts and have been little disturbed from their original position. On the borders of the Adirondacks and in the metamorphic Hudson River region, however, they have been more or less broken up by faulting and erosion and in places have a very patchy distribution.

The main limestone formations of the State are the Beekmantown, developed in the Champlain and Mohawk valleys, usually rather impure and hence not very important economically; the Chazy limestone in the Champlain valley, with its time equivalent the Pamelia limestone in Jefferson county, one of the highest grade calcium limestones in the State and suitable for nearly all purposes, even being employed as ornamental stone by reason of its attractive color and the ornamental pattern it takes on in polished condition, from the presence of fossils; the Trenton limestones which include the several members known as the Lowville, Black River and Trenton, developed on the eastern, southern and western sides of the Adirondacks, extensively employed for cement, lime, flux and various structural uses; the Niagara beds, mainly represented in the western part between the Genesee and Niagara rivers, including dolomite with minor beds of calcium limestones; the Cayugan group of the eastern and central parts; the Helderbergian limestones, strongly represented in the Hudson valley from Albany county to Ulster county, employed in portland cement manufacture, lime-making and structural purposes; the Onondaga limestone, developed from the Niagara river across the State to Albany county and thence through Greene, Ulster and Orange counties to the Delaware river, probably the most extensively quarried of all; and the Tully limestone, a relatively thin formation extending from Ontario to Madison county, used by the cement works at Portland Point on Cayuga lake. In addition to the hard limestones there are beds of marl or earthy carbonate of lime in many parts, particularly in the lower ground which are or have been occupied by swamps and lakes.

As has been noted in a previous paragraph, limestone takes first place among the kinds of stone represented in the production of the State. In value it constitutes considerably more than one-half of the total, although for some uses it ranks far inferior to other kinds. Its main use is as crushed stone for concrete and road work; material for such purpose may be had from practically all the formations that contain these rocks. It also finds extensive employment for chemical and metallurgical purposes, serving as reagent in numerous ways. Lime manufacture still holds a prominent place in the industry, although it has felt the competition of cement and gypsum plasters. Of late a growing demand has been felt for ground limestone and for burnt lime in agriculture. As a building stone limestone is of secondary importance.

The production of limestone in 1916 increased somewhat, the value $3,672,454 comparing with $3,177,700 in the preceding year, which also was smaller than in 1914.

The output of crushed stone was returned as 3,612,177 tons, valued at $2,085,748. Of this the quantity used for road purposes was 1,566,530 tons, with a value of $903,350, that for railroad ballast 891,118 tons valued at $494,858, and the quantity for concrete was 1,154,521 tons valued at $687,540. In 1915 the quantity was reported in cubic yards, each cubic yard representing about one and one-fourth tons, and the total for all kinds was 2,985,347 yards, valued at $2,072,852.

Building stone, rough and dressed, was returned at a value of $59,492, against $63,121 in the preceding year. The decline was small but was a continuance of the trend that has been maintained for several years past; the total was scarcely one-third that of 10 years ago, so rapidly has this branch of the business fallen off.

The quantity of stone quarried for furnace flux was reported as 657,788 tons valued at $405,774. In 1915 the quantity was 822,729 short tons with a value of $440,237. This material largely consists of high-calcium limestone, and to meet the requirements the stone has to be quite low in silicious and aluminous ingredients, and contain little or no phosphorus or sulphur. The large flux quarries are in the Onondaga limestone of Erie and Genesee counties; the Clinton limestone of Niagara county; the Chazy limestone of Clinton county; and the Precambrian crystalline limestones or marbles of the Adirondack region.

Lime manufacture is still one of the larger outlets for the product, although the business has undergone considerable change in the last few years. Building lime, formerly the most important branch of the business, has only a limited market now, with the general use of cement and gypsum plasters; on the other hand various other uses have developed to take its place. The paper mills afford a large market for the product, and one of the most profitable, since the local burners command certain advantages from their situation near the markets. The recent campaign for the improvement of farm lands has brought about a large increase in the amount of lime employed as an amendment, though there is still a great field for further development along this line. Metallurgy is another outlet of growing importance. The curtailment of supplies of magnesite has caused manufacturers of refractory materials to turn to dolomite as a substitute. The State has ample resources of this material. The statistics of the industry for 1916 show a total output of lime amounting to 117,490 short tons with a value of $636,668, which represented a large gain in the business. The principal centers of the industry are in Warren, Washington, Clinton, Fulton, Lewis and Dutchess counties.

Ground raw limestone for agricultural uses was reported to the value of $164,237. This would correspond to about 80,000 tons, which is probably somewhat short of the actual sales in that form.

MARBLE

True marble is a thoroughly crystalline limestone, in which the carbonates are developed as more or less equidimensional rhombohedra. Such form of limestone results from the crystallizing influence of heat and pressure and consequently is found in metamorphic areas that accompany mountain-making and igneous intrusions. In New York State this form occurs in the Adirondacks in the north and the Taconic-Highlands region in the southeast. It is thus of early geological age, since the period of crustal movement and metamorphism in the Adirondacks was terminated before the beginning of Cambrian time, and in southeastern New York was completed with the Paleozoic.

In the Adirondack region the crystalline limestones useful for quarry materials are most abundant on the western border in Jefferson, Lewis and St Lawrence counties where they occur in belts up to 4 or 5 miles wide and several times that long, interfolded and more or less intermingled with sedimentary gneisses, schists and quartzites. They are found in smaller and more irregularly bounded areas in Warren and Essex counties on the eastern side, but have little importance elsewhere. The serpentinous marbles that have been quarried at different times belong to the same series. The marbles of the Adirondacks comprise both calcite varieties with little magnesia, and magnesian varieties ranging into true dolomites, with 40 per cent of more of magnesium carbonate. No definite relations seem to underlie their respective occurrence and both calcic and dolomitic marbles are found in the same belts and sometimes in close association.

The southeastern New York marbles occur in belts which follow the north-south valleys that parallel the ranges of hills to the east of the Hudson from Manhattan island north to Columbia county. On the west side of the river in Orange county are found a few smaller belts. In this region the marbles mostly belong to the dolomite class. They are interfolded with schists and quartzites, the whole series having steep dips like those of strongly compressed strata. The geologic age of the southern belts may be Precambrian, but on the north and east within the Taconic area they are perhaps Paleozoic. Individually the marbles range from very coarse to fine-grained rocks, white to grayish in color, rarely showing color pattern and are either magnesian marbles or true dolomites.

Some compact granular limestones that are capable of taking a good polish are classed as marbles in the trade. They lack the brilliancy of the crystalline varieties, but may possess an attractive color or a variety of pattern such as is lent by the presence of fossils. In some instances a subcrystalline texture has been developed as a result of solution and precipitation of the carbonates by ground waters. There are quarries in the Chazy, Trenton and Becraft limestones that have produced stone for decorative purposes.

The marble quarries reported a more active business last year than in 1915, which was an exceptionally dull season. The value of the output reached $268,391, of which about 50 per cent represented building marble, or in exact figures $133,238. Monumental stone accounted for $75,587 and other kinds for $59,566. There were 8 quarries altogether in operation distributed among Clinton, Warren, St Lawrence, Dutchess and Westchester counties.

SANDSTONE

Among the sedimentary formations which occur in the State, sandstone probably has the largest areal distribution, while in economic importance it has normally ranked second to limestone. Nearly all the recognized stratigraphic divisions above the Archean contain sandstone in one or more horizons. The kinds chiefly quarried are the Potsdam, Hudson River, Medina, Hamilton, Chemung and Portage sandstones. A few quarries have been opened also in the Shawangunk grit, the Rensselaer grit and the Clinton and Triassic sandstones.

Of the Potsdam sandstone, which represents the Upper Cambrian in New York State, the most extensive outcrops occur along the northern and northwestern borders of the Adirondacks, in Clinton, Franklin, St Lawrence and Jefferson counties. Other exposures are found in the Lake Champlain valley and a few uneroded remnants occur in the Mohawk valley. The sandstone in many places has the character of quartzite, consisting of quartz grains cemented by a secondary deposition of quartz, and is an exceedingly hard and durable material. It is the purest of the sandstones and in certain exposures carries over 95 per cent silica. There are some beds which are adapted for glass-making or for the manufacture of metallic silicon and ferrosilicon, and in fact the latter products are now being made from this material. The principal quarries of building stone are situated near Potsdam, St Lawrence county, Redwood, Jefferson county, and Malone and Burke, Franklin county.

The Medina sandstone has been quarried extensively for building stone, paving blocks and curbstone, and there is still an important industry based on the production of those materials in Orleans and Niagara counties. It is a fine-grained sandstone of pink, white and variegated color. The pink is an excellent freestone that has been employed in many of our cities for large structures.

The Shawangunk conglomerate is more widely known for its use in millstones than for constructional purposes. It outcrops along the Shawangunk mountain ridge in Ulster county. The quarries near Otisville have supplied considerable quantities of stone for abutments and rough masonry.

The Rensselaer grit is limited to a rather small belt in the so-called Rensselaer plateau east of the Hudson river. The stone has a close texture which may resemble that of a trap, and is used for crushed stone. The largest quarries are near Brainard Station, Rensselaer county.

The sandstones in the Hamilton, Portage and Chemung formations of the Devonian are popularly known as bluestone, a name first applied to those in Ulster county where in many places they are distinguished by a bluish gray color. They are for the most part fine-grained, evenly bedded, bluish gray, green or pinkish sandstones, that often have a well-developed "reed" or capacity for splitting along planes parallel to the bedding so as to yield smooth, thin slabs. For that reason they are extensively used for flag and curbstone, and a large industry is based on the quarrying of these materials for sale in eastern cities. Most of the flagstone is produced in the region along the Hudson and Delaware rivers, where there are convenient shipping facilities to New York, Philadelphia and other places on the Atlantic coast. The Hudson River district includes Albany, Greene and Ulster counties, but the quarries are mainly situated in the area that includes southern Greene and northern Ulster, with Saugerties and Kingston as the chief shipping points. The Delaware River district embraces Sullivan, Delaware and Broome counties; the shipping stations are along the Erie and Ontario & Western Railroads. Large quarries outside of these districts are found near Norwich, Chenango county, and Warsaw, Wyoming county, which produce building stone chiefly, for the general market. Numerous small quarries have been operated at different times in Otsego, Chemung, Tompkins, Tioga, Schuyler, Steuben, Yates, Allegany, Cattaraugus and Chautauqua counties.

The production of sandstone in 1916 showed a decline of about 20 per cent, marking a continuance of the downward trend in the business that has been noted for several years past. The combined value of the output was $714,558, whereas in 1915 it amounted to $890,411. The extent and rapidity of the decline in this branch of the quarry industry may be appreciated from the figures reported 10 years ago: in 1907 the total was $1,998,417 and in earlier years it reached over $2,000,000. An examination of the conditions year by year shows that the industry has been depressed by the strong competition it has had to meet from other kinds of material in the building and city engineering markets. Granite and cement have been gradually superseding sandstone for street work, and the same holds true for building stone.

Of the total returned for 1916, the bluestone quarries reported an aggregate value of $376,845, against a value of $339,779 in the preceding year. The slight gain may doubtless be accounted for by the high prices of cement that ruled during the year. The value of the building stone included in the total was $168,834 against $178,577 in 1915. Curb and flagstone amounted to $169,973, against $155,288 in 1915. Of other kinds, there was produced crushed stone valued at $27,767 and miscellaneous kinds valued at $10,271. The Hudson River district accounted for an aggregate of $98,669, mostly curb and flagstone; the Delaware River district contributed $67,493, made up largely of curb and flagstone but with some building stone.

The sandstone other than bluestone represented a value of $337,713 as compared with $550,632 in 1915. Paving blocks were the largest single item, with a value of $131,430, while crushed stone was worth $96,788, building stone $16,137 and other kinds $4284. Orleans county alone contributed a product worth $226,945, which was little more than one-half of the value reported in 1915, in actual figures $449,620.

TRAP

Trap is not a distinct variety of rock, but the name is given collectively to the fine-grained, igneous rocks that occur in intrusive sheets and dikes. From granite it differs by its darker color, due to the absence of quartz and the participation of the ferromagnesian minerals in large amounts. Some of the so-called "black granites," however, are really trap. The particular value of trap lies in its hardness, toughness and lack of cleavage. Its fine, compact, closely knit texture gives the stone great wearing powers, and it is eminently adapted for road metal and concrete of which heavy service is required. The principal outlet, therefore, is for crushed stone. It has been used to some extent, also, for paving blocks, but these are rather difficult to prepare, since trap very seldom shows any capacity for parting comparable to the rift and grain structures of granites. As building stone it finds very little application, probably on account of its somber color. The expense of cutting and dressing trap is also an obstacle to its employment for building or ornamental purposes.

The largest body of trap in New York State is represented in the Palisades of the Hudson, and the continuation of the same intrusion is found southward in New Jersey and on Staten island. This occurrence, properly, is diabase, with plagioclase, feldspar and pyroxene as the main ingredients. The Palisades are the exposed edge of a great sill or sheet of the rock which came up from below and forced its way along the bedding planes of the Triassic sandstones and shales. The sheet is several hundred feet thick, in places nearly 1000 feet, but the outcrop is narrow, seldom over a mile wide and in places is limited to a single vertical escarpment. The principal quarries are near Nyack and Haverstraw at the base of the cliffs. Other quarries have been opened near Suffern, on an isolated intrusion of a similar rock, and also near Port Richmond, Staten island, at the southern end of the Palisades sill.

There are numerous occurrences of trap in the Adirondacks, where it occurs in the form of dikes that intersect the older Precambrian crystalline formations. The dikes occur literally in thousands in Essex and Clinton counties, but they seldom attain any considerable thickness, 20 to 30 feet being about the maximum. Near Greenfield, Saratoga county, and at Little Falls, Herkimer county, occur dikes of much larger size. The Greenfield dike has been worked in years past for crushed stone.

The output of trap in 1916 was valued at $956,100, a large gain over the total of $550,960 reported in the preceding year. The quantity of crushed stone reported was 1,280,500 tons, consisting of crushed stone for roads 561,000 tons, for railroad ballast 64,250 tons, and for concrete 655,250 tons. In 1915 the quantity was reported in cubic yards and amounted to 683,700, a yard amounting to nearly one and one-half tons.

TALC

The conditions in the talc trade showed notable improvement in 1916 and more than made up for the dulness of the preceding season. The demand in the paper trade was especially active, with the curtailment in the supply of foreign clays which used to enter the market very freely. In their place southern clays are being employed quite extensively, but not in the full proportion to the former use of foreign material. While the paper industry, especially the branches engaged in book and writing paper manufacture, are the largest consumers of St Lawrence county talc, other important outlets are found in the manufacture of wall plasters, in the paint and rubber trade, and many other industries.

The production reached record figures, amounting to 93,236 short tons valued at $961,510, larger by nearly 20,000 tons than the total reported in the best previous year. The contributing mining companies were the same as enumerated in the preceding year, inclusive of the International Pulp Co., the Uniform Fibrous Talc Co., and the Ontario Talc Co. in the Gouverneur district and the St Lawrence Talc Co., with a mine at Natural Bridge. The International Pulp Co. operated several mines situated in the Talcville and Sylvia Lake sections, the principal producers having been No. 2½ and No. 3 mines in the former section and the Balmat mine in the other. The Uniform Fibrous Talc Co. worked its single property on Wintergreen hill, below Talcville, where its mill is also situated. The Ontario Talc Co. lost its mill by fire and has gone out of business. Its mine near Fullerville contains a good body of fibrous talc and will doubtless be worked again, although it has been allowed to fill with water.

The St Lawrence Talc Co. produces a different grade of talc from the others, which finds special uses.

There has been no new work undertaken in the St Lawrence county talc district for several years. The industry in fact suffered for a long time from overexpansion, with mine and mill capacity that far exceeded the market outlet for the product. This condition has been gradually remedied by the shutting down of mines from time to time, and recently by the unexpected expansion of the trade which it is not yet certain will prove more than a temporary feature. There is no doubt that the profits in the business hitherto have been smaller than they should have been by reason of competition among the producers on the one hand and the payment in many instances of excessive royalties to the owners of the mineral rights covering the talc. The latter are often held apart from the land surface and the owners have been able to exact heavy royalties, amounting to as much as $1 a ton on the output, several times over what is ordinarily considered a fair tax on other minerals of approximately the same value.

The talc business was started in St Lawrence county in the last of the seventies of the last century, and began to take on importance about 1880 since which time the output has amounted to nearly 1,800,000 tons valued at nearly $16,000,000.

ZINC

The production of zinc ore in 1916 was all made by one mine, that of the Northern Ore Co., which began operations in the preceding year. The shipments were in the form of mill concentrates, carrying around 48 or 49 per cent zinc. They were of such size as to place the property on a very successful basis, in fact establishing it as one of the prominent zinc mines in the east. Owing to the fact that there were no other producers, the actual figures of output are withheld from publication.

The developments in the mine at Edwards have continued to be favorable and have warranted the policy of gradual expansion of operations. A verticlal shaft was started to intercept the ore bodies on their extension in dip that have been worked through the Brown incline. The shaft starts in the gneiss, overlying the limestone ore formation. It is expected to continue the shaft to a depth of around 800 feet but it will be used for production before that point is reached, since the first ore body will be encountered at around 500 feet. The drift on the 400-foot level of the Brown shaft has been extended northeast to test the ground explored by the White and Williams shafts which are not used for hoisting, all the ore from that section being taken to the Brown shaft on account of its convenient situation.

There is enough ore assured on the property to sustain operations for several years to come.

Prospecting was carried on in other parts of the district but no deposit was actually developed to the productive stage. So far little more than surface testing, supplemented by diamond drilling in one or two places, has been undertaken.

No new occurrences in addition to those listed in the report for 1915 have been uncovered during the year.

In southeastern New York preparations were under way for restoring some of the old mining properties along the Shawangunk mountain ridge, which were opened 75 years ago and worked for a time for the lead content of the ore. The principal work in 1916 was in the Summitville property, which was taken over by the St Nicholas Zinc Co. The ore body consists of a brecciated zone in Shawangunk grit that has been filled by secondary quartz and the sulphides of zinc, lead, iron and copper. The principal fracturing has taken place along the bedding of the sandstone, and the vein consequently conforms with the dip and strike of the wall rock, although the boundary between ore and rock is more or less irregular. The sandstone shows effects of alteration by the mineralizing solutions, becoming charged with iron oxides and in places developing a greenish decomposition product.

The workings from the former operations consist of several openings on the outcrop some 200 feet below the ridge summit, together with an adit and level 220 feet below the line of outcrop, measured along the vein. This level is about 400 feet long north and south. The ore here dips 35° west and ranges from a few inches to 4 feet in thickness. A second adit was driven into the hill lower down at the level of the mill but did not encounter the vein.

Assays of ore samples as reported to the writer by Mr Kirby Thomas, consulting engineer for the company, showed an average of 21 per cent zinc, 12.6 per cent lead, a little copper and an ounce or two of silver. The sample represented the rich part of the vein of an average thickness of 18 inches.

The plans of the company are to mine the ore already in sight and simultaneously to carry on exploration for additional supplies. The milling operations are intended to effect a saving of both lead and zinc. The site of the new mill is close to the tracks of the Ontario & Western Railroad, near the base of the ridge. A 1600-foot aerial tramway will lower the ore by its own gravity from the working adit to the mill. J. MacDonald Mitchell is the engineer in charge.

At Wurtsboro, to the south of Summitville, is a similar occurrence of lead and zinc sulphides. It is referred to in the reports of the First Geological Survey as the Shawangunk mine, and Mather states that three solid masses of galena weighing 800, 1000 and 1400 pounds were taken from the vein at the time of his visit to the property about 1838. The vein apparently parallels the bedding planes of the grit and ranges up to 5 feet wide.

The Ellenville mine is another of the occurrences, similar in its metal contents to the two just described but differing in the fact that the vein occupies a cross-fracture in the sandstone rather than conformable with the bedding. It has been worked at different times since its first opening, which is stated by Mather to have been 23 years before his investigation, or before 1820. It is famous for specimen ores, which exhibit crystallized quartz intergrown with chalcopyrite, galena and sphalerite, also often in good crystals. A mill equipped with crushing and separating machinery of modern type remains on the property from the last period of operations in the years 1903–4.

INDEX

The University of the State of New York

New York State Museum

JOHN M. CLARKE, Director

PUBLICATIONS

Packages will be sent prepaid except when distance or weight renders the same impracticable. On 10 or more copies of any one publication 20% discount will be given. Editions printed are only large enough to meet special claims and probable sales. When the sale copies are exhausted, the price for the few reserve copies is advanced to that charged by secondhand booksellers, in order to limit their distribution to cases of special need. Such prices are inclosed in [ ]. All publications are in paper covers, unless binding is specified. Checks or money orders should be addressed and payable to The University of the State of New York.

Museum annual reports 1847–date. *All in print to* 1894, 50c *a volume*, 75c *in cloth*; 1894–*date, sold in sets only*; 75c *each for octavo volumes; price of quarto volumes on application.*

These reports are made up of the reports of the Director, Geologist, Paleontologist, Botanist and Entomologist, and museum bulletins and memoirs, issued as advance sections of the reports.

Director's annual reports 1904–date.

1904. 138p. 20c.
1905. 102p. 23pl. 30c.
1906. 186p. 41pl. 25c.
1907. (Bul. 121) 212p. 63pl. 50c.
1908. (Bul. 133) 234p. 39pl. map. 40c.
1909. (Bul. 140) 230p. 41pl. 2 maps, 4 charts. *Out of print*
1910. (Bul. 149) 280p. il. 42pl. 50c.
1911. (Bul. 158) 218p. 49pl. 50c.
1912. (Bul. 164) 214p. 50pl. 50c.
1913. (Bul. 173) 158p. il. 29pl. 40c.
1914. (Bul. 177) 174p. il. 33pl. 45c.
1915. (Bul. 187) 192p. il. 58pl. 5 maps. 50c.
1916. (Bul. 196) 308p. il. 50pl. mapsr 55c.

These reports cover the reports of the State Geologist and of the State Paleontologist. Bound also with the museum reports of which they form a part.

Geologist's annual reports 1881–date. Rep'ts 1, 3–13, 17–date, 8vo; 2, 14–16, 4to.

In 1898 the paleontologic work of the State was made distinct from the geologic and was reported separately from 1899–1903. The two departments were reunited in 1904, and are now reported in the Director's report.

The annual reports of the original Natural History Survey, 1837–41, are out of print.

Reports 1–4, 1881–84, were published only in separate form. Of the 5th report 4 pages were reprinted in the 39th museum report, and a supplement to the 6th report was included in the 40th museum reports. The 7th and subsequent reports are included in the 41st and following museum reports, except that certain lithographic plates in the 11th report (1891) and 13th (1893) are omitted from the 45th and 47th museum reports.

Separate volumes of the following only are available.

Report	*Price*	*Report*	*Price*	*Report*	*Price*
12 (1892)	$.50	17	$.75	21	$.40
14	.75	18	.75	22	.40
15, 2v.	2	19	.40	23	.45
16	1	20	.50	[*See* Director's annual reports]	

Paleontologist's annual reports 1899–date.

See first note under Geologist's annual reports.

Bound also with museum reports of which they form a part. Reports for 1899 and 1900 may be had for 20c each. Those for 1901–3 were issued as bulletins. In 1904 combined with the Director's report.

Entomologist's annual reports on the injurious and other insects of the State of New York 1882–date.

Reports 3–20 bound also with museum reports 40–46, 48–58 of which they form a part. Since 1898 these reports have been issued as bulletins. Reports 3–4, 17 are out of print, other reports with prices are:

Report	*Price*	*Report*	*Price*	*Report*	*Price*
1	$.50	11	$.25	21 (Bul. 104)	$.25
2	.30	12	.25	22 (" 110)	.25
5	.25	13	*Out of print*	23 (" 124)	.75
6	.15	14 (Bul. 23)	.20	24 (" 134)	.35
7	.20	15 (" 31)	.15	25 (" 141)	.35
8	.25	16 (" 36)	.25	26 (" 147)	.35
9	.25	18 (" 64)	.20	27 (" 155)	.40
10	.35	19 (" 76)	.15	28 (" 165)	.40
		20 (" 97)	.40	29 (" 175)	.45

Reports 2, 8–12 may also be obtained bound in cloth at 25c each in addition to the price given above.

Botanist's annual reports 1867–date.

Bound also with museum reports 21–date of which they form a part; the first Botanist's report appeared in the 21st museum report and is numbered 21. Reports 21–24, 29, 31–41 were not published separately.

Separate reports for 1871–74, 1876, 1888–98 are out of print. Report for 1899 may be had for 20c; 1900 for 50c. Since 1901 these reports have been issued as bulletins.

Descriptions and illustrations of edible, poisonous and unwholesome fungi of New York have also been published in volumes 1 and 3 of the 48th (1894) museum report and in volume 1 of the 49th (1895), 51st (1897), 52d (1898), 54th (1900), 55th (1901), in volume 4 of the 56th (1902), in volume 2 of the 57th (1903), in volume 4 of the 58th (1904), in volume 2 of the 59th (1905), in volume 1 of the 60th (1906), in volume 2 of the 61st (1907), 62d (1908), 63d (1909), 64th (1910), 65th (1911) reports. The descriptions and illustrations of edible and unwholesome species contained in the 49th, 51st and 52d reports have been revised and rearranged, and, combined with others more recently prepared, constitute Museum Memoir 4.

Museum bulletins 1887–date. 8vo. *To advance subscribers, $2 a year, or $1 a year for division* (1) *geology, economic geology, paleontology, mineralogy;* 50c *each for division* (2) *general zoology, archeology, miscellaneous,* (3) *botany,* (4) *entomology.*

Bulletins are grouped in the list on the following pages according to divisions.

The divisions to which bulletins belong are as follows:

1 Zoology
2 Botany
3 Economic Geology
4 Mineralogy
5 Entomology
6 “
7 Economic Geology
8 Botany
9 Zoology
10 Economic Geology
11 “
12 “
13 Entomology
14 Geology
15 Economic Geology
16 Archeology
17 Economic Geology
18 Archeology
19 Geology
20 Entomology
21 Geology
22 Archeology
23 Entomology
24 “
25 Botany
26 Entomology
27 “
28 Botany
29 Zoology
30 Economic Geology
31 Entomology
32 Archeology
33 Zoology
34 Geology
35 Economic Geology
36 Entomology
37 “
38 Zoology
39 Paleontology
40 Zoology
41 Archeology
42 Geology
43 Zoology
44 Economic Geology
45 Paleontology
46 Entomology
47 “
48 Geology
49 Paleontology
50 Archeology
51 Zoology
52 Paleontology
53 Entomology
54 Botany
55 Archeology
56 Geology
57 Entomology
58 Mineralogy
59 Entomology
60 Zoology
61 Economic Geology
62 Miscellaneous
63 Geology
64 Entomology
65 Paleontology
66 Miscellaneous
67 Botany
68 Entomology
69 Paleontology
70 Mineralogy
71 Zoology
72 Entomology
73 Archeology
74 Entomology
75 Botany
76 Entomology
77 Geology
78 Archeology
79 Entomology
80 Paleontology
81 Geology
82 “
83 “
84 “
85 Economic Geology
86 Entomology
87 Archeology
88 Zoology
89 Archeology
90 Paleontology
91 Zoology
92 Paleontology
93 Economic Geology
94 Botany
95 Geology
96 “
97 Entomology
98 Mineralogy
99 Paleontology
100 Economic Geology
101 Paleontology
102 Economic Geology
103 Entomology
104 “
105 Botany
106 Geology
107 Geology and Paleontology
108 Archeology
109 Entomology
110 “
111 Geology
112 Economic Geology
113 Archeology
114 Geology
115 “
116 Botany
117 Archeology
118 Geology
119 Economic Geology
120 “
121 Director's report for 1907
122 Botany
123 Economic Geology
124 Entomology
125 Archeology
126 Geology
127 Geology
128 “
129 Entomology
130 Zoology
131 Botany
132 Economic Geology
133 Director's report for 1908
134 Entomology
135 Geology
136 Entomology
137 Geology
138 “
139 Botany
140 Director's report for 1909
141 Entomology
142 Economic Geology
143 “
144 Archeology
145 Geology
146 “
147 Entomology
148 Geology
149 Director's report for 1910
150 Botany
151 Economic Geology
152 Geology
153 “
154 “
155 Entomology
156 “
157 Botany
158 Director's report for 1911
159 Geology
160 “
161 Economic Geology
162 Geology
163 Archeology
164 Director's report for 1912
165 Entomology
166 Economic Geology
167 Botany
168 Geology
169 “
170 “
171 “
172 “
173 Director's report for 1913
174 Economic Geology

175 Entomology
176 Botany
177 Director's report for 1914
178 Economic Geology
179 Botany
180 Entomology
181 Economic Geology
182 Geology
183 Geology
184 Archeology
185 Geology
186 Entomology
187 Director's report for 1915
188 Botany
189 Geology
190 Geology
191 "
192 "
193 "
194 Entomology
195 Geology
196 Director's report for 1916

Bulletins are also found with the annual reports of the museum as follows:

Bulletin	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*
12–15	48, v. 1	79	57, v. 1, pt 2	119–21	61, v. 1	155	65, v. 2
16, 17	50, v. 1	80	57, v. 1, pt 1	122	61, v. 2	156	65, v. 2
18, 19	51, v. 1	81, 82	58, v. 3	123	61, v. 1	157	65, v. 2
20–25	52, v. 1	83, 84	58, v. 1	124	61, v. 2	158	65, v. 1
26–31	53, v. 1	85	58, v. 2	125	62, v. 3	159	65, v. 1
32–34	54, v. 1	86	58, v. 5	126–28	62, v. 1	160	65, v. 1
35, 36	54, v. 2	87–89	58, v. 4	129	62, v. 2	161	65, v. 2
37–44	54, v. 3	90	58, v. 3	130	62, v. 3	162	65, v. 1
45–48	54, v. 4	91	58, v. 4	131, 132	62, v. 2	163	66, v. 2
49–54	55, v. 1	92	58, v. 3	133	62, v. 1	164	66, v. 1
55	56, v. 4	93	58, v. 2	134	62, v. 2	165–67	66, v. 2
56	56, v. 1	94	58, v. 4	135	63, v. 1	168–70	66, v. 1
57	56, v. 3	95, 96	58, v. 1	136	63, v. 2	171–76	67
58	56, v. 1	97	58, v. 5	137	63, v. 1	177–80	68
59, 60	56, v. 3	98, 99	59, v. 2	138	63, v. 1		
61	56, v. 1	100	59, v. 1	139	63, v. 2	*Memoir*	
62	56, v. 4	101	59, v. 2	140	63, v. 1	2	49, v. 3
63	56, v. 2	102	59, v. 1	141	63, v. 2	3, 4	53, v. 2
64	56, v. 3	103–5	59, v. 2	142	63, v. 2	5, 6	57, v. 3
65	56, v. 2	106	59, v. 1	143	63, v. 2	7	57, v. 4
66, 67	56, v. 4	107	60, v. 2	144	64, v. 2	8, pt 1	59, v. 3
68	56, v. 3	108	60, v. 3	145	64, v. 1	8, pt 2	59, v. 4
69	56, v. 2	109, 110	60, v. 1	146	64, v. 1	9, pt 1	60, v. 4
70, 71	57, v. 1, pt 1	111	60, v. 2	147	64, v. 2	9, pt 2	62, v. 4
72	57, v. 1, pt 2	112	60, v. 1	148	64, v. 2	10	60, v. 5
73	57, v. 2	113	60, v. 3	149	64, v. 1	11	61, v. 3
74	57, v. 1, pt 2	114	60, v. 1	150	64, v. 2	12, pt 1	63, v. 3
75	57, v. 2	115	60, v. 2	151	64, v. 2	12, pt 2	66, v. 3
76	57, v. 1, pt 2	116	60, v. 1	152	64, v. 2	13	63, v. 4
77	57, v. 1, pt 1	117	60, v. 3	153	64, v. 2	14, v. 1	65, v. 3
78	57, v. 2	118	60, v. 1	154	64, v. 2	14, v. 2	65, v. 4

The figures at the beginning of each entry in the following list indicate its number as a museum bulletin.

Geology and Paleontology. 14 Kemp, J. F. Geology of Moriah and Westport Townships, Essex Co., N. Y., with notes on the iron mines. 38p. il. 7pl. 2 maps. Sept. 1895. Free.

19 Merrill, F. J. H. Guide to the Study of the Geological Collections of the New York State Museum. 164p. 119 pl. map. Nov. 1898. *Out of print.*

21 Kemp, J. F. Geology of the Lake Placid Region. 24p. 1pl. map. Sept. 1898. Free.

34 Cumings, E. R. Lower Silurian System of Eastern Montgomery County; Prosser, C. S. Notes on the Stratigraphy of Mohawk Valley and Saratoga County, N. Y. 74p. 14pl. map. May 1900. 15c.

39 Clarke, J. M.; Simpson, G. B. & Loomis, F. B. Paleontologic Papers 1. 72p. il. 16pl. Oct. 1900. 15c.

Contents: Clarke, J. M. A Remarkable Occurrence of Orthoceras in the Oneonta Beds of the Chenango Valley, N. Y.
—— Paropsonema cryptophya; a Peculiar Echinoderm from the Intumescens-zone (Portage Beds) of Western New York.
—— Dictyonine Hexactinellid Sponges from the Upper Devonic of New York.
—— The Water Biscuit of Squaw Island, Canandaigua Lake, N. Y.
Simpson, G. B. Preliminary Descriptions of New Genera of Paleozoic Rugose Corals.
Loomis, F. B. Siluric Fungi from Western New York.

42 Ruedemann, Rudolf. Hudson River Beds near Albany and Their Taxonomic Equivalents. 116p. 2pl. map. Apr. 1901. 25c.

45 Grabau, A. W. Geology and Paleontology of Niagara Falls and Vicinity. 286p. il. 18pl. map. Apr. 1901. 65c; *cloth,* 90c.

48 Woodworth, J. B. Pleistocene Geology of Nassau County and Borough of Queens. 58p. il. 8pl. map. Dec. 1901. *Out of print.*

49 Ruedemann, Rudolf; Clarke, J. M. & Wood, Elvira. Paleontologic Papers 2. 240p. 13pl. Dec. 1901. *Out of print.*

Contents: Ruedemann, Rudolf. Trenton Conglomerate of Rysedorph Hill.
Clarke, J. M. Limestones of Central and Western New York Interbedded with Bituminous Shales of the Marcellus Stage.
Wood, Elvira. Marcellus Limestones of Lancaster, Erie Co., N. Y.
Clarke, J. M. New Agelacrinites.
—— Value of Amnigenia as an Indicator of Fresh-water Deposits during the Devonic of New York, Ireland and the Rhineland.

52 Clarke, J. M. Report of the State Paleontologist 1901. 280p. il. 10pl. map. 1 tab. July 1902. 40c.
56 Merrill, F. J. H. Description of the State Geologic Map of 1901. 42p. 2 maps, tab. Nov. 1902. Free.
63 Clarke, J. M. & Luther, D. D. Stratigraphy of Canandaigua and Naples Quadrangles. 78p. map. June 1904. 25c.
65 Clarke, J. M. Catalogue of Type Specimens of Paleozoic Fossils in the New York State Museum. 848p. May 1903. $1.20 *cloth.*
69 —— Report of the State Paleontologist 1902. 464p. 52pl. 7 maps. Nov. 1903. $1, *cloth.*
77 Cushing, H. P. Geology of the Vicinity of Little Falls, Herkimer Co. 98p. il. 15pl. 2 maps. Jan. 1905. 30c.
80 Clarke, J. M. Report of the State Paleontologist 1903. 396p. 29pl. 2 maps. Feb. 1905. 85c, *cloth.*
81 Clarke, J. M. & Luther, D. D. Watkins and Elmira Quadrangles. 32p. map. Mar. 1905. 25c.
82 —— Geologic Map of the Tully Quadrangle. 40p. map. Apr. 1905. 20c.
83 Woodworth, J. B. Pleistocene Geology of the Mooers Quadrangle. 62p. 25pl. map. June 1905. 25c.
84 —— Ancient Water Levels of the Champlain and Hudson Valleys. 206p. il. 11pl. 18 maps. July 1905. 45c.
90 Ruedemann, Rudolf. Cephalopoda of Beekmantown and Chazy Formations of Champlain Basin. 224p. il. 38pl. May 1906. 75c, *cloth.*
92 Grabau, A. W. Guide to the Geology and Paleontology of the Schoharie Region. 314p. il. 26pl. map. Apr. 1906. 75c, *cloth.*
95 Cushing, H. P. Geology of the Northern Adirondack Region. 188p. 15pl. 3 maps. Sept. 1905. 30c.
96 Ogilvie, I. H. Geology of the Paradox Lake Quadrangle. 54p. il. 17pl. map. Dec. 1905. 30c.
99 Luther, D. D. Geology of the Buffalo Quadrangle. 32p. map. May 1906. 20c.
101 —— Geology of the Penn Yan-Hammondsport Quadrangles. 28p. map. July 1906. *Out of print.*
106 Fairchild, H. L. Glacial Waters in the Erie Basin. 88p. 14pl. 9 maps. Feb. 1907. *Out of print.*
107 Woodworth, J. B.; Hartnagel, C. A.; Whitlock, H. P.; Hudson, G. H.; Clarke, J. M.; White, David & Berkey, C. P. Geological Papers. 388p. 54pl. map. May 1907. 90c, *cloth.*

Contents: Woodworth, J. B. Postglacial Faults of Eastern New York.
Hartnagel, C. A. Stratigraphic Relations of the Oneida Conglomerate.
—— Upper Siluric and Lower Devonic Formations of the Skunnemunk Mountain Region.
Whitlock, H. P. Minerals from Lyon Mountain, Clinton Co.
Hudson, G. H. On Some Pelmatozoa from the Chazy Limestone of New York.
Clarke, J. M. Some New Devonic Fossils.
—— An Interesting Style of Sand-filled Vein.
—— Eurypterus Shales of the Shawangunk Mountains in Eastern New York.
White, David. A Remarkable Fossil Tree Trunk from the Middle Devonic of New York.
Berkey, C. P. Structural and Stratigraphic Features of the Basal Gneisses of the Highlands.

111 Fairchild, H. L. Drumlins of New York. 60p. 28pl. 19 maps. July 1907. *Out of print.*
114 Hartnagel, C. A. Geologic Map of the Rochester and Ontario Beach Quadrangles. 36p. map. Aug. 1907. 20c.
115 Cushing, H. P. Geology of the Long Lake Quadrangle. 88p. 20pl. map. Sept. 1907. 25c.
118 Clarke, J. M. & Luther, D. D. Geologic Maps and Descriptions of the Portage and Nunda Quadrangles including a map of Letchworth Park. 50p. 16pl. 4 maps. Jan. 1908. 35c.

126 Miller, W. J. Geology of the Remsen Quadrangle. 54p. il. 11pl. map. Jan. 1909. 25c.
127 Fairchild, H. L. Glacial Waters in Central New York. 64p. 27pl. 15 maps. Mar. 1909. 40c.
128 Luther, D. D. Geology of the Geneva-Ovid Quadrangles. 44p. map. Apr. 1909. 20c.
135 Miller, W. J. Geology of the Port Leyden Quadrangle, Lewis County, N. Y. 62p. il. 11pl. map. Jan. 1910. 25c.
137 Luther, D. D. Geology of the Auburn-Genoa Quadrangles. 36p. map. Mar. 1910. 20c.
138 Kemp, J. F. & Ruedemann, Rudolf. Geology of the Elizabethtown and Port Henry Quadrangles. 176p. il. 20pl. 3 maps. Apr. 1910. *Out of print.*
145 Cushing, H. P.; Fairchild, H. L.; Ruedemann, Rudolf & Smyth, C. H. Geology of the Thousand Islands Region. 194p. il. 62pl. 6 maps. Dec. 1910. $1.00, *cloth.*
146 Berkey, C. P. Geologic Features and Problems of the New York City (Catskill) Aqueduct. 286p. il. 38pl. maps. Feb. 1911. 75c; *cloth*, $1.
148 Gordon, C. E. Geology of the Poughkeepsie Quadrangle. 122p. il. 26pl. map. Apr. 1911. 30c.
152 Luther, D. D. Geology of the Honeoye-Wayland Quadrangles. 30p. map. Oct. 1911. 20c.
153 Miller, William J. Geology of the Broadalbin Quadrangle, Fulton-Saratoga Counties, New York. 66p. il. 8pl. map. Dec. 1911. 25c.
154 Stoller, James H. Glacial Geology of the Schenectady Quadrangle. 44p. 9pl. map. Dec. 1911. 20c.
159 Kemp, James F. The Mineral Springs of Saratoga. 80p. il. 3pl. Apr. 1912. 15c.
160 Fairchild, H. L. Glacial Waters in the Black and Mohawk Valleys. 48p. il. 8pl. 14 maps. May 1912. 50c.
162 Ruedemann, Rudolf. The Lower Siluric Shales of the Mohawk Valley. 152p. il. 15pl. Aug. 1912. 35c.
168 Miller, William J. Geological History of New York State. 130p. 43pl. 10 maps. Dec. 1913. 40c.
169 Cushing, H. P. & Ruedemann, Rudolf. Geology of Saratoga Springs and Vicinity. 178p. il. 20pl. map. Feb. 1914. 40c.
170 Miller, William J. Geology of the North Creek Quadrangle. 90p. il. 14pl. Feb. 1914. 25c.
171 Hopkins, T. C. The Geology of the Syracuse Quadrangle. 80p. il. 20pl. map. July 1914. 25c.
172 Luther, D. D. Geology of the Attica and Depew Quadrangles. 32p. map. August 1914. 15c.
182 Miller, William J. The Geology of the Lake Pleasant Quadrangle. 56p. il 10pl. map. Feb. 1916. 25c.
183 Stoller, James H. Glacial Geology of the Saratoga Quadrangle. 50p. il. 12pl. map. Mar. 1, 1916. 25c.
185 Martin, James C. The Precambrian Rocks of the Canton Quadrangle. 112p. il. 20pl. map. May 1, 1916. 30c.
189 Ruedemann, Rudolf. Paleontologic Contributions from the New York State Museum. 225p. il. 36 pl. Sept. 1916. 50c.
191 Cushing, H. P. Geology of the Vicinity of Ogdensburg. 64p. il. 6pl. map. Nov. 1916. 25c.
192 Miller, William J. Geology of the Blue Mountain Quadrangle. 68p. il. 11pl. map. Dec. 1916. 25c.
193 —— The Adirondack Mountains. 97p. il. 30pl. 2 maps. Jan. 1917. 35c.
195 Fairchild, H. L. Postglacial Features of the Upper Hudson Valley. 22p. map. Mar. 1, 1917. 25c.
Luther, D. D. Geology of the Phelps Quadrangle. *In preparation.*
Whitnall, H. O. Geology of the Morrisville Quadrangle. *Prepared.*
Hudson, G. H. Geology of Valcour Island. *In preparation.*
Economic Geology. 3 Smock, J. C. Building Stone in the State of New York. 154p. Mar. 1888. 30c.

7 —— First Report on the Iron Mines and Iron Ore Districts in the State of New York. 78p. map. June 1889. 25c.
10 —— Building Stone in New York. 210p. map, tab. Sept. 1890. 40c.
11 Merrill, F. J. H. Salt and Gypsum Industries of New York. 94p. 12pl. 2 maps, 11 tab. Apr. 1893. *Not available.*
12 Ries, Heinrich. Clay Industries of New York. 174p. il. 1pl. map. Mar. 1895. 30c.
15 Merrill, F. J. H. Mineral Resources of New York. 240p. 2 maps. Sept. 1895. [50c]
17 —— Road Materials and Road Building in New York. 52p. 14pl. 2 maps. Oct. 1897. 15c.
30 Orton, Edward. Petroleum and Natural Gas in New York. 136p. il. 3 maps. Nov. 1899. 15c.
35 Ries, Heinrich. Clays of New York; Their Properties and Uses. 456p. 140pl. map. June 1900. $1.00 *cloth.*
44 —— Lime and Cement Industries of New York; Eckel, E. C. Chapters on the Cement Industry. 332p. 101pl. 2 maps. Dec. 1901. 85c, *cloth.*
61 Dickinson, H. T. Quarries of Bluestone and Other Sandstones in New York. 114p. 18pl. 2 maps. Mar. 1903. 35c.
85 Rafter, G. W. Hydrology of New York State. 902p. il. 44pl. 5 maps. May 1905. $1.50, *cloth.*
93 Newland, D. H. Mining and Quarry Industry of New York. 78p. July 1905. *Out of print.*
100 McCourt, W. E. Fire Tests of Some New York Building Stones. 40p. 26pl. Feb. 1906. 15c.
102 Newland, D. H. Mining and Quarry Industry of New York 1905. 162p. June 1906. 25c.
112 —— Mining and Quarry Industry of New York 1906. 82p. July 1907. *Out of print.*
119 —— & Kemp, J. F. Geology of the Adirondack Magnetic Iron Ores with a Report on the Mineville-Port Henry Mine Group. 184p. 14pl. 8 maps. Apr. 1908. 35c.
120 Newland, D. H. Mining and Quarry Industry of New York 1907. 82p. July 1908. 15c.
123 —— & Hartnagel, C. A. Iron Ores of the Clinton Formation in New York State. 76p. il. 14pl. 3 maps. Nov. 1908. 25c.
132 Newland, D. H. Mining and Quarry Industry of New York 1908. 98p July 1909. 15c.
142 —— Mining and Quarry Industry of New York for 1909. 98p. Aug. 1910. 15c.
143 —— Gypsum Deposits of New York. 94p. 20pl. 4 maps. Oct. 1910. 35c
151 —— Mining and Quarry Industry of New York 1910. 82p. June 1911. 15c.
161 —— Mining and Quarry Industry of New York 1911. 114p. July 1912. 20c.
166 —— Mining and Quarry Industry of New York 1912. 114p. August 1913. 20c.
174 —— Mining and Quarry Industry of New York 1913. 111p. Dec. 1914 20c.
178 —— Mining and Quarry Industry of New York 1914. 88p. Nov. 1915. 15c.
181 —— The Quarry Materials of New York. 212p. 34pl. Jan. 1916. 40c.
190 —— Mining and Quarry Industry of New York 1915. 92p. Oct. 1916. 15c.
—— Mining and Quarry Industry of New York 1916 (see Mus. bul. 196).
Mineralogy. 4 Nason, F. L. Some New York Minerals and Their Localities. 22p. 1pl. Aug. 1888. Free.
58 Whitlock, H. P. Guide to the Mineralogic Collections of the New York State Museum. 150p. il. 39pl. 11 models. Sept. 1902. 40c.
70 —— New York Mineral Localities. 110p. Oct. 1903. 20c.
98 —— Contributions from the Mineralogic Laboratory. 38p. 7pl. Dec. 1905. *Out of print.*
Zoology. 1 Marshall, W. B. Preliminary List of New York Unionidae. 20p. Mar. 1892. *Free.*
9 —— Beaks of Unionidae Inhabiting the Vicinity of Albany, N. Y. 30p. 1pl. Aug. 1890. Free.

29 Miller, G. S., jr. Preliminary List of New York Mammals. 124p. Oct. 1899. 15c.
33 Farr, M. S. Check List of New York Birds. 224p. Apr. 1900. 25c.
38 Miller, G. S., jr. Key to the Land Mammals of Northeastern North America. 106p. Oct. 1900. 15c.
40 Simpson, G. B. Anatomy and Physiology of Polygyra albolabris and Limax maximus and Embryology of Limax maximus. 82p. 28pl. Oct. 1901. 25c.
43 Kellogg, J. L. Clam and Scallop Industries of New York. 36p. 2pl. map. Apr. 1901. Free.
51 Eckel, E. C. & Paulmier, F. C. Catalogue of Reptiles and Batrachians of New York. 64p. il. 1pl. Apr. 1902. *Out of print.*

Eckel, E. C. Serpents of Northeastern United States.
Paulmier, F. C. Lizards, Tortoises and Batrachians of New York.

60 Bean, T. H. Catalogue of the Fishes of New York. 784p. Feb 1903. $1, *cloth.*
71 Kellogg, J. L. Feeding Habits and Growth of Venus mercenaria. 30p. 4pl. Sept. 1903. Free.
88 Letson, Elizabeth J. Check List of the Mollusca of New York. 116p. May 1905. 20c.
91 Paulmier, F. C. Higher Crustacea of New York City. 78p. il. June 1905. 20c.
130 Shufeldt, R. W. Osteology of Birds. 382p. il. 26pl. May 1909. 50c.
Entomology. 5 Lintner, J. A. White Grub of the May Beetle. 34p. il. Nov. 1888. Free.
6 —— Cut-worms. 38p. il. Nov. 1888. Free.
13 —— San José Scale and Some Destructive Insects of New York State. 54p. 7pl. Apr. 1895. 15c.
20 Felt, E. P. Elm Leaf Beetle in New York State. 46p. il 5pl. June 1898. Free.

See 57.

23 —— 14th Report of the State Entomologist 1898. 150p. il. 9pl. Dec. 1898. 20c.
24 —— Memorial of the Life and Entomologic Work of J. A. Lintner Ph.D. State Entomologist 1874–98; Index to Entomologist's Reports 1–13. 316p. 1pl. Oct. 1899. 35c.

Supplement to 14th report of the State Entomologist.

26 —— Collection, Preservation and Distribution of New York Insects. 36p. il. Apr. 1899. *Out of print.*
27 —— Shade Tree Pests in New York State. 26p. il. 5pl. May 1899. *Out of print.*
31 —— 15th Report of the State Entomologist 1899. 128p. June 1900. 15c.
36 —— 16th Report of the State Entomologist 1900. 118p. 16pl. Mar. 1901. 25c.
37 —— Catalogue of Some of the More Important Injurious and Beneficial Insects of New York State. 54p. il. Sept. 1900. Free.
46 —— Scale Insects of Importance and a List of the Species in New York State. 94p. il. 15pl. June 1901. 25c.
47 Needham, J. G. & Betten, Cornelius. Aquatic Insects in the Adirondacks. 234p. il. 36pl. Sept. 1901. 45c.
53 Felt, E. P. 17th Report of the State Entomologist 1901. 232p. il. 6pl. Aug. 1902. *Out of print.*
57 —— Elm Leaf Beetle in New York State. 46p. il. 8pl. Aug. 1902. *Out of print.*

This is a revision of Bulletin 20 containing the more essential facts observed since that was prepared.

59 —— Grapevine Root Worm. 40p. 6pl. Dec. 1902. 15c.

See 72.

64 —— 18th Report of the State Entomologist 1902. 110p. 6pl. May 1903. 20c.
68 Needham, J. G. & *others*. Aquatic Insects in New York. 322p. 52pl. Aug. 1903. 80c, *cloth*.
72 Felt, E. P. Grapevine Root Worm. 58p. 13pl. Nov. 1903. 20c.

This is a revision of Bulletin 59 containing the more essential facts observed since that was prepared.

74 —— & Joutel, L. H. Monograph of the Genus Saperda. 88p. 14pl. June 1904. 25c.
76 Felt, E. P. 19th Report of the State Entomologist 1903. 150p. 4pl. 1904. 15c.
79 —— Mosquitos or Culicidae of New York. 164p. il. 57pl. tab. Oct. 1904. 40c.
86 Needham, J. G. & *others*. May Flies and Midges of New York. 352p. il. 37pl. June 1905. 80c, *cloth*.
97 Felt, E. P. 20th Report of the State Entomologist 1904. 246p. il. 19pl. Nov. 1905. 40c.
103 —— Gipsy and Brown Tail Moths. 44p. 10pl. July 1906. *Out of print*.
104 —— 21st Report of the State Entomologist 1905. 144p. 10pl. Aug. 1906. 25c.
109 —— Tussock Moth and Elm Leaf Beetle. 34p. 8pl. Mar. 1907. *Out of print*.
110 —— 22d Report of the State Entomologist 1906. 152p. 3pl. June 1907. 25c.
124 —— 23d Report of the State Entomologist 1907. 542p. il. 44pl. Oct. 1908. 75c.
129 —— Control of Household Insects. 48p. il. May 1909. *Out of print*.
134 —— 24th Report of the State Entomologist 1908. 208p. il. 17pl. Sept. 1909. 35c.
136 —— Control of Flies and Other Household Insects. 56p. il. Feb. 1910. 15c.

This is a revision of Bulletin 129 containing the more essential facts observed since that was prepared.

141 Felt, E. P. 25th Report of the State Entomologist 1909. 178p. il. 22pl. July 1910. 35c.
147 —— 26th Report of the State Entomologist 1910. 182p. il. 35pl. Mar. 1911. 35c.
155 —— 27th Report of the State Entomologist 1911. 198p. il. 27pl. Jan. 1912. 40c.
156 —— Elm Leaf Beetle and White-Marked Tussock Moth. 35p. 8pl. Jan. 1912. 20c.
165 —— 28th Report of the State Entomologist 1912. 266p. 14pl. July 1913. 40c.
175 —— 29th Report of the State Entomologist 1913. 258p. 16pl. April 1915. 45c.
180 —— 30th Report of the State Entomologist 1914. 336p. il. 19pl. Jan. 1916. 50c.
186 —— 31st Report of the State Entomologist 1915. 215p. il. 18pl. June 1, 1916. 35c.
194 —— Household and Camp Insects. 84p. il. Feb. 1, 1917. 15c.
Needham, J. G. Monograph on Stone Flies. *In preparation*.

Botany. 2 Peck, C. H. Contributions to the Botany of the State of New York. 72p. 2pl. May 1887. 20c.
8 —— Boleti of the United States. 98p. Sept. 1889. *Out of print*.
25 —— Report of the State Botanist 1898. 76p. 5pl. Oct. 1899. *Out of print*.
28 —— Plants of North Elba. 206p. map. June 1899. 20c.
54 —— Report of the State Botanist 1901. 58p. 7pl. Nov. 1902. 40c.
67 —— Report of the State Botanist 1902. 196p. 5pl. May 1903. 50c.
75 —— Report of the State Botanist 1903. 70p. 4pl. 1904. 40c.
94 —— Report of the State Botanist 1904. 60p. 10pl. July 1905. 40c.
105 —— Report of the State Botanist 1905. 108p. 12pl. Aug. 1906. 50c.

116 —— Report of the State Botanist 1906. 120p. 6 pl. July 1907. 35c.
122 —— Report of the State Botanist 1907. 178p. 5pl. Aug. 1908. 40c.
131 —— Report of the State Botanist 1908. 202p. 4pl. July 1909. 40c.
139 —— Report of the State Botanist 1909. 116p. 10pl. May 1910. 45c.
150 —— Report of the State Botanist 1910. 100p. 5pl. May 1911. 30c.
157 —— Report of the State Botanist 1911. 140p. 9pl. Mar. 1912. 35c.
167 —— Report of the State Botanist 1912. 138p. 4pl. Sept. 1913. 30c.
176 —— Report of the State Botanist 1913. 78p. 17pl. June 1915. 20c.
179 —— Report of the State Botanist 1914. 108p. 1pl. Dec. 1915. 20c.
188 House, H. D. Report of the State Botanist 1915. 118p. il. 4pl. Aug. 1, 1916. 30c.

Archeology. 16 Beauchamp, W. M. Aboriginal Chipped Stone Implements of New York. 86p. 23pl. Oct. 1897. 25c.
18 —— Polished Stone Articles Used by the New York Aborigines. 104p. 35pl. Nov. 1897. 25c.
22 —— Earthenware of the New York Aborigines. 78p. 33pl. Oct. 1898. 25c.
32 —— Aboriginal Occupation of New York. 190p. 16pl. 2 maps. Mar. 1900. 30c.
41 —— Wampum and Shell Articles Used by New York Indians. 166p. 28pl. Mar. 1901. *Out of print.*
50 —— Horn and Bone Implements of the New York Indians. 112p. 43pl. Mar. 1902. *Out of print.*
55 —— Metallic Implements of the New York Indians. 94p. 38pl. June 1902. 25c.
73 —— Metallic Ornaments of the New York Indians. 122p. 37pl. Dec. 1903. 30c.
78 —— History of the New York Iroquois. 340p. 17pl. map. Feb. 1905. 75c.
87 —— Perch Lake Mounds. 84p. 12pl. Apr. 1905. 20c.
89 —— Aboriginal Use of Wood in New York. 190p. 35pl. June 1905. *Not available.*
108 —— Aboriginal Place Names of New York. 336p. May 1907. 40c.
113 —— Civil, Religious and Mourning Councils and Ceremonies of Adoption. 118p. 7pl. June 1907. 25c.
117 Parker, A. C. An Erie Indian Village and Burial Site. 102p. 38pl. Dec. 1907. 30c.
125 Converse, H. M. & Parker, A. C. Iroquois Myths and Legends. 196p. il. 11pl. Dec. 1908. 50c.
144 Parker, A. C. Iroquois Uses of Maize and Other Food Plants. 120p. il. 31pl. Nov. 1910. *Out of print.*
163 —— The Code of Handsome Lake. 144p. 23pl. Nov. 1912. 25c.
184 —— The Constitution of the Five Nations. 158p. 8pl. April 1, 1916. 30c.

Miscellaneous. 62 Merrill, F. J. H. Directory of Natural History Museums in United States and Canada. 236p. Apr. 1903. 30c.
66 Ellis, Mary. Index to Publications of the New York State Natural History Survey and New York State Museum 1837–1902. 418p. June 1903. 75c, *cloth.*

Museum memoirs 1889–date. 4to.
1 Beecher, C. E. & Clarke, J. M. Development of Some Silurian Brachiopoda. 96p. 8pl. Oct. 1889. $1.
2 Hall, James & Clarke, J. M. Paleozoic Reticulate Sponges. 350p. il. 70pl. 1898. $2, *cloth.*
3 Clarke, J. M. The Oriskany Fauna of Becraft Mountain, Columbia Co., N. Y. 128p. 9pl. Oct. 1900. 80c.
4 Peck, C. H. N. Y. Edible Fungi, 1895–99. 106p. 25pl. Nov. 1900. 75c.

This includes revised descriptions and illustrations of fungi reported in the 49th, 51st and 52d reports of the State Botanist.

5 Clarke, J. M. & Ruedemann, Rudolf. Guelph Formation and Fauna of New York State. 196p. 21pl. July 1903. $1.50, *cloth.*
6 Clarke, J. M. Naples Fauna in Western New York. 268p. 26pl. map. 1904. $2, *cloth.*

7 Ruedemann, Rudolf. Graptolites of New York. Pt 1 Graptolites of the Lower Beds. 350p. 17pl. Feb. 1905. $1.50, *cloth.*

8 Felt, E. P. Insects Affecting Park and Woodland Trees. v. 1. 460p. il. 48pl. Feb. 1906. $2.50, *cloth*; v. 2. 548p. il. 22pl. Feb. 1907. $2, *cloth.* $4. for the two volumes.

9 Clarke, J. M. Early Devonic of New York and Eastern North America. Pt 1. 366p. il. 70pl. 5 maps. Mar. 1908. $2.50, *cloth;* Pt 2. 250p. il. 36pl. 4 maps. Sept. 1909. $2, *cloth.*

10 Eastman, C. R. The Devonic Fishes of the New York Formations. 236p. 15pl. 1907. $1.25, *cloth.*

11 Ruedemann, Rudolf. Graptolites of New York. Pt 2 Graptolites of the Higher Beds. 584p. il. 31pl. 2 tab. Apr. 1908. $2.50, *cloth.*

12 Eaton, E. H. Birds of New York. v. 1. 501p. il. 42pl. Apr. 1910. $3, *cloth*; v. 2, 719p. il. 64pl. July 1914. $4, *cloth.* $6. for the two volumes. 106 colored plates in portfolio $1.

13 Whitlock, H. P. Calcites of New York. 190p. il 27pl. Oct. 1910. $1, *cloth.*

14 Clarke, J. M. & Ruedemann, Rudolf. The Eurypterida of New York. v. 1. Text. 440p. il. v. 2 Plates. 188p. 88pl. Dec. 1912. $4, *cloth.*

15 House, Homer D. Wild Flowers of New York. *In press.*

Natural History of New York. 30 v. il. pl. maps. 4to. Albany 1842–94.

DIVISION 1 ZOOLOGY. De Kay, James E. Zoology of New York; or, The New York Fauna; comprising detailed descriptions of all the animals hitherto observed within the State of New York with brief notices of those occasionally found near its borders, and accompanied by appropriate illustrations. 5v. il. pl. maps. sq. 4to. Albany 1842–44. *Out of print.*

Historical introduction to the series by Gov. W. H. Seward. 178p.

v. 1 pt1 Mammalia. 131 + 46p. 33pl. 1842.

300 copies with hand-colored plates.

v. 2 pt2 Birds. 12 + 380p. 141pl. 1844.

Colored plates.

v. 3 pt3 Reptiles and Amphibia. 7 + 98p. pt 4 Fishes. 15 + 415p. 1842.

pt3–4 bound together.

v. 4 Plates to accompany v. 3. Reptiles and Amphibia. 23pl. Fishes. 79pl. 1842.

300 copies with hand-colored plates.

v. 5 pt5 Mollusca. 4 + 271p. 40pl. pt 6 Crustácea. 70p. 13pl. 1843–44.

Hand-colored plates; pt5–6 bound together.

DIVISION 2 BOTANY. Torrey, John. Flora of the State of New York; comprising full descriptions of all the indigenous and naturalized plants hitherto discovered in the State, with remarks on their economical and medical properties. 2v. il. pl. sq. 4to. Albany 1843. *Out of print.*

v. 1 Flora of the State of New York. 12 + 484p. 72pl. 1843.

300 copies with hand-colored plates.

v. 2 Flora of the State of New York. 572p. 89pl. 1843.

300 copies with hand-colored plates.

DIVISION 3 MINERALOGY. Beck, Lewis C. Mineralogy of New York; comprising detailed descriptions of the minerals hitherto found in the State of New York, and notices of their uses in the arts and agriculture. il. pl. sq. 4to. Albany 1842. *Out of print.*

v. 1 pt1 Economical Mineralogy. pt2 Descriptive Mineralogy. 24 + 536p. 1842.

8 plates additional to those printed as part of the text.

DIVISION 4 GEOLOGY. Mather, W. W.; Emmons, Ebenezer; Vanuxem, Lardner & Hall, James. Geology of New York. 4v. il. pl. sq. 4to. Albany 1842–43. *Out of print.*

v. 1 pt1 Mather, W. W. First Geological District. 37 + 653p. 46pl. 1843.

v. 2 pt2 Emmons, Ebenezer. Second Geological District. 10 + 437p. 17pl. 1842.
v. 3 pt3 Vanuxem, Lardner. Third Geological District. 306p. 1842.
v. 4 pt4 Hall, James. Fourth Geological District. 22 + 683p. 19pl. map. 1843.

DIVISION 5 AGRICULTURE. Emmons, Ebenezer. Agriculture of New York; comprising an account of the classification, composition and distribution of the soils and rocks and the natural waters of the different geological formations, together with a condensed view of the meteorology and agricultural productions of the State. 5v. il. pl. sq. 4to. Albany 1846–54. *Out of print.*
v. 1 Soils of the State, Their Composition and Distribution. 11 + 371p. 21pl 1846.
v 2 Analysis of Soils, Plants, Cereals, etc. 8 + 343 + 46p. 42pl. 1849.

With hand-colored plates.

v. 3 Fruits, etc. 8 + 340p. 1851.
v. 4 Plates to accompany v. 3. 95pl. 1851.

Hand-colored.

v. 5 Insects Injurious to Agriculture. 8 + 272p. 50pl. 1854.

With hand-colored plates.

DIVISION 6 PALEONTOLOGY. Hall, James. Paleontology of New York. 8v. il. pl. sq. 4to. Albany 1847–94. *Bound in cloth.*
v. 1 Organic Remains of the Lower Division of the New York System. 23 + 338p. 99pl. 1847. *Out of print.*
v. 2 Organic Remains of Lower Middle Division of the New York System. 8 + 362p. 104pl. 1852. *Out of print.*
v 3 Organic Remains of the Lower Helderberg Group and the Oriskany Sandstone. pt1, text. 12 + 532p. 1859. [$3.50]
—— pt2 142pl. 1861. [$2.50]
v 4 Fossil Brachiopoda of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 11 + 1 + 428p. 69pl. 1867. $2.50.
v. 5 pt 1 Lamellibranchiata 1. Monomyaria of the Upper Helderberg, Hamilton and Chemung Groups. 18 + 268p. 45pl. 1884. $2.50.
—— —— Lamellibranchiata 2. Dimyaria of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 62 + 293p. 51pl. 1885. $2.50.
—— pt 2 Gasteropoda, Pteropoda and Cephalopoda of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 2v. 1879. v. 1, text. 15 + 492p.; v.2. 120pl. $2.50 for 2 v.
—— & Simpson, George B. v. 6 Corals and Bryozoa of the Lower and Upper Helderberg and Hamilton Groups. 24 + 298p. 67pl. 1887. $2.50.
—— & Clarke, John M. v. 7 Trilobites and Other Crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung and Catskill Groups. 64 + 236p. 46pl. 1888. Cont. supplement to v. 5, pt 2. Pteropoda, Cephalopoda and Annelida. 42p. 18pl. 1888. $2.50.
—— & Clarke, John M. v. 8 pt 1. Introduction to the Study of the Genera of the Paleozoic Brachiopoda. 16 + 367p. 44pl. 1892. $2.50.
—— & Clarke, John M. v. 8 pt 2 Paleozoic Brachiopoda. 16 + 394p. 64pl. 1894. $2.50.

Catalogue of the Cabinet of Natural History of the State of New York and of the Historical and Antiquarian Collection annexed thereto. 242p. 8vo 1853. *Out of print.*

Handbooks 1893–date.
New York State Museum. 52p. il. 1902. *Out of print.*

Outlines history and work of the museum with list of staff 1902.

Paleontology. 12p. 1899. *Out of print.*

Brief outline of State Museum work in paleontology under heads: Definition; Relation to biology; Relation to stratigraphy; History of paleontology in New York.

Guide to Excursions in the Fossiliferous Rocks of New York. 124p. 1899. *Free.*

Itineraries of 32 trips covering nearly the entire series of Paleozoic rocks, prepared specially or the use of teachers and students desiring to acquaint themselves more intimately with the classic rocks of this State.

Entomology. 16p. 1899. *Out of print.*
Economic Geology. 44p. 1904. *Out of print.*
Insecticides and Fungicides. 20p. 1909. Free.
Classification of New York Series of Geologic Formations. 32p. 1903. *Out of print.* Revised edition. 96p. 1912. Free.
Geologic maps. Merrill, F. J. H. Economic and Geologic Map of the State of New York; issued as part of Museum Bulletin 15 and 48th Museum Report, v. 1. 59 x 67 cm. 1894. Scale 14 miles to 1 inch. 15c.
—— Map of the State of New York Showing the Location of Quarries of Stone Used for Building and Road Metal. 1897. *Out of print.*
—— Map of the State of New York Showing the Distribution of the Rocks Most Useful for Road Metal. 1897. *Out of print.*
—— Geologic Map of New York. 1901. Scale 5 miles to 1 inch. *In atlas form $2. Lower Hudson sheet* 60c.

The lower Hudson sheet, geologically colored, comprises Rockland, Orange, Dutchess, Putnam, Westchester, New York, Richmond, Kings, Queens and Nassau counties, and parts of Sullivan, Ulster and Suffolk counties; also northeastern New Jersey and part of western Connecticut.

—— Map of New York Showing the Surface Configuration and Water Sheds. 1901. Scale 12 miles to 1 inch. 15c.
—— Map of the State of New York Showing the Location of Its Economic Deposits. 1904. Scale 12 miles to 1 inch. 15c.
Geologic maps on the United States Geological Survey topographic base. Scale 1 in. = 1 m. Those marked with an asterisk have also been published separately.
Albany county. 1898. *Out of print.*
Area around Lake Placid. 1898.
Vicinity of Frankfort Hill [parts of Herkimer and Oneida counties]. 1899.
Rockland county. 1899.
Amsterdam quadrangle. 1900.
*Parts of Albany and Rensselaer counties. 1901. *Out of print.*
*Niagara river. 1901. 25c.
Part of Clinton county. 1901.
Oyster Bay and Hempstead quadrangles on Long Island. 1901.
Portions of Clinton and Essex counties. 1902.
Part of town of Northumberland, Saratoga co. 1903.
Union Springs, Cayuga county and vicinity. 1903.
*Olean quadrangle. 1903. *Out of print.*
*Becraft Mt with 2 sheets of sections. (Scale 1 in. = ½ m.) 1903. 20c.
*Canandaigua-Naples quadrangles. 1904. 20c.
*Little Falls quadrangle. 1905. Free.
*Watkins-Elmira quadrangles. 1905. 20c.
*Tully quadrangle. 1905. Free.
*Salamanca quadrangle. 1905. *Out of print.*
*Mooers quadrangle. 1905. Free.
Paradox Lake quadrangle. 1905.
*Buffalo quadrangle. 1906. Free.
*Penn Yan-Hammondsport quadrangles. 1906. 20c.
*Rochester and Ontario Beach quadrangles. 1907. 20c.
*Long Lake quadrangle. 1907. Free.
*Nunda-Portage quadrangles. 1908. 20c.
*Remsen quadrangle. 1908. Free.
*Geneva-Ovid quadrangles. 1909. 20c.
*Port Leyden quadrangle. 1910. Free.
*Auburn-Genoa quadrangles. 1910. 20c.
*Elizabethtown and Port Henry quadrangles. 1910. 15c.
*Alexandria Bay quadrangle. 1910. Free.

*Cape Vincent quadrangle. 1910. Free.
*Clayton quadrangle. 1910. Free.
*Grindstone quadrangle. 1910. Free.
*Theresa quadrangle. 1910. Free.
*Poughkeepsie quadrangle. 1911. Free.
*Honeoye-Wayland quadrangles. 1911. 20c.
*Broadalbin quadrangle. 1911. Free.
*Schenectady quadrangle 1911. Free.
*Saratoga-Schuylerville quadrangles. 1914. 20c.
*North Creek quadrangle. 1914. Free.
*Syracuse quadrangle. 1914. Free.
*Attica-Depew quadrangles. 1914. 20c.
*Lake Pleasant quadrangle. 1916. Free.
*Saratoga quadrangle. 1916. Free.
*Canton quadrangle. 1916. Free.
*Brier Hill, Ogdensburg and Red Mills quadrangles. 1916. 20c.
*Blue Mountain quadrangle. 1916. Free.
*Brier Hill, Ogdensburg and Red Mills quadrangles. 1916. 15c.
*Blue Mountain quadrangle. 1916. Free.
*Glens Falls, Saratoga, Schuylerville, Schenectady and Cohoes quadrangles. 1917. 20c.