New York State Museum Bulletin

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

Published monthly by The University of the State of New York

No. 187 ALBANY, N. Y. July 1, 1916

The University of the State of New York

New York State Museum
John M. Clarke, Director

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

INCLUDING THE SIXTY-NINTH REPORT OF THE STATE MUSEUM, THE THIRTY-FIFTH REPORT OF THE STATE GEOLOGIST AND THE REPORT OF THE STATE PALEONTOLOGIST FOR 1915

ALBANY

THE UNIVERSITY OF THE STATE OF NEW YORK

1916

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The University of the State of New York

Science Department, April 13, 1916

Dr John H. Finley
President of the University

SIR: I take this occasion to communicate to you and to recommend for publication as a bulletin of the State Museum the Annual Report of the Director for the fiscal year ending September 30, 1915.

Very respectfully yours

JOHN M. CLARKE
Director

THE UNIVERSITY OF THE STATE OF NEW YORK
OFFICE OF THE PRESIDENT
Approved for publication this 17th day of April 1916

President of the University

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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 1914–15. It constitutes the 69th consecutive annual report of the State Museum, the 35th annual report of the State Geologist (consecutive since 1881) and the report of the State Paleontologist for 1915. 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 Science 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

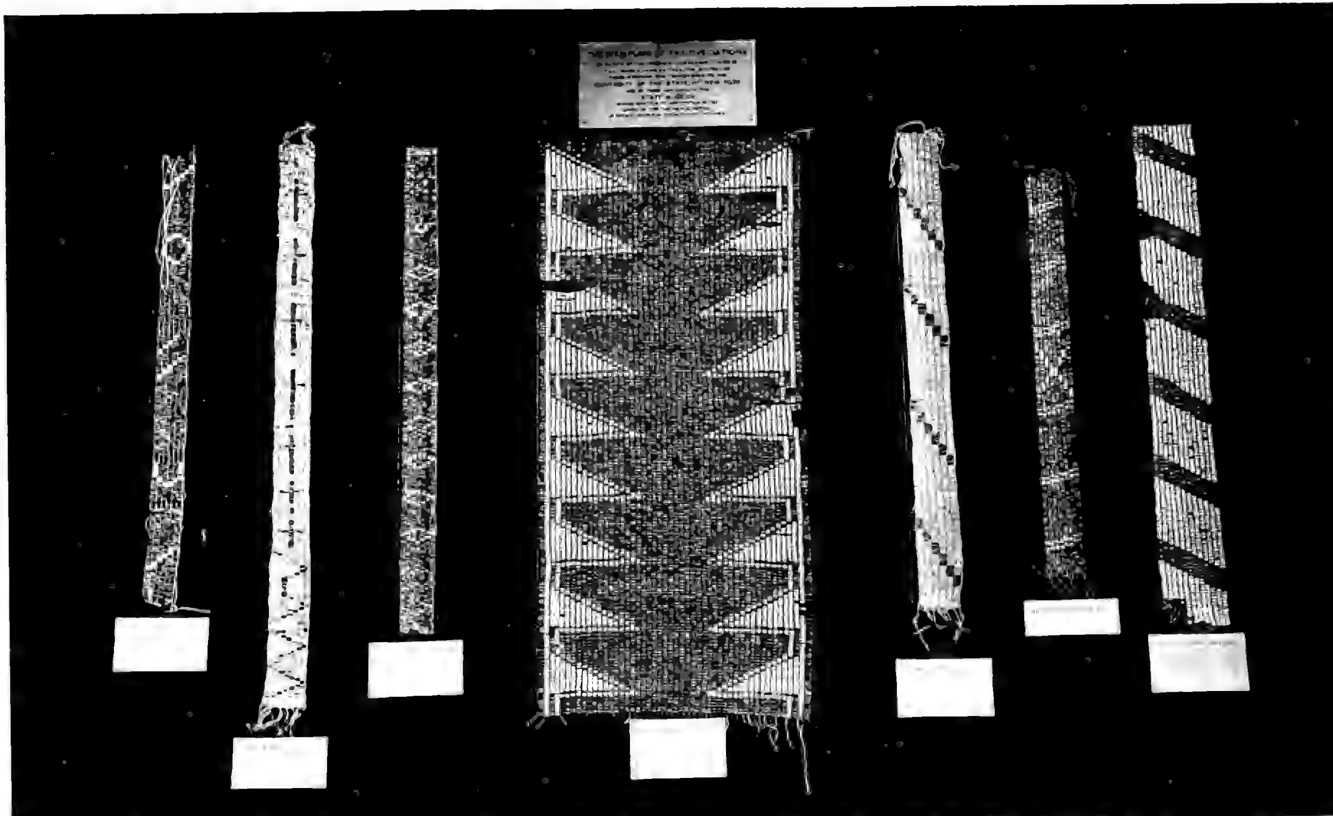
PRESENT CONDITION OF THE SCIENCE MUSEUM

COMPLETION OF THE ARCHEOLOGICAL AND ETHNOLOGICAL COLLECTIONS

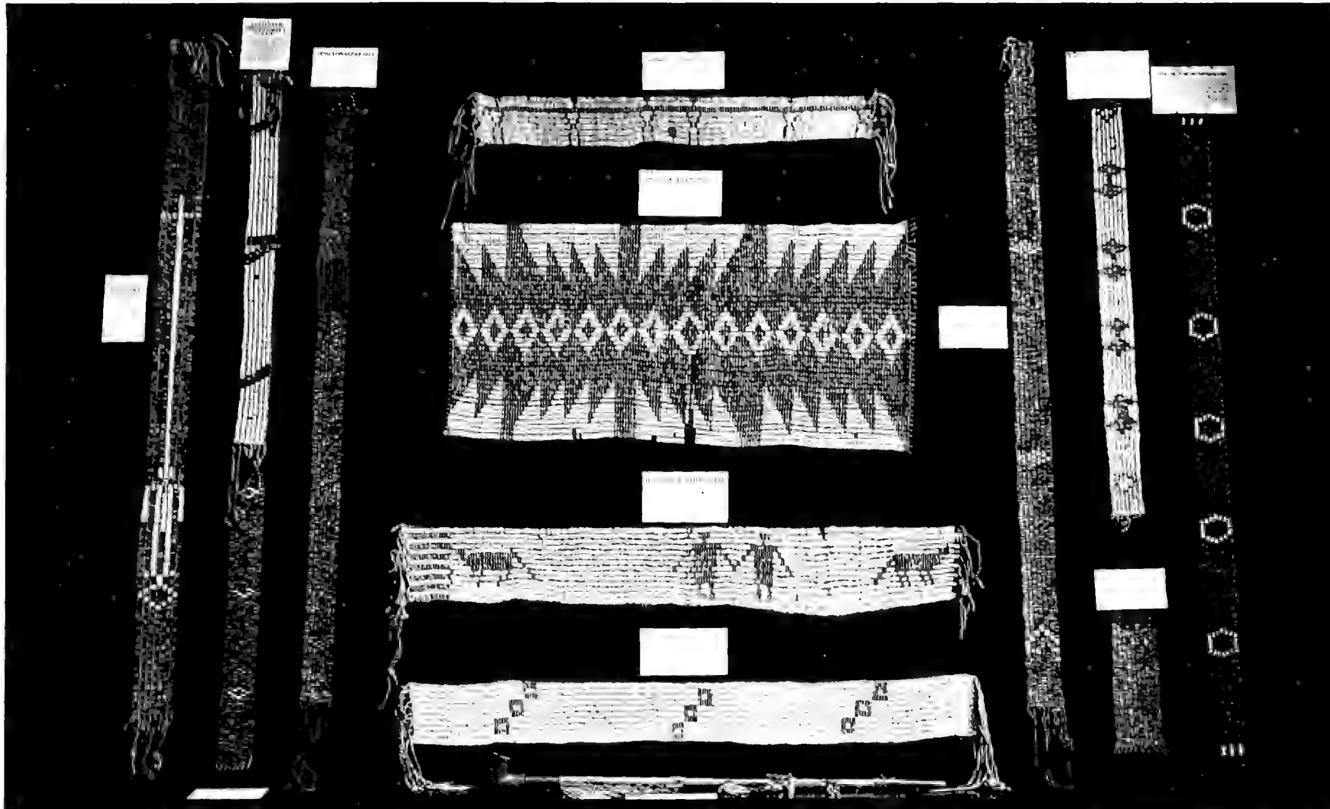
The extensive array of cultural relics of the New York Indians is now nearly completed, the hall containing seventy-seven cases. No extensive acquisitions, but some important ones, have been made during the year, among them a great Algonquin pot together with other relics from the site at Lakeside near Auburn, fuller reference to which is made in the report of the Archeologist. The ethnological collection in the west mezzanine is not yet complete, and though notable in many respects, is not an adequate display in this field. Herein is where the disastrous Capitol fire of 1911 did its greatest damage to the Museum, ancient costumes and other inflammable historic records, which it is extremely difficult to replace or substitute in any way, being then destroyed.

The Iroquois wampums. By virtue of the united action of the Iroquois League in council assembled at the State Capitol, June 29, 1898, The University of the State of New York became the official custodian of the historic wampums of the Five and the Six Nations. Since the receipt of these priceless records they have been kept in safety deposit until proper provision could be made for their exhibition. They are now displayed in a strong case in the west mezzanine with labels explanatory of their significance. There are nineteen of these belts, among them some of the largest size and most elaborate workmanship, and of fundamental significance to the history of the Iroquois Confederacy.

Iroquois Indian groups. The general plan of the Museum halls has been completed during the past year by the execution of the contract for the remodeling of the western mezzanine and construction of the alcoves for the Iroquois groups. These alcoves and cases are of steel, concrete and plaster, fully fireproofed, and become a fixed part of the building. The work consisted in the construction of four projecting blocks of cases to provide for six exhibits, these blocks extending up to a false ceiling covering them all, and containing all necessary switch boxes and adjustment doors; also the remodeling of the corridor outside the case blocks. The construction was executed by W. F. Plass & Bro. at a cost of



Wampum belts of the Iroquois Confederacy recording laws and important events. These belts are displayed in a case in ethnology hall.



Iroquois wampum belts displayed in a special case in enthnology hall. These belts record important alliances and events in Iroquois history.

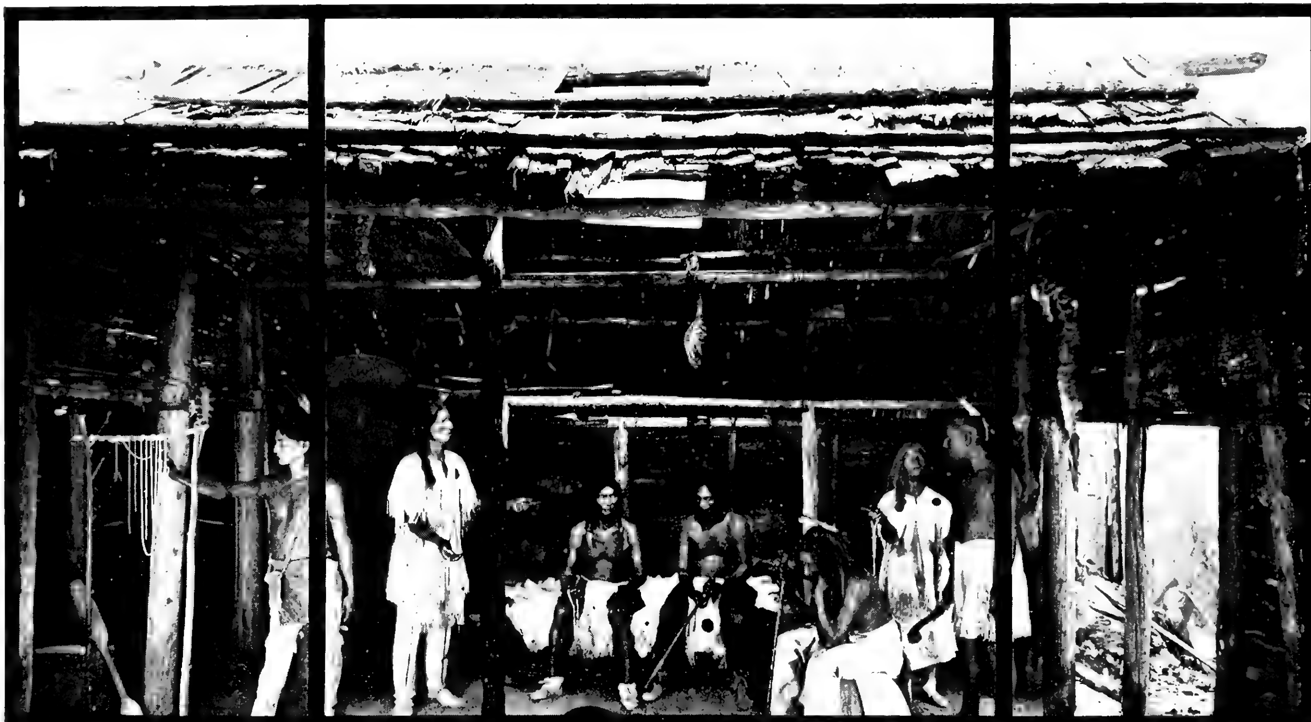
The Sun Worshippers. By David C. Lithgow. Mural lunette at entrance to Iroquois groups.

The Camp of the Seneca Hunters

This is the first group in the habitat series and represents a Seneca family encamped on a hillside overlooking Canandaigua lake, with Bare hill in the distance.

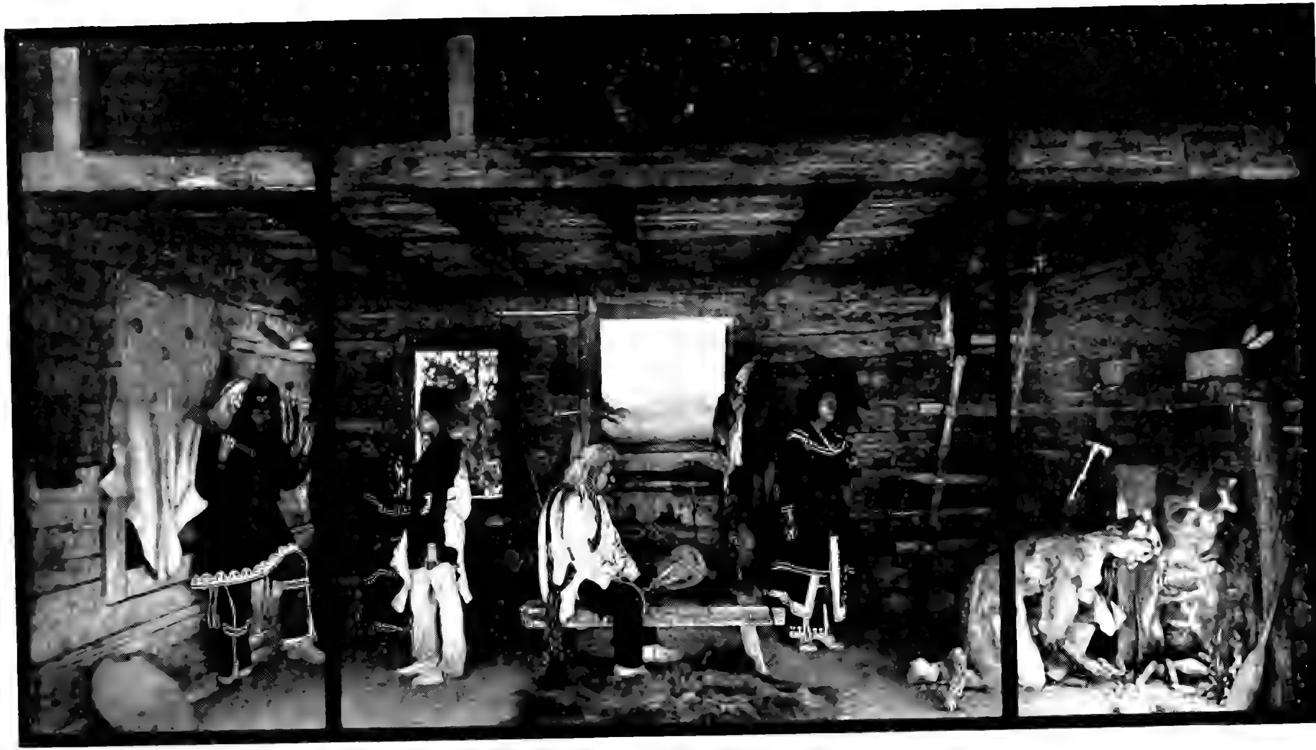
The Return of the Warriors

A group representing certain war customs of the Mohawk nation. The background is the Mohawk valley at Sprakers.



The Council of the Turtle Clan of Onondagas

This depicts the four Turtle sachems in their bark council lodge and illustrates the ceremonial use of wampum.



The Midwinter Purification Rite of the Cayugas

The period is after the coming of Europeans. The group illustrates the material changes resulting from contact but shows that the old ceremonies were retained.

Typical Industries of the Oneidas

An arrow maker, busy at his work, is telling a story to the basket maker, weaver, wood carver, skin worker, and potter. The background is Nichols pond in Madison County.

Harvest Time Among the Senecas.
The background is the Genesee gorge at Squakie hill. This is the sixth group in Myron H. Clark hall.

$13,000, and the wiring and lighting contract by the Fox Co. at $717. With the delivery and acceptance of the work the installation of the Iroquois groups at once began, and it is confidently hoped that all will be completed and opened to the public in the course of the present winter. This Iroquois exhibit, which is a memorial to the late Governor of the State, Myron H. Clark, will represent a series of prehistoric groupings of life casts in natural and historic surroundings in the following order from the west end of the hall:

1 *Seneca group.* Family activities outside an elm-bark lodge on the west shore of Canandaigua lake, the background showing Genundewa, the sacred hill of the Seneca nation, across the waters of the lake. Five life figures.

2 *Mohawk group.* A bark lodge village with captured Delawares taken on the war trail. Scene from Sprakers on the Mohawk, looking west and north. Six figures.

3 *Council house; Onondaga group.* This is the interior of an actual council house, with the council in session. The scenery through the doors of the house shows the rocky ledges of the southern Onondaga country. Seven figures.

4 *Log cabin and False Face ceremony.* This is the interior of the log lodge in use among the Indians of western New York at the time of the Sullivan raid. In the cabin a ceremony of the False Face Company is in progress. Through the door and window are seen the moonlit frozen waters of Cayuga lake. Six figures.

5 *Industry group; Nichols pond; Oneida lake.* This is designed to show the characteristic Indian industrial occupations: the potter, the basket maker, the arrowmaker, the weaver, etc., and the scene is set on the banks of the pond where Champlain met the Iroquois in 1614 (?) and was defeated by them. Six figures.

6 *Agriculture group.* The harvest of the maize. An autumn view of the high banks of the Genesee river looking up from Squakie hill, Mount Morris. Six figures.

The planning of these groups has been the work of the Archeologist, Mr Parker, whose intimate knowledge of the New York Indians is an assurance of the ethnological accuracy of the representations. The very exacting and highly artistic work of executing the large background scenery (each background being fifty-five feet long and sixteen feet high), placing the figures, setting the accessories and accomplishing the living results is due to the genius and skill of David C. Lithgow. The human figures, which are, with a few exceptions, life casts, were made partly by Caspar Meyer and partly by Henri Marchand, and the latter artist is also responsible for the few modeled figures with portrait busts in the Mohawk group. The electric lighting of this hall required the installation of an entire new system of wiring to connect with the general system of the building.

The Charles H. Peck testimonial exhibit of edible and poisonous fungi. In view of the practical difficulties attending the execution of a satisfactory exhibit of the general botany of the State, it seems imperative at the present time to restrict the exhibit to such field as lends itself to this purpose and is adapted to the available space. The state herbarium is the great repository of our flora and is always accessible to students, but is not for public inspection. The skill of Mr Henri Marchand in reproducing the fungi with extraordinary fidelity of structure and color and from life in the field, has enabled us to take advantage of this opportunity to create a permanent exhibit of these destructible bodies in all their natural fulness and detail. Thus a satisfactory beginning has been made on this work with the purpose of eventually preparing a representation that will be reasonably complete. Prof. Charles H. Peck, the first State Botanist of New York, whose long term of service closed two years ago, devoted much of his life to the study of mycology and it seems very appropriate that this special exhibit of mushroom reproduction should be created as a testimonial to his excellent service. It has been intimated to some of Doctor Peck's colleagues to whom he had rendered help in their investigations that such a testimonial was intended and many of them have given substantial evidence of their desire to participate in it.

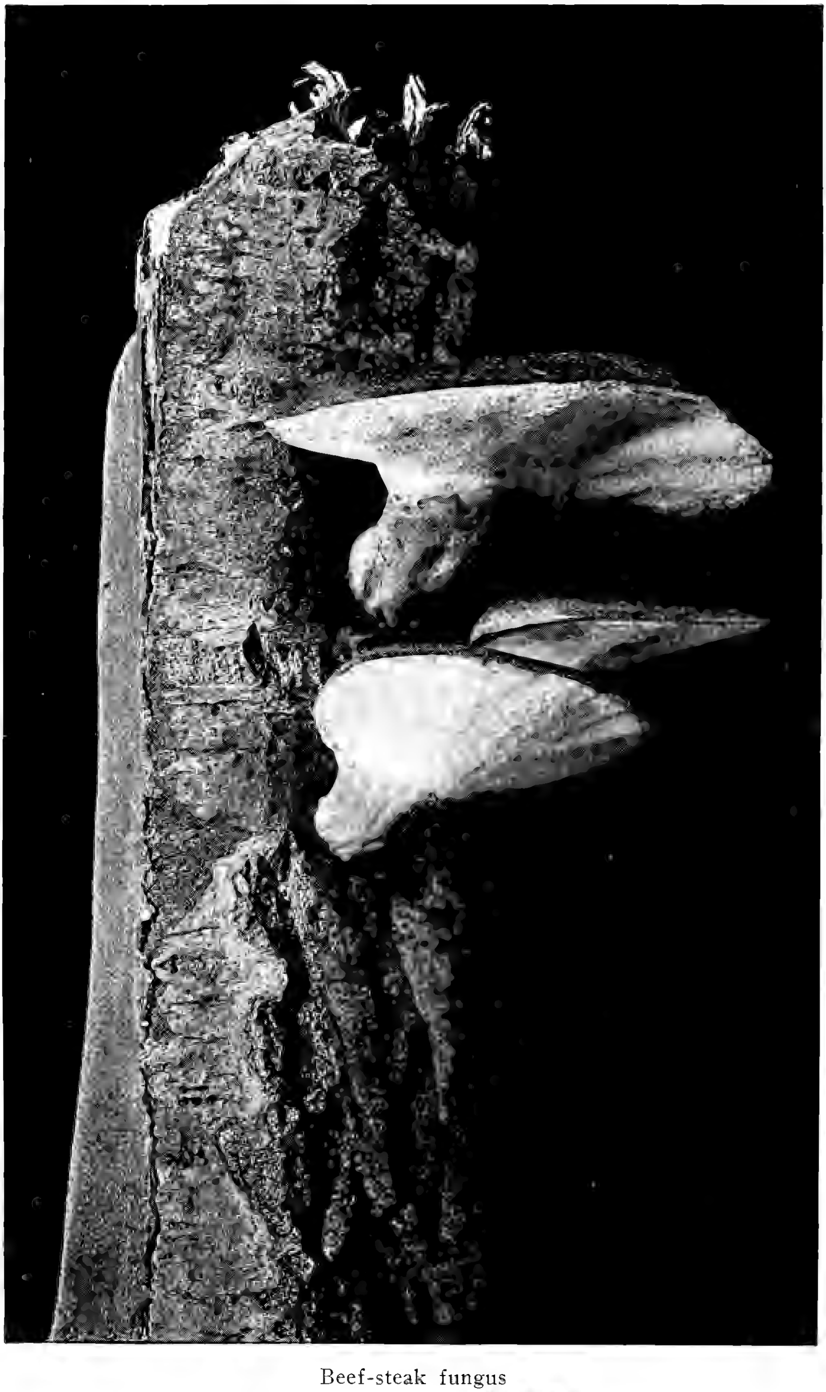
Contributors to the Peck testimonial exhibit:

Fred. S. Boughton, Pittsford, N. Y.
N. L. Britton, New York, N. Y.
E. A. Burt, St Louis, Mo.
J. J. Davis, Chicago, Ill.
W. G. Farlow, Cambridge, Mass.
Mrs Edwin P. Gardner, for the Botanical Society, Canandaigua, N. Y.
John W. Harshberger, Philadelphia, Pa.
C. C. Haynes, New York, N. Y.
Ann Hibbard, Boston, Mass.
L. R. Jones, Madison, Wis.
Louis C. C. Krieger, Chico, Cal.

Honey mushroom
Armillaria mella Vahl.
(Reproduction by H. Marchand)

Parasol mushroom
Lepiota procera Scop.
(Reproduction by H. Marchand)

Equestrian Tricholoma
Tricholoma equestre L.
(Reproduction by H. Marchand)



Beef-steak fungus
Fistulina hepatica Fr.
(Reproduction by H. Marchand)

Minnesota Mycological Society, Minneapolis, Minn.
W. S. Moffat, Chicago, Ill.
George E. Morris, Boston, Mass.
C. S. Sargent, Boston, Mass.
C. L. Shear, Washington, D. C.
E. B. Sterling, Trenton, N. J.
W. C. Stevenson, jr, Philadelphia, Pa.
Martha P. Strong, New York, N. Y.
Mary L. Sutliff, New York, N. Y.
William Trelease, Urbana, Ill.
Adaline Van Horne, Montreal, Canada
F. Watrous, New York, N. Y.

Fuertes bird paintings. These fine paintings, 120 in number, of the birds of New York, presented to the Museum by Mrs Russell Sage, have been mounted, set in fourteen large frames and placed on the walls of the two corridors leading from the main hall into the hall of zoology.

Panama-Pacific exhibition. The exhibits of the mining products of this State made at the Panama-Pacific Exposition in cooperation with a number of mineral producers, was recognized as of high excellence and its merits were indicated by the awards of the juries. The list of the awards to the Museum and to cooperating exhibitors is here given:

Grand prize. New York State Museum, Albany. Collective exhibit.
Gold medal. New York State Museum, Albany. Publications.
Silver medal. New York State Museum, Albany. Building stones.
Gold medal. Worcester Salt Co., Silver Springs. Salt works model.
Gold medal. Joseph Dixon Crucible Co., Jersey City. Graphite and graphite products.
Silver medal. Joseph Dixon Crucible Co.
Gold medal. Carborundum Co., Niagara Falls. Carborundum, aloxite, silicon.
Gold medal. Carborundum Co., Niagara Falls. Wheels and manufactured articles.
Gold medal of honor. International Acheson Graphite Co., Niagara Falls. Artificial graphite.
Silver medal. Witherbee, Sherman & Co., Mineville. Magnetite concentrates and other mill products.
Silver medal. Witherbee, Sherman & Co. Collection of ores and minerals, illustrative of Adirondack mines.

Bronze medal. Witherbee, Sherman & Co. Model of mine.

Silver medal. Sterling Salt Co., Cuylerville.

Silver medal. Association of the American Portland Cement Manufacturers, Philadelphia. Model cement road.

Silver medal. Association of the American Portland Cement Manufacturers. Colored transparencies showing methods of laying cement roads in New York State.

Honorable mention. Association of the American Portland Cement Manufacturers Association.

Bronze medal. Helderberg Cement Co., Albany. Photographs showing uses of cement in canal and building construction.

Silver medal. Crown Point Spar Co., Crown Point. Exhibit of crushed pegmatite.

Silver medal. E. J. Johnson, New York. Roofing slate.

Silver medal. Mathews Slate Co., Poultney. Roofing slate.

Silver medal. United States Gypsum Co., Chicago. Exhibit of gypsum and its products.

Silver medal. Uniform Fibrous Talc Co., Talcville. Exhibit of crude and ground talc.

Silver medal. Barton & Sons Co., H. H. Exhibit of abrasive garnet and manufactured articles of garnet.

Silver medal. Northern Iron Co., Standish. Exhibit of magnetite ores and of pig iron.

Bronze medal. Chateaugay Ore & Iron Co., Lyon Mountain. Magnetite ores and concentrates.

Bronze medal. Cheever Iron Ore Co., Port Henry. Magnetite ores and concentrates.

Bronze medal. Ontario Talc Co., Gouverneur. Talc, crude and ground.

Bronze medal. North River Garnet Co., North River. Garnet, crude.

Bronze medal. Finch, Pruyn & Co., Glens Falls. Exhibit of lime.

Honorable mention. New York Lime Co., Natural Bridge. Exhibit of cement.

Honorable mention. P. H. Kinkel's Sons, Bedford. Feldspar and quartz.

Honorable mention. Onondaga Coarse Salt Association, Syracuse. Solar salt.

Honorable mention. St Lawrence Pyrites Co., Herman. Crude and concentrated pyrite.

Honorable mention. William Connors Paint Co., Troy. Mineral paint.

Honorable mention. Clinton Metallic Paint Co., Clinton. Mineral paint.

Honorable mention. James M. Wells Co., Ogdensburg. Mineral paint.

Honorable mention. Vacuum Oil Co., Rochester. Exhibit of crude petroleum and its products.

Honorable mention. Benson Mines Co., Benson Mines. Magnetite ore.

Honorable mention. MacIntyre Iron Co., Port Henry. Titaniferous magnetite.

Honorable mention. Borst, C. A., Clinton. Hematite ore.

Honorable mention. Northern Ore Co., Edwards. Zinc ore.

Honorable mention. The Solvay Process Co., Syracuse. Exhibit of materials used in manufacture of soda compounds; and exhibit of the products.

Through the generosity of the cooperating exhibitors, who have thereby given evidence of their interest in the Museum, much of the prize material has been donated to the State, together with the cases in which this material was exhibited. Besides this, through the appreciative generosity of the State Commission for the Panama-Pacific Exposition, the Museum receives a series of fourteen exhibition cases constructed at their expense but in conformity with the designs in use in the Museum. The addition of this large amount of valuable material will permit the enlargement and improvement of the geology exhibits in lines which specially required strengthening, and it will also necessitate a rearrangement of the entire geology hall. Acknowledgments must here be made to the generosity of those who have thus presented their exhibits to the Museum:

North River Garnet Co., North River

Specimens of garnet in matrix from mines on Thirteenth Lake 2

Barton & Sons Co., North River

Garnet in matrix and prepared garnet

Northern Ore Co., Edwards

Specimens of zinc ores from Edwards 5

Carborundum Co., Niagara Falls

Specimens of carborundum, aloxite, metallic silicon and garnet, to the number of several hundred

International Acheson Graphite Co., Niagara Falls
Graphite and graphite wares made in the electric furnace
Joseph Dixon Crucible Co., Jersey City
Graphite ores and products from mine near Hague, together with many samples of manufactured articles
P. H. Kinkel's Sons, Bedford
Large specimens of beryl, pink quartz and feldspar 5
Crown Point Spar Co., Crown Point
Specimens of crude and crushed pegmatite
Paragon Plaster Co., Syracuse
Blocks of imitation granite 1
Ontario Talc Co., Gouverneur
Display specimens of crude talc and samples of prepared products 5
Uniform Fibrous Talc Co., Talcville
Display specimens of crude talc and samples of prepared products 5
MacIntyre Iron Co., Port Henry
Samples of crude and refined titaniferous magnetite, pig iron, flux and coke 25
Chateaugay Ore & Iron Co., Lyon Mountain
Samples of magnetite, crude and concentrated
Cheever Iron Ore Co., Port Henry
Samples of magnetite, crude and concentrated
Witherbee, Sherman & Co., Mineville
Large specimen of crystallized magnetite; many small specimens and samples of products
Borst, C. A., Clinton
Large specimen of hematite 1
William Connors Paint M'f'g Co., Troy
Samples of metallic paint
J. M. Wells Paint Co., Ogdensburg
Samples of metallic paint
Northern Iron Co., Port Henry
Samples of iron ores, fluxes, fuels etc., and of pig iron from furnaces at Port Henry and Standish 25
Solvay Process Co., Syracuse
Colored chart and samples to illustrate manufacture of soda products from salt 11

Enlargement of the paleontology collections. A very considerable amount of additional material has been installed in the paleontology collections, principally of invertebrates from the Paleozoic rocks of New York and from other Paleozoic regions which have been the subject of investigation and report here. Among such material which has been the basis of published studies by the Museum officers and selected parts of which are exhibited, are the Devonian fossils of the Falkland islands, undoubtedly the most complete series ever brought together, made by the cooperation of Governor and Mrs Allardyce of that province, and by the acquisition of the collections brought together by the Swedish Magellanian Expedition; the Devonian fossils of Argentina acquired by the aid of the Argentina Geological Survey and of Professor Bodenbender of Cordoba; the Devonian fossils of Brazil; of Constantinople; of Germany and elsewhere.

The hall of invertebrate paleontology now contains 104 cases and 6 large exposed mounts.

In the hall of vertebrate fossils a new case has been added of Devonian fishes with representations of their living descendants and a case containing parts of two skeletons of the extinct peccary *Platygonus*, from Gainesville, N. Y., to which further reference is made in the report of the Paleontologist.

Installations in zoology hall. Much has been done and a good deal remains to be done in the completion of the representations of the State fauna. There is now installed a practically complete series of the land and water birds of the State; an extensive and fine series of domesticated fowl, most of them prize specimens; the collection of reptiles and batrachians is effective, but for lack of adequate space is not completed; the mollusca of the State are but partially displayed and the lesser invertebrates are still poorly represented. Of the habitat groups there are now the following and it hardly seems possible with the present floor space to increase their number:

Mammals

1 Black bear
2 Buffalo
3 Canada lynx
4 Fisher
5 Mink
6 Moose
7 Muskrat
8 Opossum
9 Panther or puma
10 Red fox
11 Sewer rats
12 Virginia deer
13 Woodchuck

Birds

1 Nest of duck hawk
2 Nests of cliff or eaves swallow
3 Nest of goshawk
4 Whistling swan
5 Sora
6 Nest of clapper rail
7 Nest of green heron
8 Snowflakes
9 American goldfinch
10 Nest of long-billed marsh wren
11 Nest of oven bird and cedar waxwing
12 Nest of junco
13 Nest of yellow warbler
14 Nest of red-winged blackbird

Fish

1 Yellow perch and sunfish

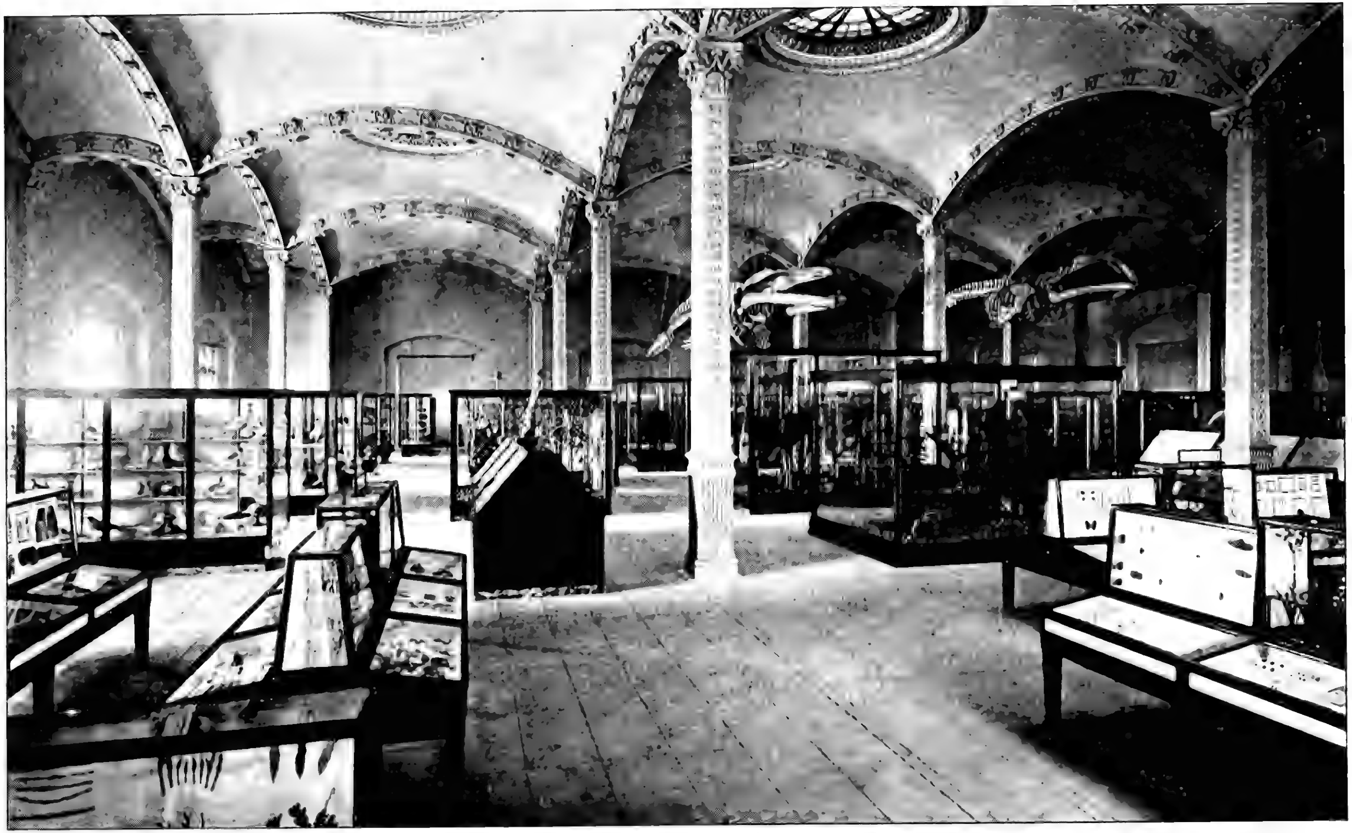
The difficult problem of presenting an effective representation of the insects and their depredatory activities has been skilfully met, and the entomological exhibit as a whole is growing to be most attractive and instructive the nearer it comes to completion. In these cases are 69 table panels and 42 upright panels now complete. Each case in this exhibit carries a small habitat group at the center of the top, and of these interesting habitat exhibits there are the following:

Insect habitat groups

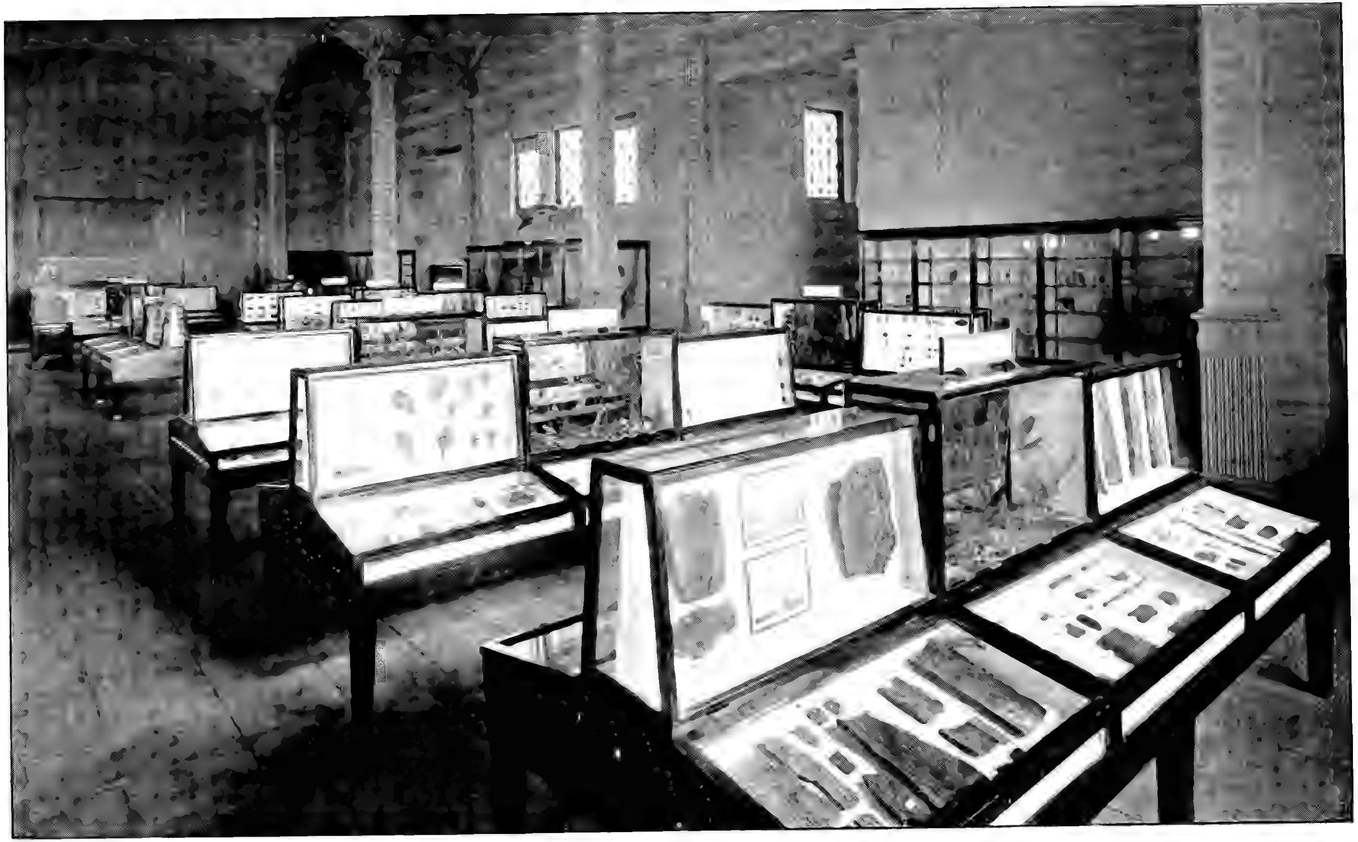
1 Milkweed insects
2 Insects of wild cherry and grass hedgerows
3 Meadow insects
4 Marsh and pool-side group
5 Aquatic group
6 Insect galls
7 Apple and pear destroyers
8 Mosquito head
9 Garden insects
10 Elm and willow insects
11 Oak and soft maple insects
12 Pine tree insects

Passenger Pigeon. Males. *Ectopistes migratorius* (Linn.)

Labrador Duck. Male (left) and female. *Camptorhynchus labradorius* (Gmel.)



Zoology hall, from west entrance.



Zoology hall, entomology exhibit.

III

CONDITION OF THE SCIENTIFIC RESERVATIONS BELONGING TO THE MUSEUM

1 **Cryptozoon ledge or Lester Park.** In order to make the extraordinary interest of this place intelligible to the visitor, tablets have been erected on the ledge and near entrances along the road. This road branches off from the state highway leading from Saratoga Springs to Luzerne, the branch of the road being about 3 miles due west from Saratoga. This branch runs through a beautiful piece of rocky woodland, and turning upon itself, forms a loop, joining the main highway again. On the Cryptozoon ledge itself has been erected an iron tablet 2 feet 8¼ inches by 1 foot 7½ inches, set on a concrete foundation and bearing this inscription:

CRYPTOZOON LEDGE

THE FOSSILS ON THE SURFACE OF THIS ROCK ARE REMAINS OF MARINE PLANTS OR ALGAE WHICH GREW ON THE BOTTOM OF THE ANCIENT CAMBRIAN SEA. THEY ARE AMONG THE OLDEST PLANTS OF THE EARTH. THEY GREW IN CABBAGE-SHAPED HEADS AND DEPOSITED LIME IN THEIR TISSUE. THIS LEDGE HAS BEEN PLANED DOWN BY THE ACTION OF THE GREAT GLACIER WHICH CUT THE PLANTS ACROSS, SHOWING THEIR CONCENTRIC INTERIOR STRUCTURE. THE SCIENTIFIC NAME OF THESE PLANTS IS CRYPTOZOON PROLIFERUM HALL.

On the other side of the road at the limestone quarry now a part of the reserve another iron tablet has been placed to indicate the significance of this limestone formation in the New York geological series. It bears the inscription:

HOYT LIMESTONE

THIS IS THE TYPICAL SECTION OF THE GEOLOGICAL FORMATION KNOWN AS THE "HOYT LIMESTONE" OF THE CAMBRIAN SYSTEM.

At the approach to the reservation from the west is a tablet, 2 feet 1 inch by 1 foot 3 inches with the following legend:

LESTER PARK

PROPERTY OF

NEW YORK STATE MUSEUM

DO NOT INJURE THE PLACE

Besides these, two markers have been set near the approaches with the inscription

LESTER PARK

This reservation requires some inconsiderable expenditure for the proper display of its interesting features. The Cryptozoon ledge itself is, in the course of a summer's growth, carpeted with patches of sod from which it should be kept free in order to make the exposure of the ledge as effective as practicable. Experience shows that this grass must be removed at least twice in a season. On the other side of the road opposite the ledge the surroundings of the quarry are grown up to brush and brambles and all of this should be cut out and kept repressed so that access may be free and inviting. In addition to the thicket which now covers much of this larger portion of the reservation, much rubbish has accumulated, which for the sake of propriety should be removed. Undoubtedly, when the work indicated has been once done, supervision twice during the season would keep the place in satisfactory and attractive condition.

2 **Clark Reservation.** This reservation is situated four miles southeast of Syracuse on the State road known as the Seneca turnpike. The remarkable features of this interesting place have been described in a previous report. The original purchase by Mrs F. F. Thompson, the donor of the property, consisted of 76 acres, and to this was added by subsequent purchase the outflow region at the east, making the present total area of the reserve 109.7 acres. Mrs Thompson has embellished this gift by beginning the erection of a suitable entrance where the reservation borders the State road. The entrance is a double curved stone wall with a graded road between, the design being effective and substantial. Some of the stone necessary for the composition of this wall in accordance with the specifications of the designer are of such large size as to impose some difficulties in finding them, but a limestone ledge has been located which can supply these large dimension pieces, and the work was under construction when the frost and snow interfered with further progress. It will be completed in the early spring within the contract price of $3900.

With the completion of this entrance and gateway we shall have put aside from encroachment by the public a highly instructive natural monument. It has never been the intention of the Department, acting as custodian of this and other properties, to attempt to treat them as parks but rather as reservations set aside for their natural beauties. The Clark Reservation will not be improved by the addition of drives and walks or any artificial constructions, but there are certain necessary and unavoidable conditions which will require attention. There is a rickety and dangerous stairway down the face of the great cliff to the lake, and in order to protect the State from any damage claims from accident on this broken construction, a sign has been posted on the ends to the effect that visitors are there at their own risk. This stairway should be repaired and the path beneath the cliffs at the bottom of the stairs should be graded sufficiently to make it possible to get along this picturesque embankment without danger. The property has almost no line fences, especially along the rear lines, and as its boundaries are very irregular it is not easy to determine them in their present condition. A survey and map of the property has been made by R. W. Jones and his assistants from the original deeds and every corner has been monumented, but the property is not in any way protected from the incursions of cattle from the adjoining farms. These and other conditions indicate that some attention requiring modest expenditures are necessary to protect the place and to make it suitable for the public use.

At the time of the present writing these are the only natural monuments in the custody of the State Museum, but we have the reasonable assurance that the Stark's knob near Schuylerville, whose historic and scientific interest has already been described, will be transferred to this Department by the generosity of Mr Emerson McMillin, and there are in mind at the present time one or two other spots of noteworthy interest likely to be invaded and destroyed in the progress of our civilization and which it is hoped may eventually come under our protection.

This subject of nature reserves is one that will command a wider attention and espousal as time goes on and the appreciation of what the community has already sacrificed becomes more keen. The State of New York has taken the first official steps in America in this matter of the conservation of its lesser monuments and the example is a wholesome one, the sentiment well worthy of nurture. Attention is here particularly directed to an admirable illustration of conservation carried out by a local organization with official municipal encouragement. This is the bird sanctuary erected and cared for by the Cayuga Bird Club within the city of Ithaca. The State Museum has done much to acquaint the citizens with a knowledge of our birds and to encourage their protection, and it is well known that the splendid color plates of the memoir "Birds of New York," were prepared by the accomplished artist, Mr Louis Agassiz Fuertes. Mr Fuertes is the president of the Cayuga Bird Club and it is under his administration that the "sanctuary" has been established. It is thus very fitting that some account of this establishment be given in this place, for it may in some sense be fair to reckon it among the fruits of our joint endeavor.

The account following has been prepared by Mr Fuertes:

The "sanctuary" of the Cayuga Bird Club at Ithaca. It is the last bit of virgin bottom-forest left in this vicinity. It lies at the very foot of the valley, and Cayuga lake forms its northern boundary, except for a few acres of cleared land. All the forest is ours. It is watered by Fall creek and its bayous; one can go all around in it in a canoe. I believe it contains about 30 or 40 acres, and is solid forest, composed of enormous sycamores along the streams, giant water elms (two-thirds of the timber), a large amount of silver maple, swamp white oak, butternut, walnut and ash, with a few tulip trees; no evergreens and rather Carolinian in its nature; great willows, too, abound around the edges and along the streams. The lower growth is very interesting: quantities of benzoin, considerable winterberry (*Ilex*), a little prickly ash, and any amount of *Rubus* of various species where the sun gets in. Large cat-tail marshes adjoin on both sides, though the biggest have been filled for factory sites, etc. Over two hundred species of birds have been recorded within the strict limits of the sanctuary. Enormous vines of wild grape and Virginia creeper depend from the crowns of the biggest trees; much poison ivy and other climbing vegetation adds to the natural beauty of the place.

Until about eighteen months ago this land was part of a wild tract known as the Renwick tract, and was put to no use except by the Sunday shooting crowd, who used to build fires against the trees, and devasted it generally. Then a wave of civic awakening came on, and the city voted $300 to "clear up" this woodland, which was regarded as an unsightly "wilderness," with the result that it liberated a crew of ignorant laborers with axes. This was highly disastrous, and most of the spicebush and the biggest vines were felled or severed before anyone with a real knowledge of what to do knew of it. Attention of the Board of Public Works was drawn at once to the damage, by the Cayuga Bird Club. The work was immediately stopped, considerable public attention directed toward the misstep, and after some weeks of rather delicate diplomatic procedure, the thing came to a good understanding, though no more funds were available for constructive work.

Then the Cayuga Bird Club put in a request that the Renwick wildwood be declared a bird sanctuary, that funds be voted for its maintenance, and that its administration be put in the hands of the Cayuga Bird Club. The club was then young, and the Common Council did not think it wise to commit the land to an untried and recently organized society, but did set the area aside permanently as a park, and extended the city corporation line to include it in its entirety. This brings it within police protection, and has had an excellent effect.

When the budget was next made up, the city voted $100 voluntarily for the improvement of the tract, and turned the entire sum over to the Cayuga Bird Club to expend in the most advantageous way. With it we constructed paths, cleaned out much of the rubbish from last year's cutting and dead wood already down, and built a very good, substantial rustic bridge over the main bayou leading out of Fall creek, obviating the necessity of a half-mile walk to get into the other part of the woods.

On Arbor Day last May, all the schools closed, and *every school child in Ithaca,* about 800, in the grades, came down to the wildwood and put in part of an afternoon's work, under guidance of the older members of the club, in constructive labor, planting water lilies, forget-me-nots, iris, etc., in the back-waters; burning brush in open places; trimming out the young shoots of spicebush over several acres of cutting; putting up signs against shooting; building fires; and placing nest boxes in good places.

This year we are asking the city for $250; we are planning an even better Arbor Day celebration, and have plans for immediately erecting two large automatic rustic food stations, a large and appropriate entrance arch designating the sanctuary, and a great many other things as soon as we can get the money.

Our club dues are very low: only 10 cents for children, 25 cents for adults, $1 for sustaining membership, and $10 for life. We give a considerable number of free lectures by the best men we can get, and all Ithaca enjoys them.

We feel that, if we can each year, for say 10 or 15 years, have all the children here develop a love for the place by really doing some *voluntary work in it,* it will be a hard matter, when these same children are grown up and compose Ithaca's citizenship, to ever divert this lovely place into any other field of usefulness than one preserving in full its wild, flowerful beauty.

Last spring we conducted each week enthusiastic field parties (6 to 9 a. m.) through and around the sanctuary. For years it has been the open-air classroom of the department of biology and limnology of Cornell University. The city is in full accord with us now, and I see no reason why we should ever lose hold of our sanctuary. The land, fortunately, is too low to be of much value. It is without doubt the most beautiful piece of old timberland left in this region, and that it is actually within the city limits is a vast advantage both to it and to the city. I know of no other place in the country with so large and magnificent a virgin area of woodland anywhere near it, let alone at its very door.

Regarding the influences back of it: as in all things of this kind, the active agents are the few who are interested and willing to give some time and thought to it. Our finances are not what they ought to be, but things are looking up, and the club is, I think, satisfactorily fulfilling its period of probation. Our city is about to adopt a new system of disbursing its funds, and we expect to be included among the organizations deserving and receiving financial aid from the city. We have plans for making a very useful and educational place of it, and only a little support would enable us to do part of it right away.

I have an idea that we shall try to negotiate for the withdrawal of about 800 acres of woodland on the east side of the inlet valley — all owned by about three men, all of whom are willing to devote it to this purpose. It is steep forested hillside; many grouse, etc., are there now, and many more would take to it if it were never hunted.

IV

DEPARTMENT PUBLICATIONS

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

No. 174 Annual Report on the Mining and Quarry Industry for 1913. By D. H. Newland.
175 29th Report of the State Entomologist. By E. P. Felt.
176 Report of the State Botanist for 1913. By C. H. Peck.
177 Director's Report for 1914.
178 Annual Report on the Mining and Quarry Industry for 1914. By D. H. Newland.
179 Report of the State Botanist for 1914. By H. D. House.
180 30th Report of the State Entomologist. By E. P. Felt.

It became obvious during the year that the number of scientific reports of the Department is now so large that many important special reports must of necessity be held back in order to facilitate the printing of the annual reports of the department officials. To correct this situation and release to the public many of these important technical reports, arrangements are in progress to issue the State Museum bulletin as a regular monthly periodical.

Wild Flowers of New York. A reasonable preliminary provision was made by the Legislature of last year for an illustrated monograph of the *Wild Flowers of New York*, and as soon as this became available, field work was begun by operators acting under the direction of the State Botanist in the preparation of autochrome plates from living flowering plants. These operations have been attended with success; nearly one hundred such color negatives with checking negatives in black and white were taken and the color prints made from these negatives are for the most part true in coloration and effect. The plants of the spring and early summer were missed in the year's operations, but will be taken up at once on the opening of the coming season.

Birds of New York. The continued demand for this work has reduced the edition to about one-seventh and as the demand does not seem to lessen, the volumes can not be much longer supplied.

Doubtless in another year it will be necessary to consider the desirability of issuing a new edition of these volumes. In order to relieve somewhat the pressure of this demand, 16,759 copies of the portfolio of the color plates of the volumes were printed early in the year and of these one copy was sent to each secondary school. The remainder of the edition was held for sale and the demand for this publication has been so great that the stock is nearly exhausted. It will be wise to increase this edition without delay.

V

CONSIDERATIONS FOR FUTURE GROWTH OF THE MUSEUM

As at present arranged, the Museum of Science is in very effective and pleasing quarters. The halls are imposing in all dimensions and agreeable in their architectural treatment. The casing of the various exhibits is essentially new throughout and their composition and grouping appropriate. It must be made clear, however, that every economy of space must be practised in order to present the collections adequately, and it should be understood that the exhibited collections in the present building can never be but a fraction of what they should be, as in fact they are today but a fraction of what the Museum now owns. The maintenance of the collections therefore must be a continuous process of elimination and substitution, of replacement of the good by the better until quality shall be paramount where quantity is impracticable. The danger here is that the want of space may force the Museum to inadequacy of appropriate display.

To enhance the attractiveness and the educational value of the Museum a proper treatment of the walls is essential. These great halls (those on the main floor having a total straight length of nearly 700 feet) are divided and relieved by panels 30 feet high, arched at the top. Now they carry only the plain finish left by the architect, and the vast surface they cover is unrelieved except by their form and the upspringing arches of the overhead iron work. These walls should be appropriately decorated, if not all, at least in part, and it is the Director's conception that a symbolic treatment suggested by the spirit of the place, continuous in theme though interrupted by the borders of the panels, confined to the lunettes of the arches or at least covering only the upper and atmospheric parts of the walls, is essential to give these majestic halls their true dignity.

VI

REPORT ON THE GEOLOGICAL SURVEY

Apart from normal office duties, it has been possible to progress active field work in geology but little during the past year. This is due partly to abnormal demands made by the Museum equipment and partly also to the failure of the Legislature to make a favorable response to a request for appropriations which could be specifically utilized for this object. Appeals for assistance from various localities for intelligent direction in the development of their geological resources have had to be put aside, and sources of effective wealth neglected.

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, some progress was made in the mapping of the *Gouverneur quadrangle* by Prof. H. P. Cushing, this work covering about one-tenth of its area and confined to its northeast portion. The formations found were the direct continuation of those of the Ogdensburg and Canton quadrangles, along the northeast-southwest strike which prevails, and have been described in some detail in the reports on those quadrangles which are about to be printed. Sufficient area was not covered to warrant any statement of results.

The *Lake Placid* quadrangle was covered in detail except for about one-fourth of the area, by Dr W. J. Miller. Only a few general results of this work can here be stated.

A great variety of Precambrian rocks occurs within the quadrangle, usually being mixed in a very complicated manner. The Grenville series, including various gneisses, some quartzite and little limestone, is not extensively present, the largest area probably being that south and southeast of Lake Placid village, but the drift there is so heavy that exposures are scarce. Another considerable body of Grenville occurs at the south end of Wilmington mountain. Most of the other Grenville is scattered about in small masses.

Anorthosite is very prominently developed, varying from the typical coarse-grained, bluish gray rock consisting mostly of labradorite of a dark-gray, somewhat finer grained, gneissoid, gabbroic facies on the one hand, and a white, almost purely feldspathic facies on the other.

The syenite-granite series exhibits the usual variations from a typical, greenish gray, moderately quartzose syenite to both quartzless dioritic or gabbroic facies and granitic, very quartzose facies. Tongues of syenite and granite were found clearly cutting the anorthosite at several localities. There are many occurrences of a peculiar syenitic looking rock with large bluish gray labradorite crystals and this is almost certainly a rock intermediate between anorthosite and syenite, having been produced by assimilation of anorthosite around the borders of the molten syenite.

Bodies of gabbro are not common, one considerable stock having been found on Pulpit mountain, while another large mass enters the quadrangle from one to two miles southeast of Upper Jay.

Diabase dikes of small size are numerous, being especially abundant from Keene Center northward for several miles.

Zones of excessive jointing, accompanied by more or less faulting, are prominently developed through the Wilmington notch and in the valley from Keene Center northward.

Perhaps the most remarkable topographic feature of the quadrangle is the Wilmington notch which is certainly of postglacial origin, the waters first having started over a preglacial divide there as the outlet of a large lake which occupied the broad lowland area south and southeast of Lake Placid village.

The very interesting glacial lakes of the quadrangle are being studied by Mr H. L. Alling.

The survey of the Ausable and Mount Marcy quadrangles, which has been in charge of Prof. J. F. Kemp, is well toward completion, but the final touches to the work have been temporarily suspended.

Landslides in the Hudson valley. The clays of the Hudson valley have long been the seat of soil displacements of greater or less moment, and during the past season one occurred on the property of the Knickerbocker Portland Cement Co. near Hudson, which was attended with very serious results. It was made the occasion for a careful investigation by Mr D. H. Newland, in which he was aided in every way by the company. The condition governing these displacements and the important results of this investigation are given in the appendix to this report.

Underground waters. Requests for information in regard to underground water supplies increase every year. These inquiries can be answered only tentatively and with great reserve, for knowledge of the underground waters of New York is very largely confined to local experience. Except on Long Island in connection with the work of the United States Geological Survey and the New York City Board of Water Supply, no systematic boring for the determination of underground water has been carried on. These investigations are of great importance and will soon become of imperative necessity. It is now impossible to advise with local communities seeking artesian water or abundant supplies of pumped water, but the exactions of the State and local boards of health and the demands of the communities will soon require this information from the State. This line of investigation has not yet been taken up by the water supply division of the Conservation Commission, and probably could not be intelligently handled except by a corps of experienced geologists.

The study of surface water supplies of this State was inaugurated in this office and the first report thereupon, " The Hydrology of New York," published as one of its bulletins. The proposed line of investigation of the subsurface supplies of water might with equal propriety be inaugurated here.

INDUSTRIAL GEOLOGY

Exhibit at the Panama-Pacific Exposition. In further reference to this exhibit it may be stated that the materials included a comprehensive array of the products of mine and quarry, as well as illustrative matter in the forms of models, charts and maps, and was grouped in an area of about 3500 square feet under the central dome of the building, most accessible to visitors. The exhibit was surrounded by others from states and countries more especially noted for their mineral endowments, but none the less attracted much attention. The variety of products was one of its features that caused much comment. In the distribution of awards it received favorable consideration; the grand prize was given for the display as a whole, and numerous medals — gold, silver and bronze — were allotted among the individual exhibits.

Much of the material will be returned to Albany and used to supplement the State Museum collections. In the list of exhibits to be thus disposed of is the large model of the Silver Springs works of the Worcester Salt Co. This was built recently with a view to its display at the exposition where it was the center of much interest, and no doubt it will be an attractive feature of the economic section of the Museum, in which now, through the generosity of the exhibitor, it will find a permanent place. A second model illustrates the methods of occurrence and of extraction of rock salt, as exemplified in the mines of the Sterling Salt Co. This also is to be set up in the Museum as a gift of the exhibitor.

Mines and quarries. The general trend of the mineral industries in 1914 showed a reversal of that of the preceding year; nearly all branches suffered declines which collectively amounted to about 15 per cent. The total value of the output was returned as $35,870,004, whereas in 1913 it amounted to $41,598,399. The decline of activity was really greater than indicated by the loss of output, since the reaction did not assume serious proportions until late summer and then developed rapidly to the close of the season. The foreign situation, of course, was the dominant factor in bringing on the depression which affected the whole country. The substances on which the valuations above mentioned are based included over thirty different products, most of them in the forms in which they come from the mines and quarries, without elaboration except so far as is necessary to make them of marketable character. They do not include secondary products like iron and steel, alkali products, coke and its by-products, aluminum, carborundum, calcium carbide, sulphuric acid, etc., the manufacture of which constitutes a large industry with an output many times greater than that covered by the industries reviewed in this report.

Zinc ores. The first shipment of zinc ores from a New York mine, of any considerable consequence at least, was made in 1915 as the result of work begun in the Edwards district, St Lawrence county, well known as a source of talc. The deposits are not exactly new in the usual meaning of that phrase, for some of them have been known to local prospectors and mining men for many years, but not until recently have they become the object of an enterprise capable of conducting their development on a commercial basis. The new undertaking started under the most favorable circumstances, the inquiry for zinc ores in the past year having been unprecedented, and the work has served to awaken general interest in the possibilities of the district. The area in which the ores are known or may be expected to occur is rather extensive, embracing a belt of the Precambrian sedimentary formations (the so-called Grenville) that reaches from Sylvia lake in the town of Fowler through the town of Edwards, near the village of which the present operative mine is situated. The belt is somewhat irregular in its bounds, but of unbroken continuity in the stretch of 12 miles or more. The different showings or prospects are well scattered over the area, although they appear to be more numerous on the southwest and northeast, at the extremities. The ore is sphalerite, usually of dark, nontransparent character indicative of a relatively large iron content, associated with pyrite and occasionally with a little galena. The wall rock invariably is limestone of the granular metamorphosed type that is an important element of the Grenville strata in the Adirondack region, and is folded and contorted, usually resting at a high angle. Quartzites and various feldspathic schists and gneisses accompany the limestone as a part of the same series. The mineralization is in the form of lenticular bodies, streaks, bands, and zones of disseminated ores within impure beds of the limestone. At times they show a high degree of crushing and brecciation, the fragments having been recemented by flowage of the limestone or infiltration of mineral matter in solution. Apparently the formation of the ore bodies dates back to an early geologic period, probably the Precambrian. The area comes within the Gouverneur quadrangle of which the geological survey is now in progress.

Molding sands. A preliminary paper on the Albany molding sands was prepared as a contribution to a discussion of the subject at a meeting of the American Foundrymen's Association. It is planned to complete the study with laboratory investigations of the physical and chemical properties of the sands, as soon as the necessary opportunity is presented. The molding sands have an interesting geological history, being one of the deposits formed in the expanded waters that occupied the Hudson valley in late Pleistocene time and that have become known as *Lake Albany*. The sands were the last of the sediments then laid down and originally formed a mantle over the whole area covered by the waters, which reached up to nearly 400 feet above present sea level. Since their deposition they have been partially removed by erosion of the streams and have been shifted about by the winds, the latter agency having a prominent part, it would appear, in the formation of the molding sands proper. The field work has brought to light a number of features of scientific and practical import. The account of these molding sands referred to is printed in the appendix to this report.

Hudson River clays. An investigation of the clay beds in the Hudson valley with particular reference to the possible extension of their uses, hitherto confined practically to the manufacture of common grades of building brick, seems to be a present need that is emphasized by the unfavorable conditions obtaining in the brick-making industry. This industry, it is well known, is of enormous proportions, but subject to great fluctuations of activity with changes in the market demand, which varies materially from season to season. Its situation in the last few years has been rather precarious. Prices have been low and the market uncertain, so that many manufacturers have closed their plants, some having withdrawn altogether from business. This is well brought out by the statistics collected for the annual mining and quarry report which show that in 1914 there were only 98 operators in the nine counties along the river, whereas in 1905 there were 119 in the same territory. That the industry has reached its full development under present conditions seems quite conclusive from the record, and its future welfare is to a great extent dependent upon possible improvements and the opening of new channels for its products. The study of the clays themselves, their composition, physical properties and behavior in the kiln, is the first requisite for the proper knowledge of the problems connected with the industry, and such study has been undertaken.

MINERALOGY

Several important additions have been made to the mineral collections during the past year.

A representative series of the recently discovered microcline (Amazon stone) crystals was collected from quarries to the east of Valhalla, Westchester county. Some of these compare favorably in color and in perfection of crystal development with the amazon stone from the famous locality on Pike's Peak, Colorado.

A suite of forty-two specimens was acquired by exchange from the Egleston Mineralogical Museum of Columbia University. These were selected with special reference to the needs of the present collections and serve admirably to strengthen some of the weaker portions both of the general mineral collection and of the collection of New York State minerals.

By exchange with Mr Shimmatsu Ichikawa of Kitashinjo-mura, Japan, the general collection has been enriched by a number of beautiful specimens of Japanese minerals. Notable among these is a series of extremely interesting quartz crystals, including several examples of the famous Japanese twin crystals.

The collection of New York minerals has recently been expanded to the extent of about 14 per cent in exhibited specimens. The material which has been added has been distributed throughout the collection and represents a gain of the contents of four type B cases.

A collection of models and specimens illustrating the laws of crystallization, occupying about 40 lineal feet of shelf space along the south wall of the hall of minerals, has been added to the collections of this division. This collection is accompanied by very full explanatory labels and it has been planned in the hope that by careful reading of the labels and study of the models and specimens, the observer may acquire a reasonable conception of the laws governing unit and derived forms of crystals.

PALEONTOLOGY

The Museum. In continuing the installation and labeling of the collections in the hall of invertebrate paleontology, the synoptic series of the stratigraphic exhibits was completed and provided with large guide labels for each case, outcrop maps of the formations in the State, and charts showing the aspect of the American continent at the time of the periods represented. These explanatory details give at a glance the most important data concerning each formation. Wherever possible, rock specimens, illustrating the varieties of rocks comprising the strata of each formation, have been assembled at the sides of the cases. The addition of new and better material is a constant process, and as such material is found in the great reserve of the Museum, or is acquired in other ways, it is incorporated into the exhibited collections so far as space will permit. Thus the synoptic collection of the New York Paleozoic fossils is constantly growing in quality and size. Into the 37 wall cases, which have been installed during the past year, the large specimens of the stratigraphic collection have been placed. These form an addition and supplement to the synoptic collections and the wall cases are made to correspond as far as possible with those of the general series alongside them. The large slabs placed on pedestals along the walls have all been labeled. The special exhibits of the Devonian sponges (six cases), of Devonian fossils from the Falkland islands, Argentina, Brazil, Turkey and Germany, most of which have been the basis of reports and investigations carried on in this office (4 cases), were finished. Of the starfishes and sea-urchins, 2 cases are finished, while only 1 case of the crinoids has been thus far installed. The wall cases of the special coral exhibit (4 cases) are finished and the others are now in process of installation and labeling. The work of mounting and labeling the material for the synoptic series has been done by Winifred Goldring, Edwin

J. Stein and H. C. Wardell; the special exhibit of sponges was prepared by Ira Edwards; the foreign Devonian and the starfishes and sea urchins by Winifred Goldring; the synoptic and special wall-cases were equipped by C. A. Hartnagel and H. C. Wardell. Mr Hartnagel has very efficiently supervised the making of the cases, blocks, frames and other accessories and is installing the special exhibit of corals.

Restorations in wax of Devonian fishes have been made by Mr Henri Marchand, and a series of such models of the graptolites has been commenced by the same artist. These models attract much attention, because of their artistic effectiveness and their scientific accuracy. They have proved so attractive and instructive that this work should be continued.

The recent discovery of skeletons of the extinct peccary (Platygonus compressus Le Conte) in a sand and gravel bank on the farm of Elihu Russell, near Gainesville, Wyoming county, is worthy of special note. Remains of this extinct swine, which is related to the Central and South American peccaries, have been found but once before in this State (near Rochester), although they have been known from Indiana, Ohio and Michigan and other states. The material from Gainesville belongs to two individuals, and consists of 2 skulls, remains of 5 ribs, 5 vertebrae, 2 scapulae, one left and one right, 2 metacarpals, 1 innominate, 1 ilium, 1 radius and ulna and 2 tibias. Of the two skulls, one is complete; in the other the lower jaw is missing. The complete one belongs to an older individual, the incomplete skull to a younger, though grown, specimen, which still has the temporary molar teeth.

The peccaries are a family of Suiidea peculiar to America, representing the hogs of the Old World. They have longer legs than living hogs, and inhabit today the Americas from Texas southward. Platygonus compressus had the size of the largest living peccaries.

The remains of these animals are seldom found alone. At Columbus two lots of six individuals each were found, the skeletons all pointing with the snouts toward the southeast. The remains are always found within the area occupied by the Wisconsin drift of the Pleistocene glacial period; it is therefore inferred that these peccaries took possession of the northern states soon after the withdrawal of the last, or Wisconsin, ice sheet. They were contemporaries of the mammoths and mastodons. Doubtless, so soon after an extensive glacial period, fierce snow storms raged at times

Part of paleontology hall (invertebrates). From east mezzanine.

Case of Devonian crinoids.

Slab of Cherry Valley limestone (Marcellus shale) with characteristic cephalopods. Much reduced.

in the northern states. It is therefore assumed that these peccaries were overcome by heavy snow storms or blizzards, as frequently happens to gregarious animals, like sheep, goats and swine. The specimens from near Columbus may have fallen in the direction in which they were running before the storm. The Gainesville specimens were found in excavating for sand in a delta knoll and the numerical majority of their bones were carried away with the sand for mixing concrete. As there is slight hope of completing these skeletons, the remains obtained have now been put on exhibition in the Museum.

List of cases and contents in hall of invertebrate fossils

CASES NO.	
20	Synoptic collection of the New York formations and faunas
25	Synoptic collection (supplementary; along walls)
12	Eurypterida
9	Trilobites
1	Eusarcus group — restoration
6	Cephalopods
3	Graptolites
1	Crinoids (others to be prepared)
2	Starfishes
1	Starfishes, echinoids and Paropsonema
6	Hexactinellid sponges
11	Devonian corals
1	Fossil parasites
1	Devonian of Falkland islands
2	Silurian and Devonian of Brazil
1	Silurian sea bottom. Black Cape, P. Que.
1	Recent glass sponges
103	

Added to these are 6 floor mounts and 11 wall mounts.

Field work. From lack of funds, only about three weeks could be given to field work. The investigation of the Middle and Upper Ordovician shales was extended from Utica northwestward, the shales overlying the Frankfort shales were studied, and for the first time contacts between the Utic aand Frankfort shales, and the latter and the superjacent formation, observed. This investigation is to be continued in the following field seasons.

Research. The research work has consisted chiefly in the investigation of a large number of new and interesting types of fossils which had been brought out from the general collection during the selection of material for exhibition. These fossils include about 50 species and a number of genera new to science, nearly all from the rocks of New York; among them a considerable number of new starfishes (11 species and 2 genera). About 25 genera and species hitherto incompletely known are discussed with the help of more complete material. The results of these investigations will presently be printed in bulletin form with full illustrations. The scope of this work is provisionally indicated by the following list of species discussed:

Subkingdom **Coelenterata**

Plectodiscus, new genus

Plectodiscus molestus nov. Portage beds. Ithaca, N. Y.

Airograptus, new genus. Beekmantown limestone, Deep kill, Melrose, N. Y.

Inocaulis kirki nov. Trenton limestone, Kirkfield, Ont.

Subkingdom **Echinoderma**

a Cystoidea

Pleurocystites squamosus mut. matutina nov. Trenton limestone, Kirkfield, Ont.

b Asterozoa

Clarkeaster, new genus

Clarkeaster perspinosus nov. Chemung beds. Avoca, N. Y.

Lepidasterina, new genus

Lepidasterina gracilis nov. Chemung beds. Avoca, N. Y.

Urasterella ruthveni mut. arisaigensis nov. Arisaig series, Nova Scotia

U. lutheri. Portage beds, Naples, N. Y.

U. stella. Portage beds, Naples, N. Y.

U. schucherti. Chemung beds, Kirkwood, N. Y.

Urasterella sp. nov. Ithaca beds, Messengerville, N. Y.

Eugasterella bicatenulata nov. Portage beds, Naples, N. Y.

E. aranea nov. Portage beds, Park Station, N. Y.

Encrinaster pusillus. Chemung beds, Elmira, N. Y.

Klasmura, new genus

Klasmura mirabilis nov. Portage beds, Naples, N. Y.

K. clavigera. Portage beds, Naples, N. Y.

Class *Brachiopoda*

Lingula semina nov. Pittsford shale, Pittsford, N. Y.

L. testatrix nov. Bertie waterlime, Litchfield, N. Y.

L. vicina nov. Pittsford shale, Farmers Mills, N. Y.

L. subtrigona nov. Manlius limestone, Union Springs, N. Y.

Lingulasma (?) elongatum nov. Schenectady shale, Schenectady, N. Y.

Orbiculoidea molina nov. Pittsford shale, Farmers Mills, N. Y.

Class *Gastropoda*

Protospira, new genus

Protospira minuta nov. Hoyt limestone, Greenfield, N. Y.

Hormotoma gregaria nov. Bertie waterlime, Marcellus, N. Y.

Class *Lamellibranchiata*

Pterinea poststriata nov. Pittsford shale, Pittsford, N. Y.

Ctenodonta ? salinensis nov. Salina beds. Lenox, N. Y.

Class *Cephalopoda*

Orthoceras vicinus nov. Bertie waterlime. Marcellus, N. Y.

Gomphoceras osculum nov. Cobleskill limestone, Morganville, N. Y.

Phragmoceras accola nov. Bertie waterlime, Litchfield, N. Y.

Hexameroceras microstoma nov. Guelph (Shelby) dolomite, Niagara Falls, N. Y.

Subkingdom **Vermes**

Protonympha marcellensis nov. Marcellus shale, Clarksville, N. Y.

Serpulites interrogans nov. Deep kill shale, Grant's Hollow, N. Y.

S. lumbricoides nov. Trenton limestone, Trenton Falls, N. Y.

S. crassimarginalis nov. Utica shale, Holland Patent, N. Y.

S. gracilis nov. Canajoharie (Dolgeville) shale, Dolgeville, N. Y.

S. gracilis nov. Utica shale, Holland Patent, N. Y.

S. magnus nov. Canajoharie shale, Menands, N. Y.

S. tener nov. Hamilton beds, Clarksville, N. Y.

S. longus nov. Keokuk beds, Crawfordsville, Ind.

Class *Crustacea*

Agraulos cushingi nov. Theresa dolomite, Greenfield, N. Y.

Amphilichas conifrons nov. Trenton limestone, Trenton Falls, N. Y.

Ceratiocaris (Limnocaris) salina nov. Pittsford shale, Pittsford, N. Y.

Spathiocaris lata nov. Chemung beds, Avoca, N. Y.

S. chagrinensis nov. Chagrin shale, Brecksville, Ohio

S. cushingi nov. Cleveland shale, North Dover, O.

S. williamsi nov. Cleveland shale, Newburg near Cleveland, O.

Anatifopsis wardelli nov. Shawangunk grit, Otisville, N. Y.

Class *Arachnoidea*

Pseudoniscus clarkei nov. Bertie waterlime, Litchfield, N. Y.

Eusarcus trigonus nov. Bertie waterlime, Litchfield, N. Y.

Argentinian Asterozoa

Encrinaster jachalensis nov. Silurian, Cerro Blanco, Argentina

Argentinaster, new genus

Argentinaster bodenbenderi nov. Silurian, Cerro Blanco, Argentina

The paper contains special articles on the following subjects: Favosites turbinatus Billings, in which the character of the opercula is discussed; Plumalina plumaria Hall, presenting evidence for a reference of this problematic fossil to the Alcyonaria; Inocaulis lesquereuxi (Grote & Pitt), in which this Bertie waterlime fossil, hitherto referred to the algae, is considered a graptolite; Climacograptus parvus is shown to have possessed a compound colonial stock, such as has been made known before of genera of Diplograptus, Glossograptus and Lasiograptus. A note on Paropsonema cryptophya and Discophyllum peltatum discusses the nature of these problematic fossils; the early growth stages of Devonaster eucharis are described, and Palaeosolaster (?) gyalum shown to be a Lepidasterella. The generic character of Ptilonaster, Hallaster and Squamaster are discussed with the aid of the type material in the State Museum. In Stenaster salteri (Billings), one of the earliest starfishes, the dorsal integument is recognized and the presence of an anus, which closed in later starfishes, suggested.

In Klasmura a stelleroid is described which is distinctly transitional to the ophiuroids in many features, especially in the nearly complete closing of the ambulacral furrow by an integument and by a column of ventral plates. The mollusks and brachiopods of the Pittsford shale and Bertie waterlime are described and the bearing of this associated fauna on the probable marine habitat of the eurypterids is set forth. The relations of a variety of forms described as Conularia, Serpulites, Sphenothallus, Enchostoma and Torrellella are discussed in a note, as also the probable nature of Spathiocaris. The presence of eyes in Pseudoniscus is shown; and additional parts of the Utica shale eurypterid Schizognathus are described. There are also described two new starfishes from the Silurian of the Argentine Republic, one of them representing a new genus. Dr P. E. Raymond has furnished the description of a new, large form of Ceraurus C. ruedemanni of the Chazy limestone.

The study of material being put on exhibition led also to the discovery of evidence that many trilobites possessed besides the large, compound or lateral eyes, small median or parietal eyes upon the glabella. It was found that about thirty genera possess the tubercle upon the posterior portion of the glabella, which corresponds to the median eye of the lower crustaceans. Where it is best developed, as in the "blind" Cryptolithus (Trinucleus), it even possesses a lens; in most other genera, however, it is merely a transparent spot for the reception of light intensities, and in the last Devonian trilobites it apparently has lost its visual function and disappeared as a tubercle. This investigation will be published in detail during the present year, together with observations of the true suture-line in Cryptolithus (Trinucleus) and other genera of the order Hypoparia.

VII

REPORT OF THE STATE BOTANIST

Scientific investigations. The investigations of the State Botanist during the season of 1915 have been chiefly directed toward the collection, identification and preparation of specimens of plants and fungi for the state herbarium. A limited amount of time has been spent in the study of the vegetation and ecology of the Oneida lake region.

The diversified character of the vegetation of New York has attracted the attention of botanists since the earliest colonial days and since the publication at Upsala between the years 1743 and 1751 of "Plantae Coldenghamiae" by Cadwallader Colden, the earliest publication relating specifically to the flora of this State, down to the present time, over 350 separate articles and books by 185 different authors have been published upon the flora of the State. The growth of scientific societies in most of the larger cities and the progress of botanical work in colleges and universities throughout the State have contributed largely to the study of local floras with a corresponding increase in the publications upon the vegetation of the State. A complete bibliography which may serve as a source of information regarding the publications upon the flora of the State and as a guide in future investigations seems now particularly opportune. Considerable time has been given to the preparation of such a bibliography, which is presented in another place.

Plant diseases. The principal plant diseases caused by fungi, which have been submitted for examination this year have been parasitic leaf diseases of ornamental and shade trees species. The most noteworthy is a disease of the foliage of the wild and cultivated clematis caused by Ascochyta clematidina; a disease of oak leaves caused by Gloeosporium canadense and also a peculiar association of an insect gall and Phyllosticta phomiformis; diseases of the leaves of the woodbine or Virginia creeper caused by Cercospora ampelopsidis and Phyllosticta ampelopsidis, and a disease of horse chestnut leaves caused by Phyllosticta paviae. These are illustrated and discussed in another place under "New or Interesting Species of Fungi."

Shrubby Cinquefoil

Trumpet or Coral Honeysuckle

Memoir on the Wild Flowers of New York. Active work upon this undertaking was begun in August and photographs were made in central New York, vicinity of Albany, Catskill, New York, and on Long Island, of over 100 flowering plants which bloom during the latter part of the summer and autumn. In this work both dry and lumiere plates were used. Preliminary proofs of several of the illustrations have been received showing the natural color and grace of the wild plants in a manner that could not be secured by any other process.

Exchanges. Valuable exchanges of herbarium material have been effected through which the state herbarium has been enriched by the addition of 254 specimens from Prof. J. J. Davis of the University of Wisconsin, 47 specimens from the New York Botanical Garden, 62 specimens from Prof. John Dearness of London, Ont., and 68 specimens from Prof. L. H. Pennington of Syracuse University, in addition to several minor exchanges.

Condition of the collections. With the addition to the staff of Mr Joseph Rubinger, assistant to the botanist, it has been possible to place the herbarium in an excellent condition of arrangement and availability for study. The collections, exchanges and contributions of the current year have been mounted and placed in the herbarium, together with a large quantity of unmounted material which had accumulated in years past.

Additions to the herbarium. The number of specimens which have been added to the herbarium during the past year from current collections is 584, from contributions and exchanges 396, a total of 980 specimens, representing 938 species in addition to more than 400 additional specimens which have been mounted from the unnamed material accumulated in the past.

Of these, 222 species were not previously represented in the herbarium and 30 species and varieties are described as new to science. The number of those who have contributed specimens to the herbarium is 20. This includes those who have sent specimens merely for identification and which were desirable additions to the herbarium.

Identifications. The State Botanist's office has been called upon to identify or report upon 650 specimens of flowering plants, ferns, mosses, lichens and fungi, by 110 different persons.

VIII

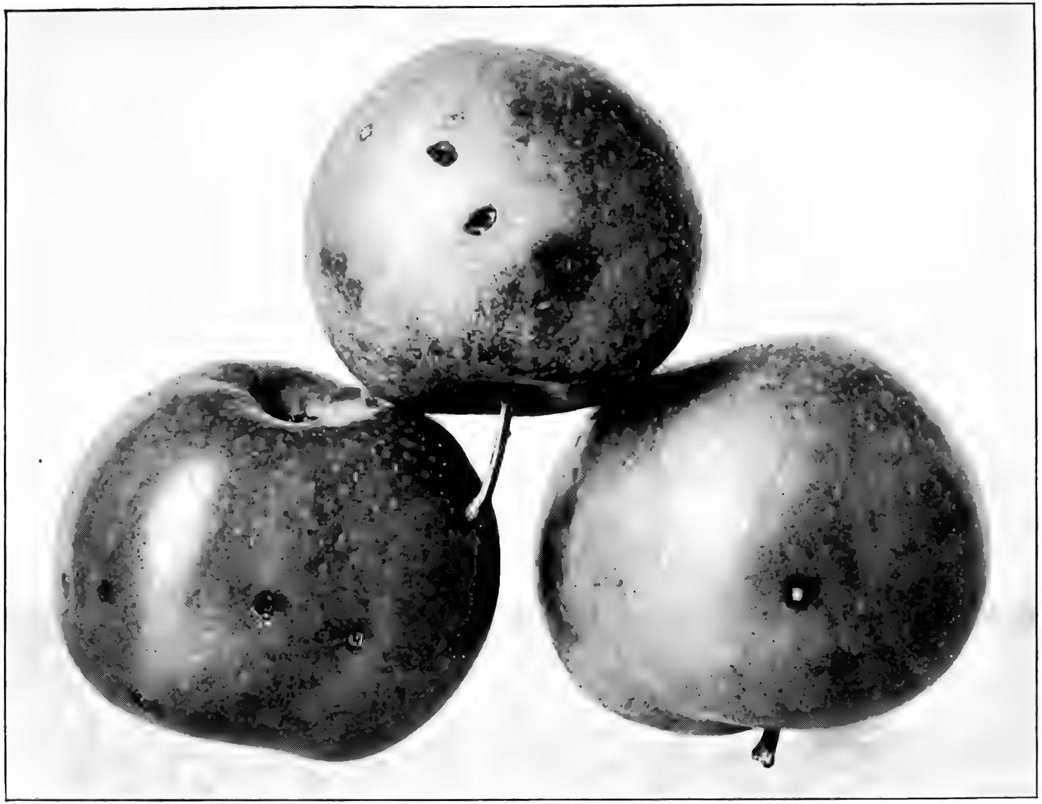
REPORT OF THE STATE ENTOMOLOGIST

The State Entomologist reports that the depredations of the apple tent caterpillar and the forest tent caterpillar, so evident the last two years, were continued the past season, though severely infested localities were more restricted than in earlier years. Popular warning notices were sent out by him early, and on Long Island in particular, a power-spraying outfit was used most successfully though the large areas of infested oak made it impossible to cover all satisfactorily with the equipment available.

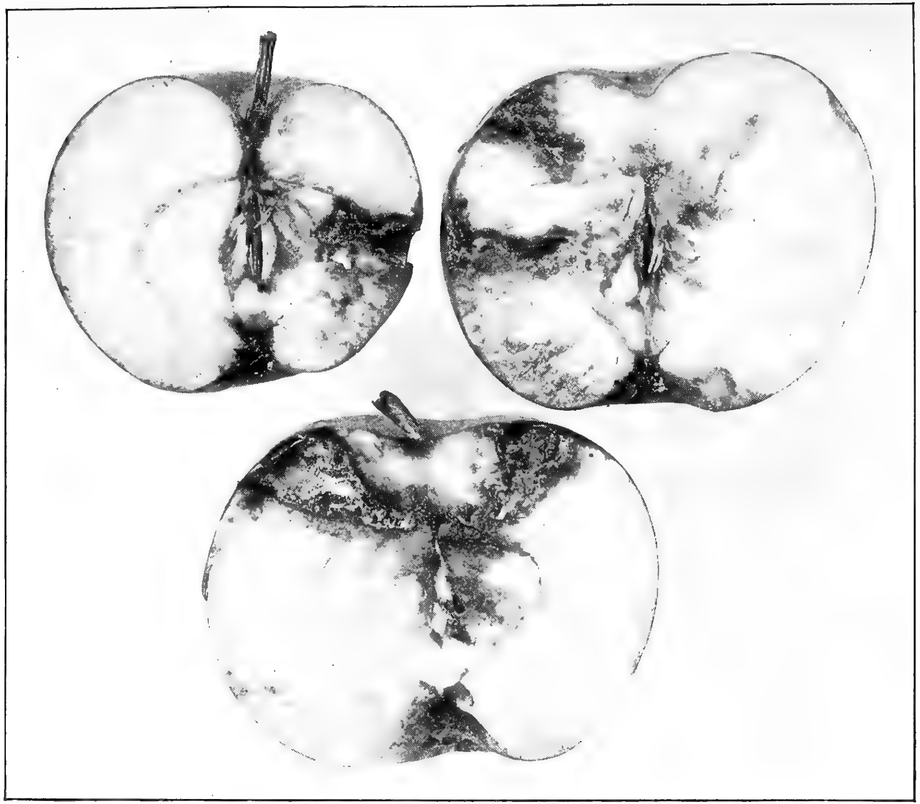
The work of the season showed an unusual and entirely unexpected outbreak of the cherry leaf beetle, Galerucella cavicollis Lec., a small, reddish brown insect which appeared in immense numbers in widely scattered localities and caused considerable apprehension because of its feeding upon cherry and peach tree foliage, though in most instances the damage was comparatively insignificant.

Oil injuries. The unfortunate developments following the applications of oils or oily compounds to the bark of deciduous trees, noted in earlier years, has again come to attention and in one locality was followed by serious injury to forest trees. The Entomologist experimented with this compound upon small forest trees of different varieties under normal conditions, and within six months of treatment six out of ten trees were dead, while the remaining four showed evidence of injury which may be followed by death another season. Details of this work are given in the report of the Entomologist.

Fruit tree insects. Practical work with the codling moth was undertaken by the Entomologist in cooperation with the bureaus of farmers' institutes and of horticulture of the State Department of Agriculture, and the Monroe County Farm Bureau. These studies, conducted in three commercial orchards in western New York, extended through the growing season and showed, first of all, a marked discrepancy between the habits of the insect in portions of the western part of the State as compared with what obtained in the Hudson valley. The cool evening temperatures prevailing near Lake Ontario at about the time the moths appear result, in some years at least, in a delayed deposition of eggs and a very high



Typical "side injury," a type of damage previously almost ignored and one commonly attributed to the work of the second brood of the codling moth. The prevention of this type of injury is one of the serious problems for the apple growers of the western part of the State.



Sections of apples showing the usual type of large worm holes opening on the side of the apple

percentage of side injury caused by the young codling moth larvae entering the smooth surface of the fruit and then, in many instances, migrating to the blossom end. This characteristic and heretofore almost ignored blemish affected 20 per cent or more of the yield in many orchards. The data obtained in this work emphasize the great importance of the spraying given just after the blossoms fall, and also the advisability in sections where this injury is prevalent, of making annual applications whether the trees be fruiting or not, and show, furthermore, that the second spraying ordinarily advised for the codling moth, namely, the one made ten days to two weeks after the first, would probably be more effective in reducing this side injury if it were made the latter part of June. The general prevalence of apple scab in this section amply justifies three sprayings after the blossoms drop, even though the latter two are not necessary for the control of insect pests. A detailed account of this work is given in the Entomologist's report.

Leaf roller. Investigations made in connection with the above-named codling moth work showed this insect to be generally distributed and frequently very abundant in apple orchards of western New York. Furthermore, the data obtained when classifying the fruit for codling moth work indicated very little reduction in leaf roller injury as a result of any of the poisoned applications made after the blossoms fall. This species is much less injurious in the Hudson valley.

Green fruit worm. This characteristic leaf and small fruit eater, as shown by investigations made in connection with the codling moth work, was somewhat more abundant in western New York and less so in the Hudson valley orchards, the damage apparently not equalling that caused by the leaf rollers.

San José scale has been less abundant in some Hudson valley orchards than in earlier years, though this does not appear to be equally true of the western part of the State. Examinations in several infested and unsprayed orchards in the town of Schodack, showed a decrease in the infestation compared with that of two years ago. The reduction was probably attributable in large measure to the activities of various small parasites. The condition of most of these infested trees, however, is not entirely satisfactory and although the damage resulting from scale infestation is much less, it is not considered that this justifies the abandonment of dormant applications for the control of the pest.

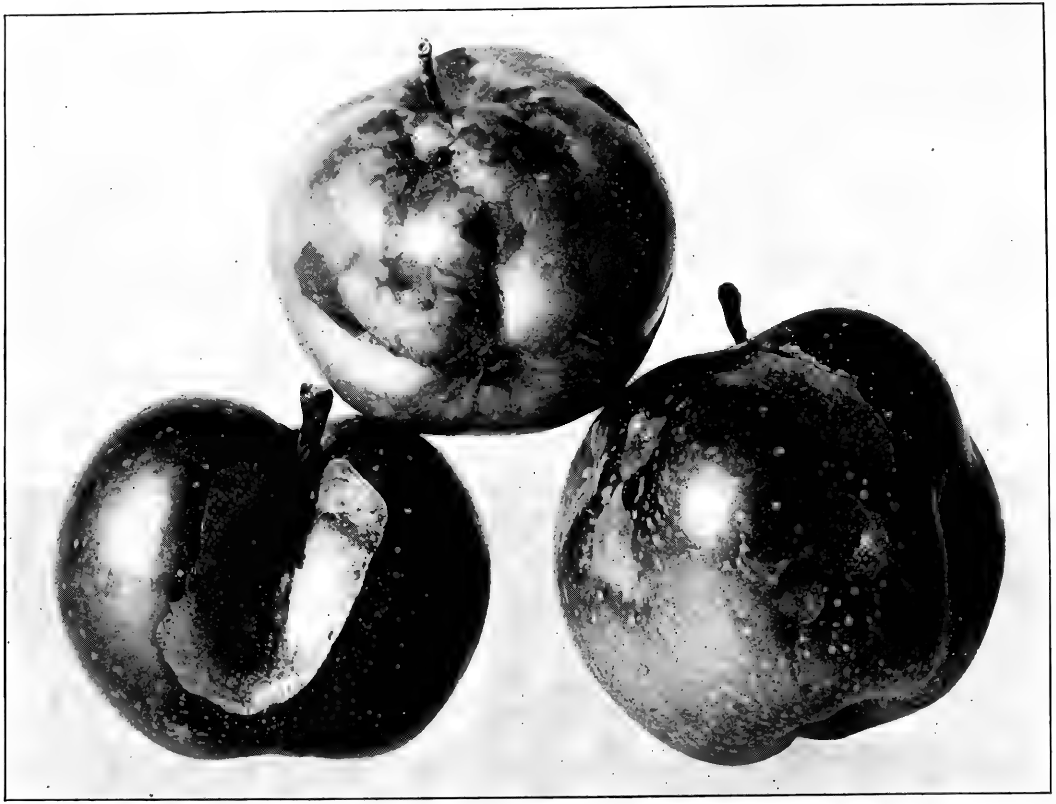
The apple maggot, generally known in New England as the railroad worm, has become locally abundant in some fruit-growing sections of the Hudson valley. The insect has been studied as opportunity offered and it is evident, should conditions of last year continue, that active, repressive measures must be adopted for the control of this pest.

Red bugs. The studies of the past season have shown that the two red bugs are both widely distributed in the Hudson valley and, where unchecked, have frequently inflicted serious damage upon the apple crop. The lined red bug appears to be more numerous though the other species is sometimes abundant. Practical work during the past summer, in cooperation with fruit growers, has demonstrated the efficacy of a tobacco application just before the blossoms open.

Pear thrips. The work of this new and erratic pest has been followed somewhat closely. It has appeared in numbers in widely separated pear orchards and in some cases completely destroyed the crop. It was especially serious the past season because an early and extremely warm period caught many growers unawares and gave the thrips an opportunity to enter the blossoms. This was followed by comparatively cool weather accompanied by a slow development of the leaves and flowers, a condition favorable for severe damage by any insects which might have gained entrance to the buds during the warm weather. These unusual climatic developments prevented carrying out certain projected cooperative work. Observations showed that an attack by this pest may be very sudden and that trees apparently free from thrips one day may be infested by large numbers the next, this even occurring in orchards where the pest was practically unknown the preceding season.

Pear psylla. Observations showed that serious injury by this insect has occurred in some Hudson valley orchards, though the outbreaks were usually very limited and were, as noted the preceding year, frequently closely related to unusually favorable winter shelters such as nearby brush heaps, fences or stone walls and their accompanying weedy growths. Here also, abnormal weather conditions necessitated the postponement of certain experimental work.

The sinuate pear borer, an European insect which became established in New Jersey some years ago, has extended its range slowly in New York State and is already known from several localities. The study of infested orchards shows this insect to be an extremely dangerous pest, owing to its insidious method of work, because the larvae make numerous serpentine, interlacing galleries in the inner



Apples badly injured by leaf rollers, serious pests in the western part of the State

"Aphis apples," showing a characteristic cluster and the deformation following aphis injury.

bark and outer sapwood, thus speedily destroying limbs or entire trees before there are marked signs of the borer's presence.

Gipsy moth. The Entomologist examined conditions obtaining at Mount Kisco where an infestation of several years' standing was discovered in 1914, and found that very satisfactory work had been done in the control of the pest. The infested areas have been well cleaned, banded with tanglefoot and sprayed, and the outlying unsprayed area banded with burlap for the purpose of catching any possible straying caterpillars. The great reduction in the infestation as compared with the conditions obtaining last year, is most gratifying and if the work is continued along present lines the probabilities are excellent of eliminating this local infestation.

Grass and grain pests. Investigations showed that the extended grasshopper devastations of last year on the borders of the Adirondacks, especially in portions of Fulton, Saratoga and Warren counties, continued, though the insects were present in much smaller numbers. This was especially true in Fulton county where poisoned bait was used very effectively the preceding season. The Entomologist, cooperating with the State Department of Agriculture and the Saratoga County Farm Bureau, conducted a series of experiments for the destruction of young grasshoppers. It was found that while the poisoned, fruit-flavored bait, frequently known as the Kansas bait, would kill many of the grasshoppers, especially in sections where vegetation was sparse, a sweetened solution of sodium arsenite was most effective in destroying the young pests in fields where there was considerable vegetation, particularly in clover seedings. The work of the past two seasons has demonstrated beyond all question the practicability of controlling outbreaks of this character, even on individual farms, though cooperation in badly infested areas is extremely desirable. The details of this work are given in the Entomologist's report.

The *white grub* outbreak of last season, predicted by the Entomologist the preceding fall and spring, was very serious in southern Rensselaer and northern Columbia counties in particular, though the damage was mitigated to a considerable extent by an unusually copious and well-distributed rainfall during the summer months. Last fall and early in the spring the Entomologist sent out popular notices regarding this insect, giving directions for the location of badly infested areas and advising certain preventive measures. In spite of these warnings numerous farmers suffered unnecessary losses, either by allowing badly infested land to remain unplowed, or by planting potatoes, corn and other susceptible crops upon recently turned and seriously infested sod.

Depredations by *grass webworms* in Dutchess county were again brought to the attention of the Department. In one case a five acre field of corn near Pine Plains was destroyed by the insects. The work of these pests, as has been pointed out before, can be avoided to a large extent by refraining from planting badly infested sod to susceptible crops, such as corn. An effort has been made to interest several persons in the practical control of these insects and it is possible that infested grasslands can be effectively freed from the pests at a very moderate cost.

Shade tree insects. Observations showed that elm leaf beetle injuries have not been particularly severe the past season, due in part presumably to low temperatures prevailing in June and thus delaying egg deposition, and also probably to the abundant rainfall which has enabled the trees to withstand successfully a considerable amount of leaf injury. Many of these pests completed their transformation successfully, and with favorable climatic conditions another season, severe damage may be expected in localities where the trees suffered but little the past summer.

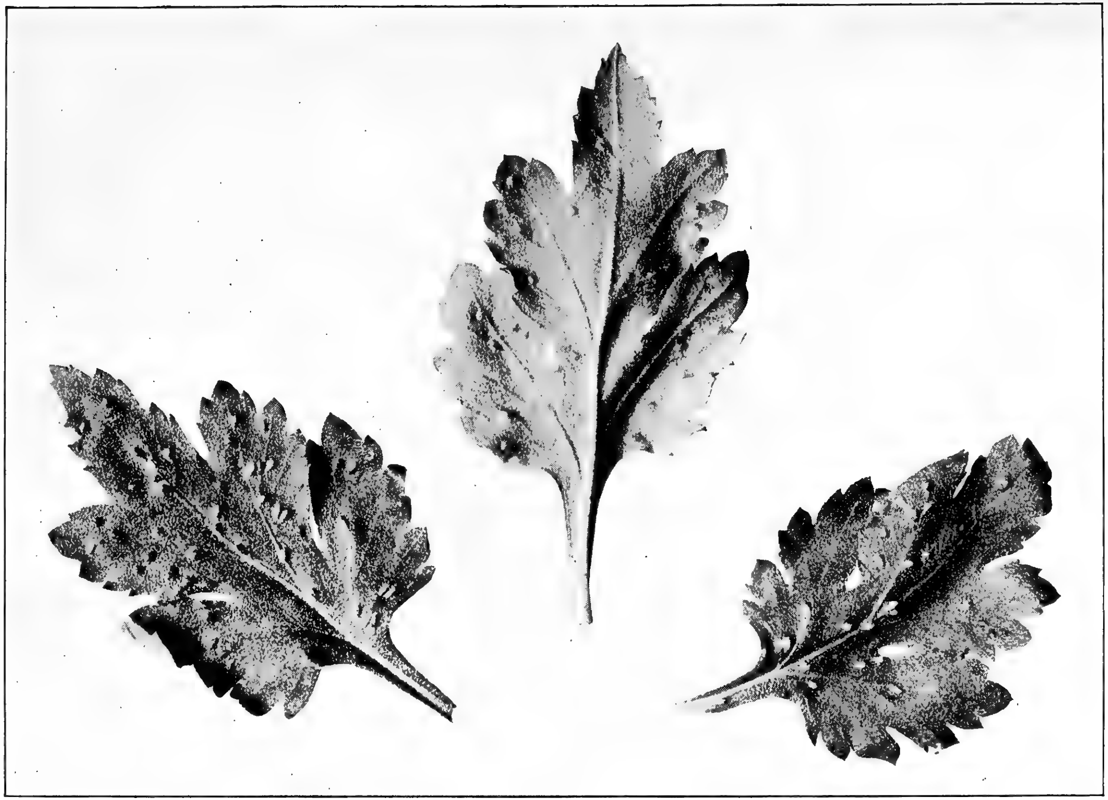
Other rather common shade tree pests, such as the *white marked tussock moth,* the *false maple scale* and the *cottony maple scale,* have attracted comparatively little attention the past season.

Forest tree pests. There has been continued injury by the *hickory bark beetle* in the vicinity of New York City and in other sections of the State, though the insects do not appear to be so abundant and destructive as in earlier years. The general interest in the protection of forest trees, especially in the vicinity of New York City, has resulted in cutting out many dead and dying trees, which has had a material influence in reducing the numbers of the pest. In connection with work upon this insect, the Entomologist has been able to rear large series of secondary forms occurring in dying and dead trees.

The *two-lined chestnut borer* is continuing its nefarious work and destroying groups of oaks, especially in regions about New York City. The prompt removal and destruction of infested trees has proved of much value in checking the pest.

The recently established *bayonet* or *post horn pine borer,* an introduction from Europe, has been reported from several localities and bids fair to develop, unless kept under rigid control, into a serious enemy of our native pines.

Work of white grubs in potatoes. These pests caused a loss of 30–75 per cent of the crop in some of the badly infested sections.



Galls of the chrysanthemum midge, a recently introduced pest which has been identified and studied by the State Entomologist.

Another pine twig borer Dioryctria abietella Zinck, was brought to the Entomologist's attention because of its work in the buds of Austrian pine at Rochester. This insect tunnels the young shoots and in some instances produces a deformation very similar to the species noticed above.

Periodical cicada. A scattering infestation of this interesting species was reported the past season and investigations indicate a somewhat general and sparse distribution in the lower Hudson valley, of a brood almost unknown heretofore north of the immediate vicinity of New York City.

Flies and mosquitoes. Interest in the control of the house fly and its associates has continued. There have been a number of requests for information in regard to these insects and their control.

The practical control of mosquitoes has been undertaken in cooperation with several local improvement societies, the most important being with the Sodus Point Improvement Association. The conditions in this locality are unusual, in that there are large areas of practically lake-level swamps in the immediate vicinity of a summer resort, consequently draining or filling were out of the question, the former being impossible and the latter impractical on account of the great expense involved. Another peculiar feature was the occurrence of considerable areas of floating or nearly floating cat-tails, and, as subsequent investigation showed, adapted to the breeding requirements of the irritating mosquito, a species remarkable because the larvae depend for their air supply upon that contained in the roots of various aquatic plants. A reliable person, working under the direction of the Entomologist, ascertained the most important breeding places and directed their treatment with oil before there was an opportunity for the wrigglers to mature. Incidentally, observations were made upon the mosquito fauna of the region for the reason that such biological data is the only logical basis for future work. The results were very satisfactory from both the practical and scientific standpoints and are discussed in some detail in the Entomologist's report.

Gall midges. The past season was marked by the discovery and identification of the chrysanthemum midge, Diarthronomyia hypogaea H. Lw., in widely separated localities in the country. These European midges deposit their eggs upon the young growth and when abundant may produce such marked deformations as to render the plants practically worthless. The Entomologist has studied this insect and its habits and an extended account may be found in his report.

The studies of gall midges have been continued and a number of common species, mostly reared, and several new genera have been described. One of the more important papers relating to this group appeared in the Proceedings of the United States National Museum. It characterizes a number of exotic species and contains a revised tabulation for the separation of the genera in the Asphondyliariae.

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 county farm bureau agents. Several lectures have also been given under the auspices of local improvement associations.

Publications. A number of brief, popular accounts regarding such common pests as the apple and forest tent caterpillars, pear thrips, white grubs, etc. have been widely circulated through the press. Several important technical papers have also appeared.

Faunal studies. Investigations 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. The list is a growing one, additions being constantly made thereto in connection with other work carried on within the limits of this faunal area, such as the study of grasshoppers noted above.

Collections. The assembling and preparation of the enlarged exhibit of insects has required much time on the part of the members of the staff and has resulted in deferring very desirable and necessary work on the arrangement and classification of the reference collections. Additions to the latter are constantly being made. This is especially true 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 the various species. The state collection now contains 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 very advantageous exchange has been made with Dr Nathan Banks, East Falls Church, Va., and a similar one with Mr R. R.

Parker, now of Montana, who has made a special study of the very difficult flesh flies or Sarcophagidae.

The Entomologist calls attention to the need of additional boxes or trays referred to in previous reports. The wooden cases containing the insect collections should be replaced by steel cabinets and more provided to accommodate the extra boxes and trays required. No adequate provision has as yet been made for the constantly increasing biological material, and for the large number of microscopic slides, many of which contain types of species and genera and therefore are impossible of duplication. A metallic filing case for the collection of negatives and photographs illustrating insects or their work is also greatly needed.

Nursery inspection. The nursery inspection work of the State Department of Agriculture has resulted in numerous specimens representing various stages in insect development, some in very poor condition, being submitted to this office 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 very important, since the disposal of entire shipments of nursery stock must depend in considerable measure upon the character of the infestation.

The work of the office 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 stated above, very effective cooperation with the State Department of Agriculture, a number of county farm bureaus and other public welfare agencies in the State. A number of correspondents have donated valuable specimens (listed elsewhere) and many of them have rendered efficient service by transmitting important data respecting various insects.

IX

REPORT OF THE ZOOLOGY DIVISION

The installation of new exhibits and the arrangement of the collections in zoology hall have continued during the fiscal year without interruption, and this work, together with the repairs and remounting required by many of the specimens retained from the old collection formerly on exhibition in Geological Hall has occupied all the time of the zoologist and taxidermist not required by the routine work of the Department. During the early part of the year the collection of mounted fishes, which had previously been cleaned and repaired by the taxidermist, was put in place in the cases prepared for it in the entrance corridors leading to zoology hall. Work on the moose and buffalo groups, which were mentioned in the last report as still unfinished, has been completed, and several trees added to the accessories of the black bear group, providing a background which shows off the animals to better advantage.

Important progress was also made in new groups. The Museum was fortunate in obtaining three young fishers which, with adult specimens already in the Museum, will permit a fine group of these uncommon animals to be arranged. The specimens (male, female and one young) for a group of Canada lynxes, ordered some time ago from Ward's Natural Science Establishment, have been delivered, and the work of arranging this group can now be begun as soon as a case is provided for it. A group of five whistling swans from the Niagara river, presented to the Museum, has also arrived and been installed in its case, although it was found necessary to make many changes in its arrangement and accessories; and a group of three Virginia deer, one buck and two does, was purchased and was in process of installation at the close of the fiscal year.

The right whale skeleton, reported purchased last year, has been delivered and put together and hung by wire cables from the ceiling of zoology hall. This skeleton has the baleen or whalebone in place in the mouth. Several life-size models of the smaller cetaceans native of New York State waters, which were acquired by the Museum some time ago but not placed on exhibition, have been mounted over the cases at the north end of the room. Another unusual and attractive feature added to the exhibit during the year is a collection of about twenty pairs of domestic pigeons representing different breeds and color varieties; a few additions to the poultry collection were also made.

The additions to the collection are therefore of a character which adds greatly to the popular interest and instructiveness of the zoology exhibit, and make the list of accessions for the year fully up to the average in importance and value, although the actual number of specimens acquired has been less than in some other years.

Such conspicuous additions to the material on exhibition do not, however, represent more than a small part of the actual progress that has been made. The zoologist has gone over the entire collection of wild birds, giving it its final arrangement and grouping, attached the individual and species labels, and painted the legs and bill of the specimens the natural color where drying or fading had altered it. In many instances the old specimens were found to have glass eyes of some incorrect color. These have been replaced, and the lifelike appearance and value of the collection to bird students increased through attention to these details.

Not only the bird collection, but by the close of the year, nearly all the specimens on exhibition had been labeled, the cards giving in many cases not only the popular and scientific names of the animals, but such information as to its distribution in the State, or its habits, as could be conveyed in two or three lines of reading matter. It is believed that this greatly increases the educational value of the exhibit, and it is proposed to carry it out more extensively when the completion of more urgent work will permit more time to the preparation of labels. They require care in wording, and any information added to the label has to be stated in the most concise manner possible. Museum visitors have neither the time nor inclination to read lengthy labels, and will probably not look at them at all if their length exceeds what can be taken in at a glance.

During the past year a beginning has also been made in the preparation of an exhibit of invertebrates, a considerable part of the collection of New York State mollusks having been cleaned, mounted and labeled by the zoologist and put in readiness for installing in the cases reserved for it.

X

REPORT OF THE ARCHEOLOGIST

Archeological collections. In the division of archeology and ethnology the activities of the year have been principally directed to the installation of the archeological collections. This has necessitated a continuance of the work of last year and in the cataloging and classification of some twenty thousand specimens, which brings the number handled to more than fifty thousand. Out of this number, by careful selection for the purpose of exhibition, more than ten thousand articles have been chosen and installed in the cases in archeology hall. The limitations of the division made it necessary that the matter of judging the articles for exhibition purposes and their installation be personally done by the archeologist, and it was also necessary for him personally to prepare the text for the labels throughout the exhibit.

The plan of the exhibit calls for the display of archeological objects having different relations: (1) by localities, (2) by comparison, (3) by usage, (4) by method of manufacture. The advantages of this scheme are apparent when it is seen that by it one may view an Indian implement correlated with other artifacts from single sites, compared with others of its type from any part of the State or continent, its usage shown and with various other implements employed for the same general purpose, and the various tools and processes by which it was made.

In the exhibition of western New York archeology it has been possible to begin our exhibit by showing first, prehistoric and pre-Iroquoian articles, such as were used by the unknown tribes of Algonkian, stone grave people and the mound-building Indians; second, the prehistoric Seneca sites; third, Iroquoian sites which give evidence of having been visited by the early traders but upon which native artifacts predominate and in which European beads, iron and brass are extremely scarce; fourth, a series of Seneca sites of the middle colonial period, ending about 1687; fifth, a series of cases showing a range of objects found on Iroquoian sites of the late colonial period, consisting almost entirely of trader's iron, brass and glass articles. By means of this exhibition it is possible to delineate the various cultural phases as evidenced by archeology and to illustrate the changes that came after the period of white contact, up to the point where the Indian usage of native-made tools and utensils has become entirely obsolete.

The central New York section embraces articles from a series of sites in the vicinity of Elmira, northward through the counties of Oneida, Madison, Onondaga, Cayuga and Oswego, the northern counties containing specimens largely selected from the Bigelow collection acquired last year. The central New York collections being from so many varied sites, are arranged mostly by the comparative method, that is, objects of similar character are placed together in individual cases.

In eastern New York the Hudson river and Mohawk region is represented by a few articles from the Hudson river on both sides from mouth to the source. Those from the tidewater region have been acquired mostly through the kindness of Mr Alanson Skinner of the American Museum of Natural History, who arranged for a satisfactory exchange with the State Museum. The region about Albany, Troy and the upper waters of the Hudson is represented by specimens selected from the collections of Mr James Holden, Mr Albert Hurd, Rev. O. C. Auringer and Prof. D. F. Thompson.

The northern New York region is represented by materials from the counties south of the St Lawrence along the state line and eastward from Jefferson county in a direct line to Lake Champlain, but not including the county of Warren. A number of exceptional objects from Jefferson county, arranged by classes, have been installed, including some three hundred pottery smoking pipes and nearly fifteen hundred specimens of bone and antler.

In order that the objects may be of educational interest to the visitor to the Museum, not versed in the more technical side of archeology, the specimens have been arranged in a synoptic exhibit to show the methods by which implements were made and the purposes for which they were employed. By careful experiments the archeologist has worked out the aboriginal methods of pottery manufacture and the character of implements employed in decoration. By observation it has been possible to discover from among the native implements found in various village sites, the tools and with these tools the manufacture and methods of decoration have been demonstrated. In the exhibit of flint chipping, the method by which flints were worked into shape has been shown. All the various tools that have been discovered on Indian sites are shown and their purposes explained, and a series of glass arrowheads and knives made with these tools, is shown.

In other exhibits there are displayed series of articles illustrating the graphic art and carving among the New York aborigines. In this exhibit it has been possible to depict the decorative art and to illustrate the various geometric forms understood by the primitive artist, the various types of surface decoration, such as by polishing, by pitting, by natural color and by cross hatching. A series of articles used in the procuring of food is one of the interesting exhibits. These objects are mostly archeological in character and bear unmistakable evidences, which make it possible to deduce the uses postulated.

This brief summary indicates in a general way that the archeological collection is arranged with a definite purpose and with a studied idea of giving it a teaching value in several different lines, and by such a method that comparison is possible. It is the intention to continue the plan still further by adding maps, photographs and transparencies, and special labels.

The physical method of display on card mounts has met with widespread commendation by museum men throughout the country. Before the exhibition was arranged the archeological division made a study of the methods of display in museum cases and after consulting with curators in several large museums, concluded that most museum cases were far too greatly crowded to appeal to the average visitor. It was therefore planned to display each specimen where it would be individually seen and properly understood through a descriptive label. The color of the background upon which the specimen rested was also considered in conjunction with the color and size of the descriptive label. In installing the collections the desire has been to make a pleasing display which may be easily seen without tiring the eye and which at the same time will be highly instructive. The ultimate plan calls for a descriptive booklet to be attached by a chain or cord to the outside of each case. This plan therefore makes it possible to study a specimen through the general descriptive label found in each case, through the individual label attached to the specimen mount, the information contained in the guide book to the hall and through a specially prepared book found attached to the case itself.

Ethnological collection. The use of the eastern mezzanine floor in the Museum for the hall of archeology has left free for the ethnological collections the long upper mezzanine hall in the west end of the building. In this hall the State Architect prepared a set of plans for the cases for the ethnological tribal groups. Space is left at the west end for a special hall in which there may be exhibited the articles and utensils collected among the New York Indians during the past three-fourths of a century. The section of the hall containing the life groups is to be known as the Myron H. Clark Hall of Iroquoian Ethnology and it is suggested that the ethnological hall be given the name of Lewis H. Morgan Hall, in appreciation of the work done by Morgan, not only for the Museum, during its early history, but for the sciences of ethnology and sociology. To provide properly the exhibition material for the hall of ethnology, the entire collection of ethnological specimens has been carefully examined. The collection consisted almost entirely of the articles collected by Lewis H. Morgan, 1848 to 1854; articles collected by Mrs Harriet Maxwell Converse, 1895 to 1899; and those collected by the present archeologist of the Museum. Nearly one-half of the Morgan collection perished in the Capitol fire of 1911 and almost all of the Converse collection except the silver articles. Thus, the specimens available consist largely of the more recent acquisitions. These have been divided into six classes for the purpose of exhibition: (1) articles used and worn by women and children; (2) articles used and worn by men and boys; (3) textile and woodworking industries and the various tools used in these pursuits; (4) articles, utensils and tools employed in the gathering and preparation of food; (5) paraphernalia of the various rites and ceremonies; (6) articles used in games and pastimes. Beside these, several other exhibits have been arranged for installation, the most notable of which is the valuable collection of wampum belts that constituted the national memorials of the Iroquois Confederacy. It has been the plan to display these in a special case and to have a suitably engraved inscription. Minor exhibits depicting various features of the disintegration of Iroquois material culture have been arranged. This includes the comparative exhibits of prehistoric implements and those derived from Europeans and contrast between the decorative art of purely aboriginal character and that made by Indians in native design but with European material; silver-working and the tools used therefor; and a series of mission pamphlets, hymn books, tracts and bibles used by the missionaries in their work among the New York Indians. By means of this exhibit the visitor will be able to compare the Indians before contact and the various stages of his progress thereafter in the acquisition of European customs. When this report has been printed the exhibition will have been installed and the series of six habitat groups completed.

Research work. The large amount of time consumed in purely curatorial work has necessarily curtailed detailed researches. Opportunity, however, has been found to continue certain lines of study, as the investigations into the distribution of the various sites of occupation and the distribution of the certain classes of artifacts. It has now been possible for us to form a hypothesis of the origin of the Iroquois, the time of their occupation of this State and to state more or less definitely certain facts concerning their material culture. These studies, it is hoped, will shortly be published. From the facts examined it would seem that the Iroquois have not been inhabitants of this area for more than 650 years and that though the Laurentian Iroquois came down into New York from the St Lawrence basin, the Seneca-Erie division probably never went across the Detroit or Niagara rivers for permanent settlement in the regions north of Lake Ontario. The migration of the Iroquois has therefore been from the west or southwest to the east, and not from the north, into New York. This is in contradiction to the older theory first advanced by Colden and long held by later writers.

Publications. During the year the manuscript notes on the Constitution of the Five Nations' Confederacy have been put into shape for publication. This work will give several versions of the Dekanawidah — Hiawatha tradition and be properly annotated. These traditions handed down by word of mouth for generations were reduced to writing by several native annalists and are now for the first time published in such a manner that parallel versions will be available.

We have already under way a work to be known as "The Archeological History of New York." This work has been greatly expanded during the year by additional notes and when completed will give the principal sites of aboriginal occupation throughout the State and describe the various culture areas and the implements and utensils which characterize them.

Public interest. The interest of the public in the work of this division of the Museum is greatly increasing and we are in constant receipt of letters requesting information and help along lines of our interest. These requests come from those interested in arranging pageants, tableaux, field days, games and exercises of interest to boys and girls, the naming of places, boats and summer homes and in the supplying of information for artists, musicians and authors.

The interest of the student and collector of Indian implements is increasingly attracted to this institution and a movement is now under way which will bring to every earnest collector the feeling that this division of the Museum has been created for his use and benefit.

Cooperation with state departments. This division is frequently called upon by the various departments of the state government and by the national government for information and opinions regarding New York State Indian subjects. These departments include the Secretary of State's office and the Attorney General's office. In the national government information and opinions have been rendered to the Secretary of the Interior and the Commissioner of Indian Affairs.

The legal status of the New York Indians and a definite determination of their holdings have never been made. Questions constantly arise as to their rights under treaties and as to the proper interpretation of tribal laws and customs. Our division constitutes in no uncertain sense a repository of source material, making it a valuable center of information.

Relations with the Indians of the State. Cordial relations are maintained with the descendants of the Iroquois Indians who still live within the borders of our State. Those who live on reservations number about five thousand and are distributed according to tribe, on reservation tracts. These reservations are situated as follows: the Allegany Seneca reservation in the southern portion of Cattaraugus county, along the Allegheny river; the Cattaraugus reservation in the northern portion of Cattaraugus county and the western portion of Erie county, along Cattaraugus creek; the Tonawanda reservation in the northeastern portion of Erie county, along Tonawanda creek; the Tuscarora reservation in central western Niagara county near Lewiston; the Onondaga reservation seven miles south of Syracuse in Onondaga county; the St Regis reservation on the northern border of St Lawrence and Franklin counties and extending over the international line into Canada. The so-called reservations on Long Island are not held under any state or national treaty right, but were set aside by the land grantors during colonial times and confirmed to the Poosepatuck and Shinnecock Indians. These tribes have now become practically extinct through the admixture of white and negro blood and are never regarded in the light of Indian communities, though certain Indian traditions still continue among the colored folk who have supplanted the original occupants.

Certain studies are conducted among the Indian reservations of the State proper with special reference to obtaining a complete knowledge of what is remembered of tribal ceremonies and customs. An endeavor is also made to provide these Indians with such information as they may call for. This is justified by certain provisions in the Education Law. Help has been rendered the Oneidas, Stockbridges, Senecas, Cayugas and St Regis-Mohawks.

During the Constitutional Convention the president and secretary of the Seneca Nation were present in Albany and participated in the reception of the Education Department to the members of the Convention. Secretary Walter Kennedy, in full Seneca regalia, presented for inspection to the Hon. Elihu Root, President of the Convention, the great constitutional wampum belt of the Iroquois Confederacy. This belt is in the possession of the State Museum, which by the consent of the Iroquois Confederacy and by act of the Legislature is trustee in perpetuity for the wampum archives of the Iroquois.

The Owasco Algonkian site. An early Indian village or camp site on the shores of Owasco lake, near its present outlet, has been reported by several students of archeology during the period of twenty years and considerable quantity of material has been discovered in the vicinity. In the spring of 1915, Mr E. H. Gohl of Auburn, by fortunate circumstance, discovered one of the large dump heaps of the village and succeeded in unearthing several hundred fragments of pottery and numerous stone implements. At the joint invitation of the Auburn and Syracuse Electric Railway Company and Mr Gohl, this Department was enabled to make an examination of the site by excavation.

An inspection of the site led to the conclusion that it was a small village site. The ground which it covered was on one of the shore or beach lines of Owasco lake, that had been laid down when the lake was twenty or thirty feet higher than at present. The Indian site covered the slope at a point most convenient to access to the outlet, which was undoubtedly a fishing place.

Mr Gohl had opened up one refuse heap and had discovered the fragments of two large pots which he succeeded in partially restoring, when the operations of the Museum commenced. Excavations covering a period of about three weeks resulted in obtaining some two hundred fragments of pottery including rims, fragments of about ten pipes and one complete pipe. The implements of chipped flint were rare and nearly all of a triangular pattern and the arrowheads are not notched. One ovate knife is of chalcedony. The bone material consists of phalangeal cones of a type frequently found on similar sites, bone awls, cylindrical beads and bone needles and shuttles. One harpoon tip and two antler pitching tools or pins were discovered. The stone material consists of metates, anvils, hammer stones, notched sinkers and small scrapers. A large block of chert was found in one section of the site and among the numerous fragments scattered about it were several partially completed implements. The block was probably the source of an arrow maker's material. Two perforated stones were found, one a large discoid bead and the other a fragment of an unfinished gorget. Unio shells were numerous and there were fragments of the bones of deer, bear, wild turkey, raccoon and several varieties of fish.

Ash pits were numerous and within an area of one hundred square feet, fourteen were noted. In nearly all of them the underlying sand was burned hard and red and the accumulation of white ash in several instances was from three to six or seven inches in depth. In a large deposit which appeared to be a central location there was a saucer-shaped depression filled with ashes and carbonaceous substances. This depression was fourteen feet in diameter and in the center there was a depression paved with flat stones. This was filled with ashes. The remains of a dog's jaw, fragments of split deer bone, fish bones and several kernels of charred corn and hickory nuts were found in the ashes. The stone basin was taken up and has been restored for exhibition purposes in the Museum.

An examination of the pottery articles leads to the conclusion that they are of Algonkian origin. They are similar in every respect to articles found on Algonkian sites along the Seneca river, Oneida lake and along the east shore of Lake Ontario stretching northward to the St Lawrence. Similar material is also found southward in the valley of the Chenango and along the tributaries of the Susquehanna. From the character of the articles we judge that the site was precolonial and perhaps prehistoric. The occupants were probably some division of the Delaware family who came into the region before the Iroquois obtained control of central New York. The collection has been cataloged and has already been installed in archeological hall.

One of the important specimens in the collection is the pottery vessel restored from more than two hundred fragments. This vessel is typical Algonkian in shape and decoration and is the largest Algonkian pottery vessel now in the possession of the State Museum.

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
Paul E. Reynolds, 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*
C. A. Hartnagel, Assistant in Geology, *Curator of Stratigraphy*
Robert W. Jones, Assistant in Economic Geology, *Assistant Curator of Industrial Geology*
D. Dana Luther, Field Geologist
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 Bylancik, Junior Clerk

Temporary experts

Areal geology

Prof. H. P. Cushing, Adelbert College
Prof. James F. Kemp, Columbia University
Prof. W. J. Miller, Hamilton College
Prof. G. H. Hudson, Plattsburg State Normal School
Dr W. O. Crosby, Massachusetts Institute of Technology
Prof. George H. Chadwick, St Lawrence University
James C. Martin, Princeton University

Geographic geology

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

Paleontology

Edwin J. Stein, Albany
Ira Edwards, Holley

BOTANY

Charles H. Peck, State Botanist
Homer D. House, 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
A. S. McGaughan, Page

ZOOLOGY

Willard G. Van Name, Zoologist, *Curator of Zoology*
Arthur Paladin, Taxidermist

Temporary experts

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

MINERALOGY

Donation

Dr John M. Clarke, Albany
Calcite (Mexican onyx, polished) 3
Detroit Rock Salt Co., Detroit, Mich.
Halite, Petit Anse, La 1
Dr George E. Gorham, Albany
Quartz (chalcedony) Tampa, Fla 50
C. A. Holmes, New Berlin
Calcite, Hot Springs, S. D 1
Shimmatsu Ichikawa, Japan
Arsenic, Akadani, Echizen, Japan 22
Molybdenite, Kimbuzan, Kai, Japan 1
Quartz, Tanokamiyama, Omi, Japan 1
Quartz, Aikawa, Sado, Japan 1
Quartz, Kimbuzan, Kai, Japan 2
Quartz, Tatemori, Kai, Japan 1
Opal (hyalite) Tategama, Etchu, Japan 1
W. B. Kane, Joplin, Mo.
Marcasite, Joplin, Mo 2
Sphalerite on quartz, Joplin, Mo 2
Chalcopyrite, Joplin, Mo 1
Galena, Joplin, Mo 2
Quartz, Joplin, Mo 1
Calcite, Joplin, Mo 1
C. W. Lyon, Albany
Quartz (jasper, polished) Loc? 9
Quartz (heliotrope, polished) Loc? 6
Quartz (chalcedony, polished) Loc? 1
The Morton Salt Co., Chicago, Ill.
Halite, Detroit, Mich 13
Dr John R. Palmer, St Johnsville
Quartz (crystals) 15
A. C. Terrill, Los Angeles, Cal.
Vanadinite, Goffs, Cal 3

Exchange

The Charleston Museum, Charleston, S. C.
Tourmaline (crystals), Mesa Grande, Cal 9
The Egleston Museum, Columbia University, N. Y.
Halite, Borax Lake, Cal 2
Sylvite, Staasfurt, Saxony, Germany 1
Boleite, Boleo, Lower California 4

Cummengite, Lower California	1
Bauxite, Floyd county, Georgia	1
Bauxite, Arkansas	1
Opal (matrix), Queensland, Aust	1
Opal (cut), Mexico	7
Smithsonite, Vielle Montagne, France	1
Anorthite, Uriyake, Japan	5
Anorthite, Mount Vesuvius, Italy	1
Pyroxene, Nordmark, Norway	1
Pyroxene, Otty Lake, Canada	1
Pyroxene, Piedmont, Italy	1
Pyroxene, Port Henry, N. Y	1
Pyroxene, Tilly Foster Mine, N. Y	1
Pyroxene, Arendal, Norway	1
Amphibole, Langban, Sweden	1
Amphibole, Russell, N. Y	1
Topaz, Omi, Japan	2
Epidote, Alaska	1
Epidote, Yancy county, North Carolina	1
Tourmaline, St Gothard, Switzerland	1
Colemanite, San Bernardino, Cal	1
Chalcanthite, Chuquicamata, Chili	1
Celestite, Lockport, N. Y	1
Celestite, Schoharie county, New York	1
William Carpenter, Butte, Mont.	
Covellite, Butte, Mont	1
Shimmatsu Ichikawa, Japan	
Quartz (crystals), Kimbuzan, Kai, Japan	10
Quartz (crystals), Takemori, Kai, Japan	1
Quartz (polished ball), Takemori, Kai, Japan	1
H. S. Peck, Menands	
Calcite, York, Pa	1
Smithsonite, Kelly, N. M	1
Ward's Natural Science Establishment, Rochester	
Opal, Virgin Valley, Nev	1
Benitoite, San Bernito county, California	1

Collected

D. H. Newland, Albany	
Microcline (Amazon stone), Valhalla, N. Y	11
Chalcopyrite in calcite, Rossie, N. Y	2
Curator of Mineralogy, Albany	
Microcline (Amazon stone), Valhalla, N. Y	21

PALEONTOLOGY

Donation

Anderson, Albert S. Chazy	
Large slab Upper Chazy limestone from Chazy, N. Y	1
Chadwick, Prof. George H. Rochester	
Crustaceans from Pittsford shale at Pittsford, N. Y	15

Cleland, Prof. H. F.

Type of Caritodens demissa (Conrad), Lorraine shale...... 1

Foerste, Prof. A. F.

Eurypterid, Ordovician. Collingwood, Ont........................... 1

Harris, John G. Middleville

Endoceras proteiforme from the Trenton limestone near Middleville, N. Y.. 1

Hill, Hon. Henry W. Buffalo

Polished slab of Chazy limestone with sections of cephalopods and coralline algae 1

Jones, R. W.

Hamilton fossils from High Falls and Becraft limestone at Catskill, N. Y. 10

Shoemaker, L. D. Elmira

Fossil sponge from Wellsburg, N. Y................................ 1

Stein, Edwin J. Albany

Climacograptus parvus Hall, Normanskill shale, Kenwood, N. Y. 1

Vassar College, Poughkeepsie, through Dr Aaron L. Treadwell

Cambrian and Ordovician fossils from Stissing mountain and vicinity of Poughkeepsie, N. Y., collected by Prof. W. B. Dwight..........8000

Exchange

Baker, Dr Smith. Utica

Lituites undatus, Black River limestone, Watertown, N. Y.. 1

Gyroceras, Onondaga limestone, south of Utica, N. Y............. 2

Mathes, K. B. Batavia

Phacops rana, Hamilton, Alden, Erie co., N. Y................ 10

Phacops rana, Hamilton, Buffalo creek, N. Y................ 13

Phacops rana, Hamilton, East Bethany, N. Y.................. 18

Phacops rana and Proetus rowi on same slab, (Hamilton) from near Alden, N. Y... 1

Cryphaeus boothi Green, Hamilton shale, East Bethany, N. Y. 1

Pyrite concretions, Hamilton shales, Ellicott creek, near Alden, N. Y. 17

Goniatites found in pyrite concretions in Hamilton shales, Ellicott creek, east of Alden, N. Y.. 13

Meristella barrisi, Stafford limestone, near Stafford, N. Y.. 91

Camarotoechia sappho, Stafford limestone, Stafford, N. Y. 48

Purchase

American Museum of Natural History. New York

Restoration in miniature of the mastodon by Charles R. Knight

Restoration in miniature of the extinct elephant or mammoth Elephas primigenius Blumenbach, by Charles R. Knight

F. P. Barrett. Gainesville

Parts of two skeletons of peccaries (Platygonus compressus) found near Gainesville, Wyoming co., N. Y. 2 skulls and 27 separate bones

Plourde, Anthony.

Fossil fishes (Devonian) from Migouasha, P. Q., Canada............ 200

Kinnear, W. T. Kirkbuddo, Forfar, Scotland

The following fossil fishes from the Old Red Sandstone at Sandwick, Island of Mainland, Orkneys, Scotland:

Pterichthys milleri	2
Cheirolepis traillo	2
Diplocanthus striatus	2
Diplopterus agassizi	1
Cheiracanthus cummingi	1
Coccosteus decipiens	2

The rare Upper Silurian (Downtonian) fish from Slot Burn, Segg-holm, Ayrshire, Scotland

Lasanius armatus Traq	1

Vermont Marble Co., Proctor, Vt.

Polished slab of Isle la Motte marble 1

With sections of Maclurites magnus Leseuer.

Ward's Natural Science Establishment, Rochester

Restoration of Dinichthys intermedius Newberry 1

Restoration of head of Dinichthys magnificus Bryant 1

Restorations of

Pleuracanthus gaudryi Brongniart, Carboniferous: Coal measures, Commentry, Allier, France

Semionotus tenuiceps (Agassiz), Triassic: Triassic sandstone, Sunderland, Mass.

Models of

Neoceratodus forsteri Krefft

Polypterus bichir Geoffr.

ENTOMOLOGY

Donation

Hymenoptera

Bailey, G. A. Geneseo. Abia inflata Nort., honeysuckle sawfly, larva on honeysuckle, July 6

Dodge, J. H. Rochester. Trichiosoma tibialis Steph., hawthorn sawfly, cocoon, March 4

Burnham, S. H. Hudson Falls. Pontania hyalina Nort., gall on Salix fragilis, July 19. Also Neuroterus umbilicatus Bass., galls on burr oak, July 19; Amphibolips inanis O. S., empty oak apple, August 30; Callirhytis futilis O. S., gall on white oak; Andricus excavatus Ashm., galls on Quercus velutina; Aylax taraxaci Ashm., gall on dandelion; Rhodites dichlocerus Harr., long rose gall on Rosa blanda

Gardner, Mrs E. P. Canandaigua. Pontania hyalina Nort., gall on willow, October 5. Also P. pomum Walsh, willow apple gall on willow; Holcaspis globulus Fitch, gall on oak; Andricus batatoides Ashm., potato gall, gall and adults on live oak, March 16, from Ortego, Fla.; A. lana Fitch, woolly oak gall, October 5; Vespa diabolica Sauss., yellow jacket, adults, July 20

Bucknam, C. I. West Newton, Mass. Kaliosysphinga ulmi Sund., European elm leaf miner, larvae and work on elm, June 26

Hill, Jannette W. Malden. Through State Department of Agriculture. Monophadnoides caryae Nort., larvae on butternut, August 20

Walker, R. S. Chattanooga, Tenn. Callirhytis ceropteroides Bass., galls, April 15

Ruggles, H. E. St Paul, Minn. Andricus lana Fitch, woolly oak gall, November 16

Luke, Walter. Scarsdale. Andricus petiolicola Bass., galls on oak, May 21

Baker, T. R. Winter Park, Fla. Through W. W. Yothers. Andricus turneri Ashm., gall on oak, April

Cooke, Mabel. Lake George. Rhodites rosae Linn., mossy rose gall on rose, June 24

Stene, A. E. Kingston, R. I. Rhodites fulgens Gill., gall, February 2

Edwards, O. S. Rensselaer. Megarhyssa lunator Fabr., lunate long sting, August 14

Greene, Mrs Horace L. Fort Plain. Sceliphron caementarium Dru., mud dauber, nest, March 6

Coleoptera

Wood, Mrs Walter A. Hoosick Falls. Through State Department of Agriculture. Hylesinus opaculus Lec., dark elm borer, adult on elm, June 24

Burnham, S. H. Hudson Falls. Hylesinus aculeatus Say, ash timber beetle, work on ash, January 18. Also Diaperis maculata Oliv., larvae on Polyporus, September 9; Saperda concolor Lec., gall on poplar, March 30; Phymatodes amoenus Say, work on Vitis riparia, April 22; Agrilus otiosus Say, gall on Ostrya, March 30

Livingston, J. H. Tivoli. Eccoptogaster 4-spinosa Ratz., hickory bark beetle, adult and work on hickory, July 29

Simons, L. R. Mineola. Conotrachelus crataegi Walsh, work in quince, September 29. Also Coptocycla bicolor Fabr., golden tortoise beetle, May 31; Chalaepus dorsalis Thunb., locust leaf miner on locust, May 31; Lachnosterna tristis Fabr., June beetle, adults, May 28; Agriotes mancus Say, wheat wireworm, larvae on corn, June 26

Johnston, W. C. Cooperstown. Ceutorhynchus sericans Lec. var. and Rhinoncus pyrrhopus Boh., adults on pine, May 1

Shumway, L. T. Cooperstown. Same as preceding

Sweigert, J. C. Plattsburg. Cryptorhynchus lapathi Linn., mottled willow and poplar borer, grubs and work on Carolina poplar, June 24. Also Pissodes strobi Peck, white pine weevil, larvae and pupae on Norway spruce, July 7

Dunbar, John. Rochester. Cryptorhynchus lapathi Linn., work and adults on poplar, July 19

Brown, M. A. Delhi. Pissodes strobi Peck, white pine weevil, adult and work on pine, March 6

Hunter, David. San Antonio, Tex. Epicaerus imbricatus Say, imbricated snout beetle, adult on grape?, May 1. Sent with specimens of Fidia cana. Also Fidia cana Horn, adults on grape, May 3

Rice, F. M. Albany. Rhynchites bicolor Fabr., rose curculio, adults on rose, June 14

Ennis, J. A. Pattersonville. Through State Department of Agriculture. Pomphopoea sayi Lec., Say's blister beetle, adults on locust, June 21

Barkley, J. E. Albany. Nacerdes melanura Linn., adults, July 20

Lintner, G. A. Summit, N. J. Coptocycla bicolor Fabr., golden tortoise beetle, on hickory, June 3

Zimmer, C. H. Lynbrook. Through State Department of Agriculture. Chalaepus dorsalis Thunb., locust leaf miner, adult, August 11

Rose, F. J. South Byron. Galerucella cavicollis Lec., cherry leaf beetle, adults on sour cherry, June 24

Dodge, J. H. Rochester. Same as preceding, on ornamental cherry, June 24

Thompson, J. O. Jonesville. Diabrotica vittata Fabr., striped cucumber beetle, adults, June 21

Ferris, S. B. Upper Saranac. Callidium antennatum Newm., blue pine borer in rustic work, June 24

Phelps, Katherine D. Canton. Osmoderma scabra Beauv., rough flower beetle, adult, August 12

Haggerty, D. V. Wiccopee. Euphoria inda Linn., bumble flower beetle, adults, May 21

Hollister, A. M. Saratoga Springs. Same as preceding, on corn, August 31

Bowles, F. P. Gloversville. Same as preceding, adults on maple, October 14

Niles, T. F. Mount Kisco. Through State Department of Agriculture. Cotalpa lanigera Linn., goldsmith beetle, adult, June 9

Hammond, Benjamin. Garden City. Anomala lucicola Fabr., light-loving grapevine beetle, adult, July 10. Also Macrodactylus subspinosus Fabr., rose beetle, adults, July 10

State Department of Agriculture. Garden City. Hoplia sackenii Lec., adults on birch, June 29

Gardner, Mrs E. P. Canandaigua. Photuris pennsylvanica DeG., firefly, larvae, September 16

Merkel, H. W. New York. Agrilus sinuatus Oliv., sinuate pear borer, work on pear, October 7

Kniffen, A. L. West Coxsackie. Dicerca divaricata Say, divaricate Buprestis, adults, June 7

Flanders, G. L. North Chatham. Alaus oculatus Linn., eyed elater, adult, July

Reist, Mrs H. G. Schenectady. Dermestes lardarius Linn., larder beetle, adult, August 7

Velie, C. G. & Son. Marlborough. Byturus unicolor Say, raspberry Byturus, adults and work on raspberry, May 12

Darrow, Mary. New York. Thelydrias contractus Motsh., larvae, October 15

Ward's Natural Science Establishment. Through State Department of Agriculture. Carabus nemoralis Mull., adults, May 6

Diptera

Livingston, J. G. New York. Culex sollicitans Walk., salt marsh mosquito, August 31

Adams, M. J. Rensselaer. Rhabdophaga aceris Shimer, maple leaf midge, larvae on soft maple, July 27

Ropes, J. M. Albany. Same as preceding, larvae and cocoons on soft maple, July 28

Fracker, S. B. Madison, Wis. Same as preceding, adult, August 24

Gardner, Mrs E. P. Canandaigua. Rhabdophaga batatas O. S., willow potato gall on willow, October 5. Also Dasyneura communis Felt, gall on sugar and soft maple, June 14, October 5; Phytophaga ulmi Beutm., elm bud gall on elm, October 5; Rhopalomyia anthophila O. S., fuzzy goldenrod gall on goldenrod, September 7; Lasioptera corni Felt, ocellate leaf gall on Cornus, September 7; L. farinosa O. S., warty blackberry gall, October 5; Neolasioptera eupatorii Felt, snakeroot stem gall, September 7; N. hamata Felt, September 24; Asphondylia eupatorii Felt, snakeroot bud gall; Itonida foliora Rssl. & Hkr., oak leaf fold gall on oak, July 20; Cecidomyia pellex O. S. on ash, June 14; C. viticola O. S., conical grape gall on grape, October 5

Cosens, A. Toronto, Ont. Rhabdophaga salicis Schrk., European willow stem gall, galls and adults on willow, July 3

Ricker, D. A. West Springfield, Mass. Dasyneura communis Felt, galls on maple, June 8

Pettit, R. H. Adrian, Mich. Diarthronomyia hypogaea H. Lw., chrysanthemum midge, adult and gall, March 27

Smith, E. D. & Company. Adrian, Mich. Same as preceding, larvae and galls on chrysanthemum, April 13, October 9, 13

Essig, E. O. Berkeley, Cal. Same as preceding, adults and galls, September 24. Also Monarthropalpus buxi Lab., May 6

Gibson, Arthur. Ottawa, Can. Same as preceding, September 25

Chubb, S. H. Kings Bridge. Through G. Clyde Fisher. Rhopalomyia anthophila O. S., galls on Solidago, September 29

Fisher, G. C. Leonia, N. J. Rhopalomyia fusiformis Felt, fusiform goldenrod gall on Solidago, September 19. Also Asteromyia carbonifera Felt, black blister gall on Solidago graminifolia

Bethel, E. Denver, Col. Rhopalomyia millefolii H. Lw., galls on yarrow, October 2

Binkley, Mrs L. T. Austin, Tex. Walshomyia texana Felt, adults and galls on wild Texas cedar, Sabina sabinoides, October 4

Frost & Bartlett Company. Stamford, Conn. Lasioptera clavula Beut., dogwood club gall on Cornus, March 19

Headlee, T. J. New Brunswick, N. J. Lasioptera vitis O. S., tumid grape gall, June 2

Kirk, H. G. Harrisburg, Pa. Same as preceding, gall on grape, August 12

Burnham, S. H. Hudson Falls. Neolasioptera cornicola Beutm., dogwood stem gall on dogwood, March 30

Chapais, J. C. Quebec, Que. Contarina virginianiae Felt, chokecherry midge, galls on chokecherry, August 8

Simons, L. R. Mineola. Monarthropalpus buxi Lab., box leaf midge, larvae on box, April 2

Smith, H. D. Sacramento, Cal. Same as preceding, galls and adults on box, April 10

MacMillan, D. K. Chicago, Ill. Parallelodiplosis cattleyae Moll., orchid root gall, galls on orchid roots, November 12

Dobbin, Frank. Shushan. Cecidomyia bedeguar Walsh, mossy thorn gall on Crataegus, June 14

Hand, Mrs B. L. Elizabethtown. Eristalis tenax Linn., drone fly, rat-tailed larva, September 24

Miller, George. Rhinebeck. Through F. H. Lacy. Rhagoletis pomonella Walsh, apple maggot, work in apple, September 7

Lane, A. M. Schenectady. Same as preceding, October 6

Wickham, D. O. Champlain. Pollenia rudis Fabr., cluster fly, adults, September 18

Lepidoptera

Squire, Nettie E. Canton. Papilio glaucus-turnus Linn., black swallow-tail, caterpillar, September 17

Scott, Emma E. Albany. Callosamia promethea Dru., Promethea moth, adult, July 7. Also Erebus odora Linn., adult, June 23. First taken in the State and brought to the Museum in twenty years

Fahrenkopf, Margaret. Albany. Callosamia promethea Dru., Promethea moth, July 9

Mead, Mrs E. Russel. Albany. Same as preceding, larva on lilac, August 23

Greene, Mrs Horace L. Fort Plain. Tropea luna Linn., luna moth, cocoon, April 12

Albright, Thomas. West Coxsackie. Same as preceding, adult, June 30

Wakely, H. T. Corinth. Telea polyphemus Cram., American silk worm moth, June 17

Adriance, Edward. Albany. Same as preceding, adult, September 2

Gale, L. A. G. Albany. Automeris io Fabr., io moth, larva, August 30

Eldredge, Laura F. Canajoharie. Same as preceding, larvae, September 3

Hessberg, Samuel. Albany. Basilona imperialis Dru., Imperial moth, caterpillar, September 20

Atwood, G. G. Jericho. Through State Department of Agriculture. Estigmene acraea Dru., Acraea moth, June 4. Also from Cayuga county, Peridroma saucia Hubn., variegated cutworm, caterpillar, February 24; from Geneva, Yponomeuta malinella Zell., ermine moth, young caterpillars, June 4

Blunt, Eliza S. New Russia. Estigmene acraea Dru., Acraea moth, June 23

Hartnagel, C. A. Albany. Halisidota caryae Harr., caterpillar, September 20

King, Joseph. Nassau. Agrotis ypsilon Rot., greasy cutworm, larvae on gladioli, June 6

Gavit, Mrs Frances P. Stony Creek. Noctua clandestina Harr., September 16

Avery, R. F. Kinderhook. Euthisanotia grata Fabr., beautiful wood nymph, adult, July 16

Keil, P. F. Westbury, Datana ?major Grt. & Rob., larvae on Rhododendron, July 19

Simons, L. R. Mineola. Datana integerrima Grt. & Rob., caterpillars, August 6. Also Oxyptilus periscelidactylus Fitch, gartered plume moth, caterpillar on grape, May 28

Cooper, E. H. Troy. Hemerocampa leucostigma Sm. & Abb., white-marked tussock moth, eggs on horsechestnut, March 24

Griffith, L. C. Amagansett. Euproctis chrysorrhoea Linn., brown-tail moth, nests, February 11

State Department of Agriculture. Same as preceding, web on Massachusetts stock, May 11. Also from Buffalo, Evetria buoliana Schiff., European pine twig moth, work, April; on Mugho pine June 29

Gillett, J. R. Kingston. Erannis tiliaria Harr., imago, October 22

Bishop, Delbert. Millerton. Through F. H. Lacy, Ennomos magnarius Guen., notch-wing, adults, November 11

Wheaton, J. C. Yonkers. Sibine stimulea Clem., saddle-back caterpillar, larvae on golden glow, September 5

Barron, Leonard. Garden City. Zeuzera pyrina Linn., leopard moth, larva on Gordonia altamaha, September 9

Zimmer, C. H. Lynbrook. Phlyctaenia ferrugalis Hubn., greenhouse leaf-tyer, moth and work on chrysanthemum, October 22

Dunbar, John. Rochester. Same as preceding, adult and larva, January 23

Case, Ruth M. Peconic. Plodia interpunctella Hubn., Indian meal moth, adult, July 17

Waterbury, W. E. East Schodack. Same as preceding, larvae in beans, September 29

Harris, S. G. Tarrytown. Evetria buoliana Schiff., European pine twig moth, larvae, June 1

Miller, A. R. South Jamaica. Through State Department of Agriculture. Same as preceding, pupae on Mugho pine, June 15

de Vyver, J. James. Flushing. Same as preceding, pupa on pine, June 22

Butler, C. B. East Greenbush. Archips cerasivorana Fitch, ugly nest cherry worm, in web on Lombardy poplar, June 18

Howard, J. C. Ogdensburg. Ectoedemia populella Busck., ridged leaf-stem gall, galls and larva on cottonwood, August 23

Seaver, F. J. New York. Coptodisca splendoriferella Clem., resplendent shield bearer, work on wild cherry, October 19

Bailey, H. L. Bradford, Vt. Incurvaria acerifoliella Fitch, maple leaf cutter, work on maple, September 10

Platyptera

Melius, W. A. Ghent. Corydalis cornuta Linn., horned Corydalis, August 5

Odonata

Sullivan, Raymond. Albany. Aeschna clepsydra Say, dragonfly, adult, June 29

Hemiptera

Livingston, J. H. Tivoli. Tibicen septemdecim Linn., seventeen year cicada, adult, June 18

Tedford, R. H. Albany. Ormenis pruniosa Say, lightning leaf hopper, nymphs on grape, etc., July 21

Vander Veer, Albert. Big Moose Lake. Aphrophora quadrinotata Say, four-spotted spittle insect, adults and larvae on Helianthus, July 7

Haggerty, D. V. Poughkeepsie. Philaenus lineatus Linn., lined spittle insect on grass, June 25

Doubleday, Page & Company. Garden City. Oncometopia undata Fabr., adults, June 30

Dobpin, Frank. Shushan. ?Phylloxera caryaecaulis Fitch, hickory stem gall, June 14

Board of Park Commissioners. Rochester. Through John Dunbar. Same as preceding, June 26

Gardner, Mrs E. P. Canandaigua. Same as preceding, on hickory. Also P. foveola Perg., on hickory, June 14; Chermes abietis Linn., spruce cone gall on spruce, April 15; Pemphigus ulmifusus Walsh, slippery elm gall on elm, October 5; Eulecanium fletcheri Ckll., on juniper, June 14

Cowee, Arthur. Berlin. Chermes pinifoliae Fitch, pine leaf Chermes, eggs on white pine, January 19

Harter, P. W. Utica. Same as preceding, young on pine, July 30. Also C. strobilobius Kalt., woolly larch aphis, adults and young on larch, July 29

Hammond, Benjamin. Beacon. Same as preceding, adults, eggs and young, June 15. Also Schizoneura lanigera Hausm., woolly apple aphis, June 19; Aulacaspis rosae Sandb., rose scale, eggs on rose, March 27

Simons, L. R. Mineola. Pemphigus populicaulis Fitch, galls on poplar, July 16

Naramere, Martha J. Ossining. Colopha ulmicola Fitch, cockscomb elm gall on elm, June 30

Langford, J. S. Shushan. Aphis mali Fabr., green aphis on apple, April 21

Lintner, G. A. Summit, N. J. Aphis sorbi Kalt., rosy aphis on young orchard trees, June 3

Wilson, Harold, jr. Clermont. Myzus ribis Linn., currant aphis on currant, May 22

Phelps. Mrs Charles S. Canton. Same as preceding, young, June 18

Johnston, W. C. Cooperstown. Myzus cerasi Fabr., black cherry aphis, adults on cherry, June 18

Seaver, F. J. New York. Gossyparia spuria Mod., elm bark louse, adults, June 9. Also Aspidiotus abietis Schr., on hemlock, September 30

Baldwin, T. W. Nyack. Gossyparia spuria Mod., elm bark louse, adults on elm, June 12

Phelps, C. P. Canton. Eriococcus azaleae Comst., adults on huckleberry, May 22

de Vyver, J. J. Flushing. Phenacoccus acericola King, false maple scale, male cocoons. April 30. Also Chionaspis pinifoliae Fitch, pine leaf scale on pine, October 17

Smith, A. C. Mount Vernon. Same as preceding, adults on sugar maple, August 21

Mead, Mrs E. Russel. Albany. Pseudococcus citri Risso, mealy bug, August 5

Aammond, Mrs A. C. Schenectady. Coccus hesperidum Linn., soft or brown scale on fern, January 25

La Clair, Antoine. Valcour. Eulecanium fletcheri Ckll., June 15

Whaley, F. J. Albany. Eulecanium nigrofasciatum Perg., terrapin scale on red maple, November 12. Also Aspidiotus perniciosus Comst., San José scale on birch infested by parasites, October 26

Sweigert, J. A. Plattsburg. Chionaspis pinifoliae Fitch, pine leaf scale, eggs on pine, November 5

Shears, H. C. Hyde Park. Same as preceding, March 17

Harrar, Richard. New York. Same as preceding on spruce, September 18

Frost & Bartlett Company. Stamford, Conn. Leucaspis japonca Ckll., on Norway maple and privet, December 5

Orthoptera

Eldredge, C. E. Leon. Blatta orientalis Linn., cockroach, adult, September 1

Thysanura

Stubing, F. J. Mount Vernon. Thermobia furnorum Rov., silverfish, bristle-tail or fish moth, adult, March 26

Mallophaga

Van Name, W. G. Saranac Lake. Through State Conservation Commission. Docophorus haleti Osb., on Eagle, June 2

Exchange

Banks, Dr Nathan. East Falls Church, Va. Psychoda nigra Bks., P. superba Bks., P. apicalis Bks., P. albitarsis Bks., Clitellaria subulata Lw., Apatolestes comastes Will., Rhachicerus obscuripennis Lw., Dialysis rufithorax Say, Chrysopila rotundipennis Lw., C. apicalis V.d W., C. basalis Say, Exoprosopa emarginata Macq., Systropus macer Lw., Geron senilis Fabr., Leptogaster atridorsalis Back, L. brevicornis Lw., Holopogon philadelphicus Schin., Cerotania macrocera Say, Mallophora clausicella Macq., Asilus autumnalis Bks., Baccha tarchetius Walk., Myrmecomyia myrmecomoides Lw., Euxesta scoriacea Lw., Lipochaeta slossonae Coq.

Parker, R. R. Bozeman, Mont. Wohlfahrtia opaca Coq., Boettcheria latisterna R. Pkr., B. bisetosa R. Pkr., B. cimbicis Towns., Sarcophaga sinuata Meigen, S. cooleyi R. Pkr., S. aldrichi Mans., S. haemorrhoidalis Meigen, S. falculata Pandellé, S. dalmatina Schiner, S. sarraceniae Riley, S. kellyi Aldrich, S. harpax Pandellé, S. bullata Mans., S. scoparia Pandellé, S. helicis Towns., S. assidua Walk., Ravinia communis R. Pkr., R. peniculata R. Pkr., R. quadrisetosa Coq.

ZOOLOGY

Donation

Birds

Seymour, Miss M. Lake Placid
Purple finch, Carpodacus purpureus (Gmelin) 1
State Conservation Commission. Albany
Florida gallinule, Gallinula galeata (Lichtenstein) 2
Bald eagle, Haliaeetus leucocephalus (Linnaeus) 1

Reptiles

Baxter, M. S. Rochester
Banded ground lizard, Lygosoma laterale (Say) 1
Goldring, Miss W. Slingerlands
Milk snake, Lampropeltis doliatus trianguaus (Boie), female and eggs 1

Fishes

State Conservation Commission. Albany
Spawn-eater, Notropis hudsonius (Clinton) 2
Minnow, Notropis rubrifrons (Cope) 7
Black-nosed dace, Rhinichthys atronasus (Mitchill) 1
Lake herring, Leucichthys artedi (Le Sueur) 6
Lake herring, Leucichthys ontariensis Jordan and Evermann 2
Tullibee, Leucichthys tullibee (Richardson) 1
Stanley's whitefish, Coregonus stanleyi Kendall 2
Brown trout, Salmo fario Linnaeus young . . . . 1 lot
Lake trout, Cristivomer namaycush Walbaum, eggs and young . . . . 1 lot
Brook trout, Salvelinus fontinalis (Mitchill), young . . . . 8 lots
Smelt, Osmerus mordax (Mitchill), eggs and young . . . . 4 lots
Brook stickleback, Eucalia inconstans (Kirtland) . . . . 1 lot
Sunfish, Eupomotis gibbosus (Linnaeus), young 3
Small-mouthed black bass, Micropterus dolomieu Lacepede, young 6
Pike perch, Stizostedion vitreum (Mitchill), young 2
Pike perch, Stizostedion vitreum (Mitchill), eggs . . . . 1 lot
Miller's thumb, Uranidea gracilis (Heckel) 2

Invertebrates

Gould, Julia N. Boston, Mass.
Shells Pteria sterna (Gould) 6
Jones, Idwal. Quartz, Cal.
Nest of tarantula 1
State Conservation Commisson. Albany
Fresh water mussels, Unio complanatus (Solander) Dillwyn . . 3
Lobster, Homarus americanus Milne-Edwards, young . . . . . 2 lots

Purchase

Mammals (mounted)

Cliff, Harry. Albany
- Gray squirrel, Sciurus carolinensis leucotis (Gapper). 2
- Fox squirrel, Sciurus niger neglectus................... 1
- Cottontail rabbit, Sylvilagus transitionalis (Bangs).... 2
- Gray fox, Urocyon cinereoargenteus (Schreber)........ 1
- Skunk, Mephitis putida Boitard........................ 3
- Mink, Mustela vison Schreber.......................... 2
- Bonaparte's weasel, Mustela cicognanii Bonaparte......... 2
- Pine marten, Martes americana (Turton)................. 1
- Raccoon, Procyon lotor (Linnaeus)...................... 1

Ward's Natural Science Establishment. Rochester
- Canada lynx, Lynx canadensis Kerr....................... 3
- Fisher, Martes pennanti (Erxleben), young................ 3
- Virginia deer, Odocoileus americanus (Erxleben)....... 3

Skeleton

Right whale, Balaena glacialis Bonnaterre................ 1

Birds (mounted)

Barker, Fred. Parker's Prairie, Minn.
- Long-billed marsh wren, Telmatodytes palustris (Wilson). 1
- Migrant shrike, Lanius ludovicianus migrans Palmer.. 1
- Tree swallow, Iridoprocne bicolor (Vieillot)............ 1
- Crested flycatcher, Myiarchus crinitus (Linnaeus)......... 1
- Rough-legged hawk, Archibuteo lagopus sancti-johannis (Gmelin).. 1
- Upland plover, Bartramia longicauda (Bechstein)......... 1
- Lesser yellowlegs, Totanus flavipes (Gmelin)............. 1

Cliff, Harry. Albany
- Pine grosbeak, Pinicola enucleator leucura (Müller).... 1
- Nighthawk, Chordeiles virginianus (Gmelin)........... 1
- Great horned owl, Bubo virginianus (Gmelin).............. 2
- Rough-legged hawk, Archibuteo lagopus sancti-johannis (Gmelin).. 1
- Red-tailed hawk, Buteo borealis (Gmelin)................. 1
- Marsh hawk, Circus hudsonius (Linnaeus)................ 1
- Ring-necked pheasant, Phasianus torquatus (Gmelin)....... 1
- Golden pheasant, Chrysolophus pictus (Gmelin)......... 1
- Partridge, Bonasa umbellus (Linnaeus).................... 1
- Woodcock, Philohela minor (Gmelin)...................... 1

Reineke, Ottomar. Buffalo
- Whistling swan, Olor columbianus (Ord).................. 5

Domestic poultry (mounted)

Hartley, B. M. West Haven, Conn.
- Rhode Island red... 2
- White Orpington 2

Domestic pigeons (mounted)

Archangel	2
African owl	2
Silver runt	2
Black bald-head tumbler	2
Red helmet	2
Black dragoon	2
Blue barred homer	2
Black magpie	2
Swallow	2
Black jacobin	2
Red fantail	2
Common pigeon	2
Tippler	2
German beard	2
Maltese hen	2
Black mondaine	2
Russian trumpeter	2
Red carneau	2
Red nun	2

Reptiles and amphibians (casts)

Common toad, *Bufo americanus* LeConte	2
Hog-nosed snake, *Heterodon platyrhinos* Latreille	1

ARCHEOLOGY

Henry K. Deisher. Kutztown, Pa. November 1914

Clay pot	1
Stone pipe	1
Stone tube	1
Gorget	1
Strings of beads, glass and shell	4
Copper arrow points	5
Card of stone objects, arrow points and spearheads	6
Stone pestle	1

William W. Adams. Union Springs. November 1914

Banner stone	1
Celts	5
Stone scrapers	4
Flint blades	2
Lead bullet	1
Flint chips (worked)	5
Flint arrow points	3

Dr William A. Howe. Albany. February 1915

Stone pestle	1

Noah T. Clarke. Albany. April 1915

Stone pestle	1

Henry K. Deisher. Kutztown, Pa. April 1915

Grooved sinker	1
Notched sinker	1
Flint arrow points	2

Mary Seymour St Arnauld. Albany. May 1915

Clay pipe	1
Flint arrow point	1
Gouge	1
Gorgets	2
Celts	4
Potsherds	2
Spearheads	2

H. L. Bowers. Oshawa, Ont. May 1915

Pottery fragments	7
Steatite fragments	16
Banner stones	2
Flint spearheads	3
Flint blades	5
Flint drills	3
Flint arrow points	28
Broken gorget	1
Gorgets	2
Flint scraper	1
Crude axe (stone)	1
Celts	1
Gun flint	1
Pike pole head	1

F. V. L. Ryder. Troy. June 1915

Banner stone (unfinished)	1

Alden C. Merrick. Albany. August 1915

Striped bead	1

Collection

A. C. Parker. Owasco Lake. August 1915

Unio shells	3
Clay pipe bowls	2
Potsherds	54
Clay pipes	2
Flint spearheads	1
Net sinkers	51
Jaw of bear	1
Unfinished gorget	1
Celts	3
Clay pipestem	1
Arrow points	5
Stone bead	1
Bone bead	1
Phalanges	3
Mullers	2
Bone punches	2

Bone harpoon	1
Bone fishhook	1
Bone needle	1
Mealing or lap stones	3
Small piece copper tube	
Several pieces pigment	
Large lump of flint	
Small quantity charred wood	

F. Ryder and H. A. Lansing. Coxsackie. September 1915

Flint spearhead	1
Hammer stones, pitted	3
Net sinkers	2
Arrow point	1
Large worked stone (may have been agricultural implement)	

Mrs F. A. McCombs. Rushville. September 1915

Gorget	1
Celt	1
Bone awl	1
Flint blades	23
Sandstone pipe bowl	1
Flattened piece slate, polished (may have been part of gorget)	

XIII

SCIENTIFIC PAPERS

LANDSLIDES IN UNCONSOLIDATED SEDIMENTS; WITH A DESCRIPTION OF SOME OCCURRENCES IN THE HUDSON VALLEY

BY DAVID H. NEWLAND

Introduction

Landslides, or landslips, involving bodies of soft materials like the recent accumulations of clay and sand in many valleys of the glaciated region, are not unfamiliar. They have been described from time to time as individual occurrences having attracted attention by reason of some striking feature or incidental interest. Less notice has been taken, however, of their relation to the processes of degradation or surface leveling, which from a geological standpoint is of first importance.

The subject of landslides has been treated in a systematic manner by Heim[1] who gives a classification of the forms which they assume under different conditions. His work, naturally enough, is concerned rather with their occurrence and effects in mountain regions, and especially such rugged regions as the Alps, the scene of most of his observations. Howe[2] in his monograph on the San Juan landslides includes a broad study of the phenomena, adopting the general conclusions of Heim with some modifications, but giving more explicit reference to the kinds of disturbances that are under present consideration; his treatment is probably the best that the subject has received in recent years.

The observations upon which this paper is based relate mostly to the Hudson valley and are such as have been recently collected by the writer, supplemented by published data of an earlier date. The valley is typical for the well-opened glaciated valleys of the northeastern part of the country, most of which were flooded during the period of ice retreat. In the waters which reached well up the slopes of the rock-walled valley were deposited clays, sands and fine gravels in sorted beds of considerable thickness. With later

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[1] Ueber Bergstürze (Zurich, 1882).

[2] Landslides in the San Juan Mountains, Colorado. U. S. Geol. Surv. Professional paper 67 (Washington 1909)

subsidence of the waters the beds were exposed as a smooth plain, now dissected by the river and its tributaries so as to give the appearance of an interrupted series of flat-topped ridges whose level sky line marks the general terraced attitude.

Forms of Landslides in Loose Sediments

Displacements of bedded clays and sands often occur on small gradients. The materials as a whole possess less stability under varying conditions of moisture content and climate than the unsorted heterogeneous accumulations of rock weathering that are commonly involved in slides in mountain regions. Their forms are correspondingly varied and complex, in some instances embodying very puzzling mechanical features. The gravity stress which is the fundamental cause of dislocation may be transmitted long distances through the medium of a practically fluid stratum below the zone of rupture, as has not infrequently happened in the Hudson valley. Unlike the usual condition in mountain forms, there need be no essential variations in the character of the material displaced and the undisturbed beds. Any structural change that could be of significance in the formation of such slides in the very nature of the case is scarcely to be looked for, and the same is true also with respect to a slipping surface.

The conditions attendant upon the disturbances are generally determinable by observation or by testing the ground in the vicinity, from which some conclusion may be drawn as to the causes leading up to the slides. The exact impetus or proximate cause, however, can seldom be ascertained. Usually several factors must be taken into consideration in determining the origin of individual slides and their relative importance is difficult to estimate. The matter may be further complicated by the entrance of some external influence into the situation either of natural development or arising from the agency of man.

Of the conditions which govern the form taken by the movement, those of more immediate moment are the nature of the beds, that is, whether clay, sand or mixture of the two; the moisture content; and the surface contour. The forms that have come under observation in the Hudson valley are as follows:

1 Surface creep; involving soil, sand and gravel, little active in clays.

2 Slumping and flows; peculiar to clays and silts that have been rendered mobile by water.

3 Earth slides; materials of any sort, but not fluent; the movement takes place on the face of slopes that are fairly steep and is accomplished in one stage.

4 Subsidence of surface through squeezing out of a wet clay substratum on the plane of its bed.

5 Subsidence of surface from unbalanced pressure upon confined liquid substratum, leading to a reciprocal upward movement at a distance.

The forms named in the first three classes are well known and are mentioned by Howe in his classification of landslides under the division " Movements of detritus." The last two, however, do not seem to have come under general observation, at least they have not been specifically referred to in the more important treatises on landslides. The forms mentioned by Howe under " Movements of detritus " are: soil or earth slips; earth slides or soil slips; mud flows; talus slumps; and submarine flows. Of his last two classes there seem to be no equivalents in the region under discussion, although it is not unlikely that submarine flows may occur, inasmuch as the delta clays extend below tidewater in many places under conditions which make their occurrence possible.

1 **Surface creep.** Creep is the gradual downward movement of materials on slopes under the influence of gravity aided more or less by climatic conditions. It is the commonest of all forms in unconsolidated beds; that is its occurrence is to be inferred from effects frequently observed in the beds, although its progress is too slow to be followed step by step. It takes place in gravels and sands on light slopes, but not to the same extent in plastic clays which, through their coherence and tenacity, are quite resistant to its influence under ordinary conditions. Creeping operates especially in the spring, just as the frost leaves the ground; it is most effective at the surface, decreasing rapidly toward the interior where frictional resistance at a greater or lesser depth overcomes the influence of gravity. The action of frost is upon the moisture held in the pores, causing an expansion which forces the particles apart so that the body of material as a whole is enlarged. The surface in consequence is lifted or heaved, a movement that is translated into a downward one, on a slope as soon as the frost bond is dissolved. Moisture alone acts in a somewhat similar manner.

Clay beds are affected by creep only in their passage from a dry state to one of wetness. When thoroughly wet they give rise to other forms of movement, particularly slumps and flows.

The influence of creep is diminished by sod, as the interwoven root fibers give coherence to the superficial layer of soil and earth where the tendency to creep is greatest. There are no peculiar features in its workings in the region under discussion, and the subject need not be further treated at this time. A very comprehensive description of the phenomena of creep has been given by Kerr,[1] whose paper does not appear to have been generally noticed by geologists.

2 **Slumping and flows.** These are peculiar to clay beds and silts which are wet or saturated with water. They are superficial in their extent, seldom reaching more than a few feet below the soil, the depth varying with the nature of the materials, angle of slope, rainfall etc.

Slumping is a word rather loosely used for sudden movements of earthy materials on slopes, whether in the nature of flows or slides. It is here applied more strictly to the local disturbance or downward movement of clayey materials more rapid than creep, but not of such volume or continuity as involved by flow. It does not require so much moisture as the latter, but takes place when the clay is in a weakened though not thoroughly mobile state. It proceeds more slowly than flow and is apt to be intermittent, ceasing with the hardening of the clay to resume motion again when the latter has been softened once more by moisture. Its effect upon a clay bank is to produce a lunate scar that lengthens downward with progress, the resultant gradient of the exposed beds being steeper than that of the original slope. The displaced clay gathers in a formless mass at the base where it may give rise temporarily to a reversed slope, thus enclosing a longitudinal depression in which the drainage is imponded.

Slumping may be observed in almost every clay bank of the Hudson valley. It becomes a troublesome feature when buildings are placed on clays without any provision for its control, as has often been done. In the city of Albany a few years since a whole row of houses had to be abandoned and dismantled on account of the subsidence of a bank of clay bordering a ravine. The movement was not extensive or continuous, but renewed itself from time to time. Sod is a deterrent, but not preventive of slumping, and in time it leads to the rupture of the sod through removal of the supporting layer. After the sod is broken and displaced it proceeds more rapidly.

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[1] Frost in Arrangement of Superficial Materials. Am. Jour. Sci. XXI, ser. 3, p. 345. 1881.

The occurrence of slumps is subject to seasonable variation, being most frequent in spring with the melting of the winter snows and the heavy rainfall of the spring months. The same movement may renew itself from year to year if not completed in one period.

Flow refers to movements of wet clay, so mobile as to run with the freedom almost of a liquid. It occurs therefore on slight slopes, or even in a horizontal bed if there is pressure upon an underlying mass to force the clays to spread. The movement is between different layers or parts of the loose sediments, seldom of the latter along a rock surface; flows on a bed of rock have never been recorded in the Hudson valley so far as the writer has been able to ascertain, and apparently they are rare elsewhere in the glaciated region.

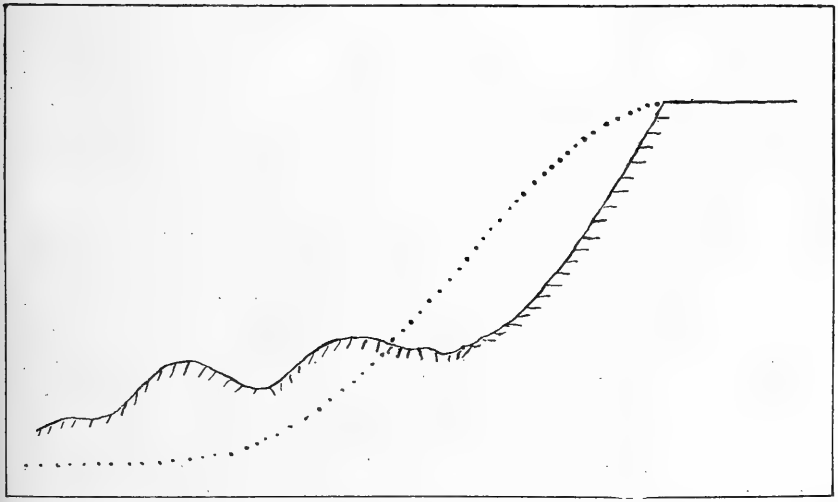

Fig. 1 Effects of slumping in bank of clay and sand

In the Hudson valley flows are restricted practically to the surfaces of the clay terraces fronting the river and may be considered simply an accelerated phase of slumping. They are relatively small. On top of the terraces where movements of larger volume might be expected, the surface clays are firm and coherent, so much so that they do not readily soften in the presence of water. The movements then take the forms referred to under classes 4 and 5.

Extraordinary examples of flow have been described from the St Lawrence valley where the bottom is floored by the silty Leda clay, which shows a marked tendency to movements of this kind on account of its ready absorption of water and its high degree of mobility when thoroughly soaked. They are perhaps the best illustrations of flow on small gradients that have yet come to notice. The flow of May 7, 1888, on the Rivière Blanche, near the village of St Casimir, Quebec, is described by Chalmers[1] as having had a length of 1050 yards and an extreme width of 600 yards, yet the descent of the bed for the whole distance was only 27 feet or only 10 inches in 100 feet. The volume of the disturbed clay was estimated by G. M. Dawson[2] at 93,654,000 cubic feet. An occurrence at St Alban in the same vicinity, on April 27, 1894, is described by Monsigneur Laflamme,[3] who placed the volume of the flow at from 600 to 700 millions of cubic feet. In the disturbance that took place on the Lièvre river, October 11, 1903, according to Ells,[4] the saturated mobile clay was not the surface layer but a bed lying some 20 feet deep into which the water penetrated from below, and the surface materials floated on this moving mass which found an outlet on the extension of its bed. The occurrence had thus points of similarity with the slides described under class 4. Other extensive slides in this region are on record or evidenced by present conditions, the first published description of them having been given by Sir William Logan.[5]

In flows of very fluid materials like the Leda clay it is not necessary that the bed or slipping surface have any pronounced slope, so long as there is a favoring surface contour. The initial stress may come from a preponderance of weight on one part of a buried horizontal layer compared with the weight exerted at another point, the stress thus set up causing a general movement of the whole mass toward the unweighted ground. If the surface layer is coherent and does not follow the motion of the lower bed but subsides in place, the slide takes on the character described under class 4 or 5.

3 **Earth slides.** These refer to disturbances of earthy materials in a nonfluid state, such as take place on a relatively high slope and resemble earth avalanches in mountain regions. They arise in

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1 Report on the Geology of the Three Rivers Map Sheet. Geol. Surv. Can. Ann. Rep't. v. 11, p. 62 J. 1900.

2 Remarkable Landslip in Portneuf County, Quebec. Geol. Soc. Ann. Bul. 10, p. 487. 1899–1900.

3 Trans. Roy. Soc. Can., v. 12, pt 4, p. 63. 1894.

4 The Recent Landslide on the Lièvre River, P. Q., Geol. Surv. Can. Ann. Rep't, v. 15, p. 136 A. 1906.

5 Proceed. Geol. Soc. London, v. 3, p. 767.

various ways but have a common cause, the oversteepening of the slope under the conditions existing at the time. This oversteepening may come about by undermining of the base through artificial or natural means, by a local softening of the mass near the base, and by the development of vertical cracks and fissures in beds of clay which weaken their structure. Some external impulse, like the jar from an earthquake or a heavy explosion, may serve to start the movement, but such impulse is not essential.

Slides of bedded clays possess some features not shared by those of other soft materials. One feature is their marked tendency to hold together and move *en masse,* which arises from their natural tenacity when dry. The dislocations consequently occur in blocks which may be of large size and develop tremendous momentum in their course down a slope. Examples of this feature are illustrated by several damaging slides that have taken place in the vicinity of Troy, where the terraced clay beds rise steeply to a level 200 feet or more above the main section of the city. Portions of the upper beds, with some surface gravels and sands, break away from the face of the terrace and slide down the slope, sweeping outward toward the river with overwhelming violence. Particulars of these disastrous disturbances are given on a later page.

As the cause of earth slides, undermining by stream erosion may be inferred to be commonly effective in such a region as the Hudson valley; its operation scarcely requires explanation. The same may be said of undermining by the hand of man which has been responsible for disastrous slides in clay banks. One such occurred a few years since in a clay pit at Haverstraw, causing the demolition of several houses and the loss of many lives.

A condition of temporary instability or oversteepening in a bank may result from the infiltration of water into the lower beds, thereby diminishing their strength and ability to sustain their load. This infiltration may take place in a horizontal direction through the presence of sandy layers which overlap on a sloping rock surface. It is probable that some of the Troy slides have been caused in this way, for they seem to have been accompanied in certain cases by more or less wet clay, the horizon of which is indicated by a shelflike projection left on the face of the cliff above the base.

Clay beds in drying out after heavy rains or melting of the winter frost are apt to develop cracks which on the edge of a decided slope may so weaken the structure as to lead to their dislodgement. Subsequent rains which cause the filling of the joints by water may facilitate the movement through the hydrostatic pressure exerted upon the jointed blocks. Small slides thus produced have been observed in actual progress by the writer on the face of a new-formed bank, where the beds had been left in a jointed condition. Mather[1] attributes the formation of the slide at Troy on January 1, 1837, to the opening of a fissure at the top of the bank into which surface waters found access, thus producing a pressure at the back of the mass sufficient to dislodge it.

4 **Subsidence from squeezing out of wet substratum.** The distinctive feature of this type of disturbance as compared with those already described is in the combination of a vertical movement or subsidence at the surface and a lateral flowage in the underlying substratum. The latter, rendered mobile by saturation

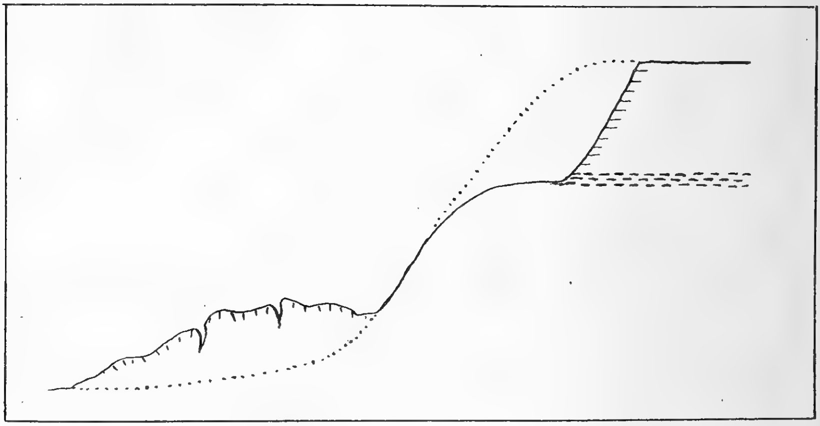


Fig. 2 Earth slide caused by soft layers between firmer beds

with water, finds escape along the plane of its bed by extrusion on the face of a slope or bank where it outcrops. On the other hand, if the saturated layer lies below the lowest point of the neighboring depression, the conditions are favorable for the occurrence of slides of the next class.

In subsidences of this kind the surface materials have to be sharply differentiated from the underlying clay stratum in their capacity for flowage. The former behave as a relatively firm coherent layer which by its weight exerts a compressive strain upon the mobile mass, squeezing this out in a horizontal direction. As the clay escapes by extrusion, the upper layer sinks down along one or more fracture lines just as in the faulting of rocks. The

1 Geology of New York. Pt 1, The First Geological District, p. 33-34.

examples of such subsidence are often remarkable in their diagrammatic resemblance to crustal displacements, a feature exemplified, for instance, in plate 2, which shows the effects of a landslide that was uncovered in the excavation for the present State Capitol at Albany.

The drag of the lower layer may suffice to displace the surface blocks more or less horizontally, but if the overlying beds are tenacious, the main component of movement will be vertical. The necessary conditions for the occurrence of slides of this type are supplied in the Hudson valley; the weathered clays, which are up to 40 feet thick, are relatively impervious to water, and tough, whereas the underlying unweathered blue clay often takes up water to change into a thin, slippery mass that flows under compressive strain. Just what change is brought about by weathering

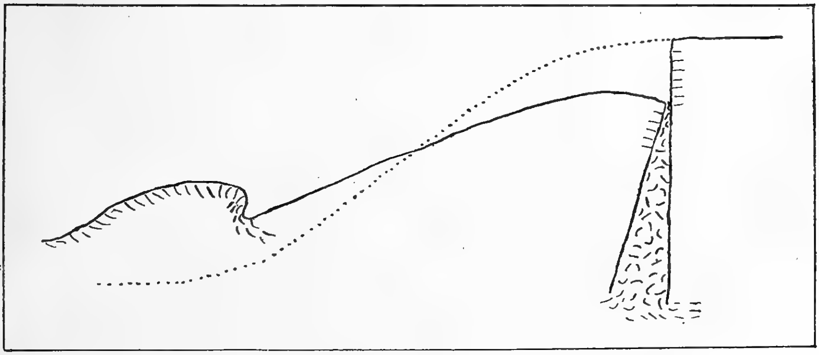


Fig. 3 Clay block displaced by subsurface flowage

to cause this difference in behavior of the clay is not yet apparent, but there is no doubt of the existence of such variations as shown by frequent instances of slides involving these precise conditions.

If the surface beds are essentially the same as the lower stratum they will settle down or "melt" into the latter, and the slip will become a flow of the kind described in the previous class.

The source of ground water which produces the zone of saturation does not come directly from the surface; rather it is to be looked for in a horizontal seepage along the bedding planes, since plastic clays are almost impermeable to the circulation of water. The sand partings invariably present in clays laid down in standing water provide the necessary channels for the horizontal movement of water that may be admitted along the edges of the strata where these overlap on a rock slope. The partings may be exceedingly thin, even of capillary size, but they afford the only means for the admission of moisture into the lower beds of a thick series of clays.

5 **Subsidence from unbalanced pressure on confined liquid substratum.** The mechanism of the movements in this case are of considerable complexity, and so far as can be ascertained, the only examples of the kind that have been recognized are from the Hudson valley where they are not uncommon but seem to have escaped general attention. The subsidences are a variation of the preceding type, but as the wet layer lies too deep to find escape on the plane of its bed, it compensates the unbalanced pressure by raising the bottom of the nearest depression or wherever the structure of the overlying beds is weakest. An outflow of liquid clay may occur from under the upraised block as a secondary phenomenon of the disturbance.

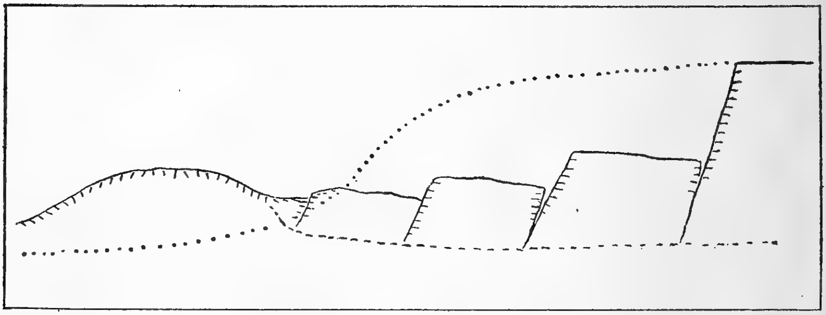


Fig 4 Subsidence arising from subsurface flowage, with compensating uplift of lower ground. A type common in the Hudson valley.

There is some similarity between the type and that of rock slides produced by artificial excavations which leave an unbalanced load upon an incompetent layer, as illustrated by certain occurrences in the Culebra cut of the Panama canal. These slides, according to D. F. McDonald,[1] are characteristic of rocks possessing low crushing strength, but high tensile strength. The load produces a downward-outward-upward movement somewhat analogous to that in the present case. But fundamentally there is a wide difference in the conditions, as the clay slides involve an upper rigid layer, the compressing medium, and a substratum that behaves practically as a fluid in transmitting the pressure; the adjustment takes place

[1] Excavation Deformations. Compte-Rendu Cong. Geol. International XII Session, p. 781. 1914.

between parts of the upper layer which lie at different levels and thus out of balance.

The physical variation of the beds, which is a necessary condition in such disturbances, is probably not a very common feature among clays although it seems prevalent over the Hudson valley within the area covered by the sediments of former Lake Albany. Similarity of absorptive powers and of tenacity between the upper and lower beds removes the possibility of the formation of slides of this kind.

There is little doubt that there have been many occurrences of such slides, and they are not at all the exceptional types which might be inferred from the little notice that has been taken of them. The writer personally has observed two occurrences, one at Stockport in 1908 and the other last year at Hudson. Only one previous record has been made, that by W. B. Dwight who in 1866 gave a description of a slide at Coxsackie, presenting sufficient details to show its relations beyond peradventure. A rather vague allusion to an occurrence of the same character is made by Mather in his Geology of the First District. No doubt many have escaped attention, or have been considered as simple cases of subsidence.

Geological and Engineering Aspects of the Landslides

The influence of the various gravity movements described as a factor in degradation is difficult to estimate, but none the less it has considerable importance within an area like the Hudson valley. There is good reason to believe that locally the work thus accomplished may predominate over that of all other leveling processes, notwithstanding the supposedly rapid erosive action to which soft sediments are exposed. As a matter of fact, erosion may be quite stagnant on a surface that is protected by sod and vegetation: and it is only when the earthy materials are directly exposed by rupture of the protecting cover that they are appreciably degraded by the runoff.

The full effects of such disturbances are likely to escape notice; for it is only the more extensive ones that manifest themselves on casual inspection, and they are the exception of course. The inconspicuous forms — too slow or too interrupted in their movements to attract attention — are responsible for the largest share of leveling, since they are widely active with cumulative effect. Of large-scale catastrophic slides, some ten or twelve are on record as having taken place in the middle Hudson valley within the last seventy-five years. The larger ones have involved upwards of 100,000 cubic yards of earth.

The study of the phenomena has a very practical side. Their range of occurrence coincides with the fertile, thickly populated districts, where they are often of serious consequence in regard to building foundations. There is need of exercising due precaution in selecting the sites for heavy structures, and also providing for their security, if they are to be placed upon earth. Ordinarily it is not a difficult matter to test the conditions that exist in any particular plot of ground, but the interpretation of the evidences requires the consideration of many factors which are not readily apparent. The changes of contour likely to occur through the hand of man and the influence of possible climatic variations particularly must be taken into account.

In nearly all cases the primary cause of earth dislocations may be ascribed to the presence of water in some portion of the beds. Consequently it may be possible to control their occurrence, if proper provision can be taken to regulate the flow of groundwater. The superfiscial phases of disturbance, like slumping, creep and flow, naturally, are the least difficult to deal with; while those involving a deeper source of instability present a more serious problem, to be solved, if at all, on the basis of a thorough investigation of the local conditions.

Characters of the Hudson Valley Clays and Their Associates

The clays of the Hudson valley consist of horizontal beds which for the most part were laid down in the expanded waters that occupied the valley in late Pleistocene time, and that are known as Lake Albany. They have a vertical range of over 300 feet, of which the lower part extends below sea level, but it is only in the immediate vicinity of the river that they reach a thickness of much over 100 feet. They are remarkably uniform and seldom are interrupted by any considerable intercalations of other materials, although there occur all through the beds minute, often paper-thin partings of fine sand which lend the bedded appearance always apparent when the clays are seen in cross section. These sand partings mark original fluctuations of sedimentation, but just what significance they may have with regard to time periods, if any, is not known. A discussion of this feature, as well as of the conditions under which the clays were probably deposited, will be found in Woodworth's "Ancient Water Levels of the Champlain and Hudson

Plate 1

Landslide topography in Lake Albany beds, showing large opening left by an old slide, Mt Ida, Troy.

Valleys."[1] The sand partings, as is observed elsewhere, have a bearing upon the formation of some landslips.

The clays are of fat, plastic nature and of bluish color except in the upper beds, which have a brownish yellow tint from the oxidation of the contained iron under weathering influences. The division between the yellow and blue clay is sharp but not constant as to depth, being in some places a few feet from the surface and in others 30 or 40 feet; it is sometimes marked by the occurrence at this level of "clay-dogs" or calcareous concretions formed by the leaching of the upper layers. The blue and yellow clays are not very different in their chemical or physical properties, but the former is usually a little higher in silica and alumina and lower in the alkalis and alkaline earths than the latter, as it is also somewhat less plastic. Both are extensively employed in the making of brick, in the molding of which they require from 25 to 30 per cent of water to develop the proper degree of plasticity.

The composition of the clays is indicated by the following analyses of samples from the vicinity of Albany:

	1	2
SiO_2	59.68	56.08
Al_2O_3	14.16	15.36
Fe_2O_3	1.76	5.22
TiO_2	.90	.90
CaO	6.68	7.20
MgO	4.84	2.76
K_2O	2.75	3.19
Na_2O	.40	1.47
Moisture	.65	1.16
Ignition	7.75	7.90
	99.57	101.24

Texturally, the clays are fine and soft, as the sand admixture which arises from the clay partings is small in amount. A sample from the recent landslip at Hudson showed 10.5 per cent of sand and silt, the particles of which were all less than .1 mm in diameter. The same clay after drying in the air bath absorbed 30.8 per cent of water by weight before crumbling or slacking began, thereby attaining the proper consistency for molding. Plasticity disappeared with the addition of 50 per cent of water, when the clay became slightly fluent in the mass and no longer would hold its form. With 75 per cent of water it was semifluid, slippery,

[1] N. Y. State Mus. Bul. 84, p. 175 et seq. 1905.

scarcely to be retained in the hand, similar to its condition observed in natural flows.

The clays rest upon an uneven rock surface with an intervening bed of gravel or till that was deposited by the Pleistocene ice sheet before Lake Albany came into existence.

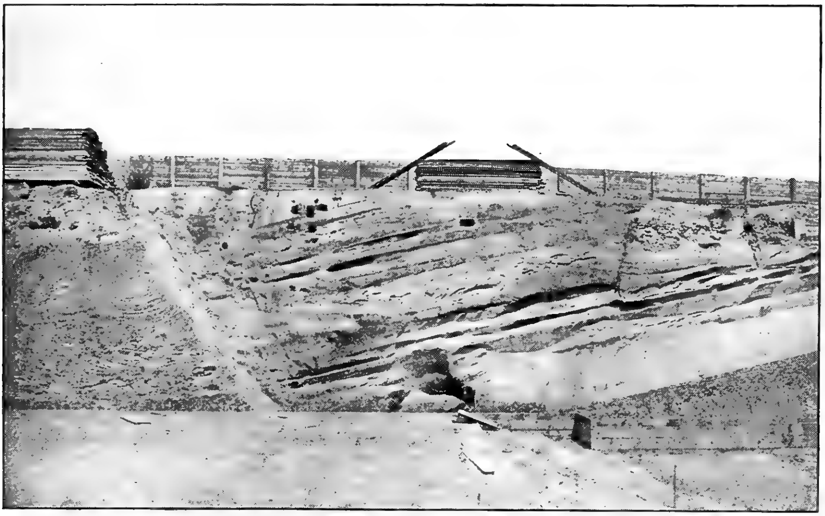
In some places the deposit is hard bowlder clay or ground moraine, but more commonly perhaps it consists of gravels and sands in imperfectly sorted conditions evidently laid down in front of the ice by the waters issuing from it. These morainal gravels and sands thicken wherever the glacier halted for any length of time in its retreat and in North Albany they rise up into a prominent ridge which overtops the adjacent banks of clay, evidently marking a rather long interruption in the general withdrawal of the ice northward. The Albany gravels have been considered by some geologists as later than the clays, but their relations appear to confirm rather the view here given, which is that adopted by Woodworth in the work already cited.

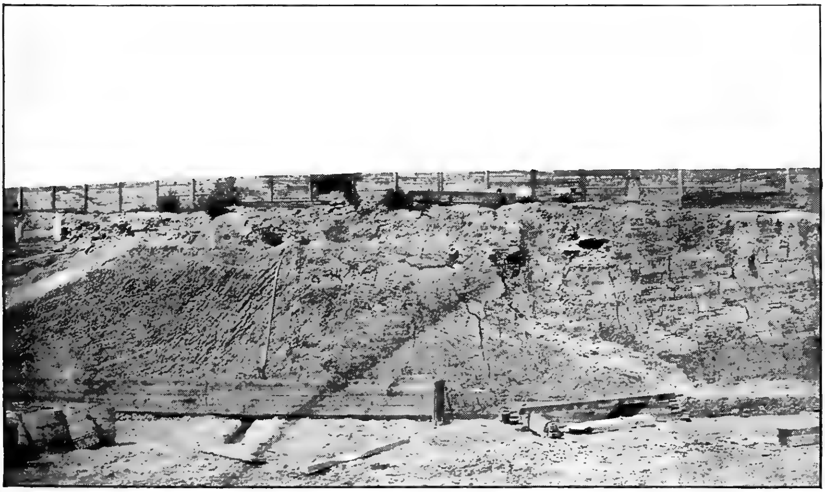
Above, the clays are succeeded by a layer of sand which extends to the surface. The layer was the last of the Lake Albany deposits and originally formed a continuous sheet over the whole area. It is now very unequally distributed as the result of erosion by the winds chiefly, which have heaped it up in dunes wherever the bed has not been protected by vegetation. Wind action is evidenced also in the well-sorted texture of much of the sand. The general run of the material is fine, some of it almost as fine as loess. In fact, the sand over considerable areas bears a striking similarity to some deposits of loess, except for the fact that it has an argillaceous bond instead of a calcareous one. The argillaceous sands are extensively shipped from the district for foundry use.

Conformation of the Rock Surface

The Hudson valley, in the section covered by the stratified clays and sands which mark the bed of the former Lake Albany, consists of an outer well-opened part with smoothly contoured sides of gentle slope and an inner gorge that is defined by much steeper rock walls. The gorge is one to three miles wide and in the stretch below Albany is bottomed well below sea level, the present river flowing over glacial and alluvial deposits well above the rock channel. The rocks, however, come to the surface near Albany, and from Troy north the gorge is above the reach of tidewater.

Plate 2





Faulted and contorted beds at Albany. Cross-bedded eolian sands are shown downfaulted, so as to abut against disturbed clays. The lower view represents the continuation of the beds to the right of the section in the upper one.

The rock under the valley is almost wholly shale, from Trenton to Lorraine in age, the so-called Hudson river formation, but outliers of Siluric limestones occur here and there, remnants of a once continuous mantle which is now all but destroyed by erosion. The shales are upturned at a high angle and have a northerly to northeasterly strike to which the course of the river approximately conforms.

The valley, it is apparent from several considerations that need not be set forth here, was marked out and largely formed as early as Tertiary time. The gorge represents a stage of erosion during a period of renewed uplift which accentuated the cutting power of the streams.

The rim of the gorge lies at about 200 feet above tide for the most part, but varies somewhat from place to place. It is defined rather sharply by a bench or terrace at the line of intersection with the outer valley which has a very gradual rise toward the bounding hills. The gorge is breached by old tributary channels now in part masked by morainal and water-laid beds. A large channel that may have carried the preglacial Mohawk lies under the site of Albany as indicated by the rock contours revealed in test holes that have been put down through the unconsolidated sediments. The soundings have shown that the clays here rest upon morainal gravels and sands, the bottom of which for some distance back from the river is below sea level. The Mohawk channel, if it does mark the ancient course of that stream, enters the gorge nearly at grade, and the same is probably true of the Stockport channel above Hudson, as well as of other streams; the indications therefore point to a long period for the gorge cutting during which the tributaries were able to adjust themselves to the lowering of the main channel. Glacial erosion was of minor importance in the formation of this part of the valley.

One feature, however, that may be ascribed to the ice or to the work of subglacial streams is the deep furrowing of the shales whereby their surface in many places shows a succession of longitudinal troughs between parallel ridges or hummocks. The bed of the gorge, especially, appears to be of this uneven character. A single ridge does not continue for any great distance but as it dies out through gradual decrease of height and contraction laterally, it is succeeded by another on either side of its axis. Soundings in the section about Albany indicate there is a great variation in the size and distribution of the ridges and hollows.

The inequalities seldom show at the surface owing to the concealing mantle of morainal and alluvial materials; the tops of the ridges may be seen occasionally to rise a few feet above the general level, disappearing again with a slope that is more rapid to the east and west than north and south on the line of their axes.

Present Topography

The clays and sands within the valley have a distinctly terraced form when the beds are viewed from a point near the river or when their bounds are traced on a topographic map. The original flat contours, a sequence of their disposition in open waters, have been modified more or less by wind and stream erosion, which has been particularly effective upon the soft, fine Lake Albany sediments; yet the terraced arrangement is still well shown, indeed lends the most characteristic feature to the topography along the river north of the Highlands.

The terraces front the river as a series of bluffs and sloping banks, that are dissected here and there by lateral stream channels. They are present, though not developed evenly throughout, as far as Fort Edward, near the junction with the Champlain valley which begins across a low divide just north of that place. Similar terraces occur in the Champlain valley, and it is considered probable by Woodworth that the waters of the two basins were confluent during a part of the period when the sediments were laid down.

In altitude, the terraces fronting the river range from 40 or 50 feet up to 200 feet. The lower elevations mark those formed as outwash plains and lateral moraines while the ice was still present in the valley. They are to be seen in the section in the Highlands southward, beyond the limits of the clay terraces of Lake Albany which extended only as far south as Kingston. The Lake Albany terraces where they front the river have their upper surfaces mostly at 150 or 200 feet above tidewater, rising slightly above the top of the rock gorge and thence extending outward over the valley floor. In the widened section of the lake near Albany the terraced beds extend back to Schenectady where they lie at an elevation of about 400 feet, and well-marked flats at that altitude are found west of Round lake, which seem to belong to the same series of deposits. These higher levels are floored with fine sands, whereas the clay does not appear to reach above 250 feet and is mainly below the 200 feet contour.

The fine sands that mantle the clays have been worked over and redistributed by the winds, as stated in a previous paragraph, so that they are now unequally distributed, forming dunes 40 or 50 feet high in places and very thin or absent in other sections. Their contact with the clays normally shows no interruption in the succession, but in one or two localities has been found to evidence a marked unconformity as the result of erosion. This relation seems best explained by an interval of erosion after the beds were exposed to the air and had been temporarily denuded of the protecting sands, following which they were again covered by wind deposits.

The beds are trenched to various depths by lateral streams which head in the ranges of hills on either side of the valley and by a network of streamlets which have their sources within the lower lands. A few powerful tributaries like the Mohawk and Hoosic carry drainage from far beyond the valley confines.

The contours along the river are rather sharp where the beds are dissected almost to their base and show no marked change of slope to the top of the terraces. The actual gradient may reach 35 or 40 degrees. This seems a high angle for such soft materials in a region of fairly heavy rainfall, and is traceable to the effects of landslides in continuously renewing the slope as the rains remove the waste which has been brought down by previous slides. In the interior the contours are less abrupt, the cross valleys for the most part being shallow except where they mark a preglacial drainage line. In the latter case their bottoms lie well below the terraces and there is a steep rise to the level of the latter. The Mohawk is exceptional among the larger streams in that it occupies a postglacial rock channel from its outlet at Cohoes to Schenectady, and falls with the Hudson gorge in a series of cataracts. The clays along its course consequently are thin.

Observations on the Hudson Valley Slides

Troy. Many evidences of slides are met with in the clay bluffs that front the river in Troy and the stretch south of there to Rensselaer. In fact, scarcely any of the banks in that section have slopes that are the result of erosion directly; their steep gradients, concavities and talus accumulations show the influence of creep or flow and of occasional large slides.

One of the earlier records of an extensive disturbance of the kind relates to a slide that took place in Troy January 1, 1837. Mather, in his report on the geology of the first district,[1] gives a rather circumstantial account of it which reveals some interesting

[1] Albany, 1843, p. 37–38.

features. The place where the disturbance occurred, he states, was a nearly vertical bank of clay and gravel 237 feet high. "The upper part of the cliff probably cracked, and the land spring . . . filled the fissure, rendered the clay slippery and acting by its great hydrostatic pressure, burst off the cliff, which tumbled in huge fragments, sliding along as a mass of ruins, carrying everything before it. The avalanche, after reaching level ground, slid onwards about 800 feet, crossed one street, and stopped at the second, crushing three houses and two barns and destroyed the lives of several persons, who were buried beneath the materials. The avalanche was accompanied by torrents of mud and water, rushing with a roaring noise over the fallen ruins. The fragments of the cliff form a very uneven surface of small irregular hills; the masses of clay are in huge fragments, with their layers placed at every angle of inclination and in every direction, and cover a surface about equivalent to 200 yards in length by 100 in breadth, and from 10 to 40 feet deep. By a moderate estimate 200,000 tons of earth were thus transported to a distance of 200 yards." The local details which Mather includes in his description point to the site of the slide as being on the west slope of Prospect Park in the southern part of the City. The occurrence apparently belonged rather to the mass slides than to the flow type, the mud and water being an accompaniment of the earth fall.

The next important slide was in 1843 (February 17th) and seems to have been the most destructive of all that are a matter of record. The only descriptions available, apparently, are to be found in the contemporary items of the local press which give few details as to the nature of the disturbance. It is said to have comprised a section of Mt Ida east of Fifth street and to have passed down Washington street to Hill street which it crossed. It moved about 500 feet on the level beyond the base of the hill. Many houses were demolished; and 15 people were killed, either entombed within their homes, or overwhelmed in the streets while attempting to flee the onrushing mass. The work of rescue and of recovering the dead went on for a whole week. In 1859 St Peters College, which was in course of construction near the base of Mt Ida at the head of Washington street, was destroyed by an earth slide. The Troy Times of March 18th states that the disaster occurred about 8 p. m., March 17th, the mass of earth advancing with little noise until it reached the near wall of the college which checked its progress momentarily, but gathering new energy it burst through with a rush and heavy report and demolished the edifice. The presence of the building at this point seems to have prevented the slide from continuing down the slope with its first force, so that the many houses and a hospital in its path escaped destruction. The noise from the disturbance was heard over the whole city. This again seems to have been a slide of earth in more or less coherent condition and not a flow.

Albany. The terraces on which Albany is built have a rather gentle slope toward the river in contrast with those on the east bank. Few large slides have taken place within recent times, but minor disturbances are common and have to be reckoned with in building and engineering operations. In some of the older sections the walls of buildings show a general settlement of the ground in one direction which is perhaps referable to creep.

The geological conditions in this vicinity are rather unusual, as has been already noted. The rock walls of the Hudson gorge are exposed north and south of the city in the first rise of ground, but under Albany itself there appears to be a broad embayment opening into the gorge at grade and extending west below the terrace of Capitol hill. Its presence is concealed by morainal gravels and bedded clays, and is inferred from test borings which have been carried down to rock. How far this depression may extend to the west has not been determined. It seems most likely to mark the mouth of some preglacial stream channel and if so it is probably the old outlet of the Mohawk now shifted 10 miles to the north.

The great depth of blue clay under Albany is an element of insecurity, accountable for most of the movements of ground that have taken place from time to time. The clay attains a thickness of over 100 feet and its lower part is likely to be wet. It lies upon a thin bed of till, below which is generally found water-saturated sand, 10 feet or so thick. As an example of the general conditions, the following section from the site of the New York Telephone Company's building on State street, below the Capitol, is shown:

Blue clay	103	feet
Clay and gravel (till)	2	"
Fine sand (water bearing)	9.5	"
Medium sand	3.19	"
Hardpan	1.06	"
Bed rock (shale)	....	

The layer of till above the sand acts as a seal to the water which may be under considerable hydraulic head. The basal part of the clay is often wet, probably through infiltration along the bedding from some distant source. This wet layer has the usual mobility of blue clay in that state and consequently tends to squeeze out under pressure whenever there is opportunity for escape. The conditions favorable to movement may develop unexpectedly. In a city where excavations are going on the surface load is changing all the time, so that caution should be exercised in the placing of heavy structures upon the clay, especially if the sites are situated on the edge or sides of the terraces.

By the subsidence of a clay bank on the north side of Elk street, west of Swan street, a few years ago, several houses were rendered uninhabitable. The ground moved downwards along the face of the bank, as the result of a slump at the base. The land has since been converted into a park.

The collapse of the Myers building on Pearl street in 1905 was caused by a giving way of the foundations which rested upon blue clay. The base of the sediments was below water level. Later excavation for foundations of the new structure showed the lower beds of blue clay to be thoroughly saturated.

That extensive movements have taken place in past times in the Albany terraces is indicated by the conditions encountered in the excavations for the present Capitol. Some views of the foundation work are preserved in the State Library, among them being photographs of the banks of clay on the northern and western sides which are of great interest. The bank exhibits evidence of disturbance over a considerable distance, especially in the northwestern section where faulting and plication have taken place on a large scale. One rather remarkable fault may be seen in the accompanying illustration reproduced from one of the photographs referred to. The fault brings the clays in juxtaposition with cross-bedded sands that apparently are an uneroded remnant of an old dune. The throw of the fault, so far as can be judged from the photograph, exceeds 35 feet. The disturbance is of the type produced by flowage of the underlying layer, as described under class 4 in the general discussion. The ground within a short distance of the fault falls away both to the north and east, in the latter direction sloping down to the Hudson which here is little above sea level.

Coxsackie. A subsidence of several acres of the terraced clays near this place, which occurred in 1863, has been described by the Rev. W. B. Dwight,[1] who seems to have first visited the locality

[1] Am. Jour. Sci., 2d ser., p. 12–15. 1866.

Plate 3

H. P. Whitlock, photo

The slide at Stockport, March 6, 1908. View along outer fracture, showing a drop of 40 feet vertically in one block.

a couple of years later when the original marks, no doubt, were more or less erased. However, his account clearly shows that it was a typical case of the adjustment of an unbalanced load on a wet substratum similar to that described as having occurred recently at Hudson.

The scene of the disturbance was on the farm of Casper Flansburgh, 4 miles north of Coxsackie and 2 miles back from the river, along the bank of a small creek which is stated to have occupied a ravine about 75 feet below the terrace level. The time of the occurrence was in March, between 5 p. m. of the 15th and 9 a. m. of the 16th. There was no frost in the ground. The more important features are thus set forth in the original account:

The mass of earth consisting of the slope of the west bank and a part of the summit level, broke off sharply and perpendicularly across the top of the bank about 30 or 40 feet back from the brow; the line of fracture then curved to the east on both sides until it touched the creek, after inclosing a semicircular tract of about 6½ acres. The flexure seems to have been determined by small ravines running toward the creek at right angles to its course.

The fragment, which was in fact an enormous wedge of earth, 75 feet thick at the back, being now free, was at once subjected to two different forces; for it was immediately separated into two parts by a chasm opening lengthwise and stretching from end to end (N. and S.), at the distance from the upper edge of about one-third of the whole width of the detached mass. The portion west of this line, consisting of the brow of the hill, and the higher part of the slope, at once sunk, partially throughout its whole extent, but most deeply at its western edge, which rested at a depth of 40 feet below its former position at the terrace level; it probably moved also a few feet to the eastward.

The other fragment also sunk considerably at its thicker end, thus bringing its surface nearer to a level; but it had also a decided sliding movement toward the creek, for the distance of from a foot or two at the southern, to 42 feet at the northern end. This measurement was obtained by ascertaining the variation of a line of stakes, trees and other landmarks, from the original line which was known.

The effect of this double movement upon the ground at the creek was extraordinary; the whole bed of the stream, together with a portion of its borders, was lifted bodily, and left at the top of a long and nearly continuous mound. This mound is from 75 to 150 feet wide at the base, and in most places 30 feet high, thus becoming the highest ground on the eastern section of the slide.

It appears that blue clay came to the surface on the outer edge of the uplifted block. Of the sunken area a large part came down as a mass and was quite unbroken, but on the north and south ends the ground was intersected by fissures, "making the surface to resemble the irregular fragments of a floe of ice left by the tide upon a sloping shore." In regard to the cause of the subsidence, Mr Dwight expresses the following view:

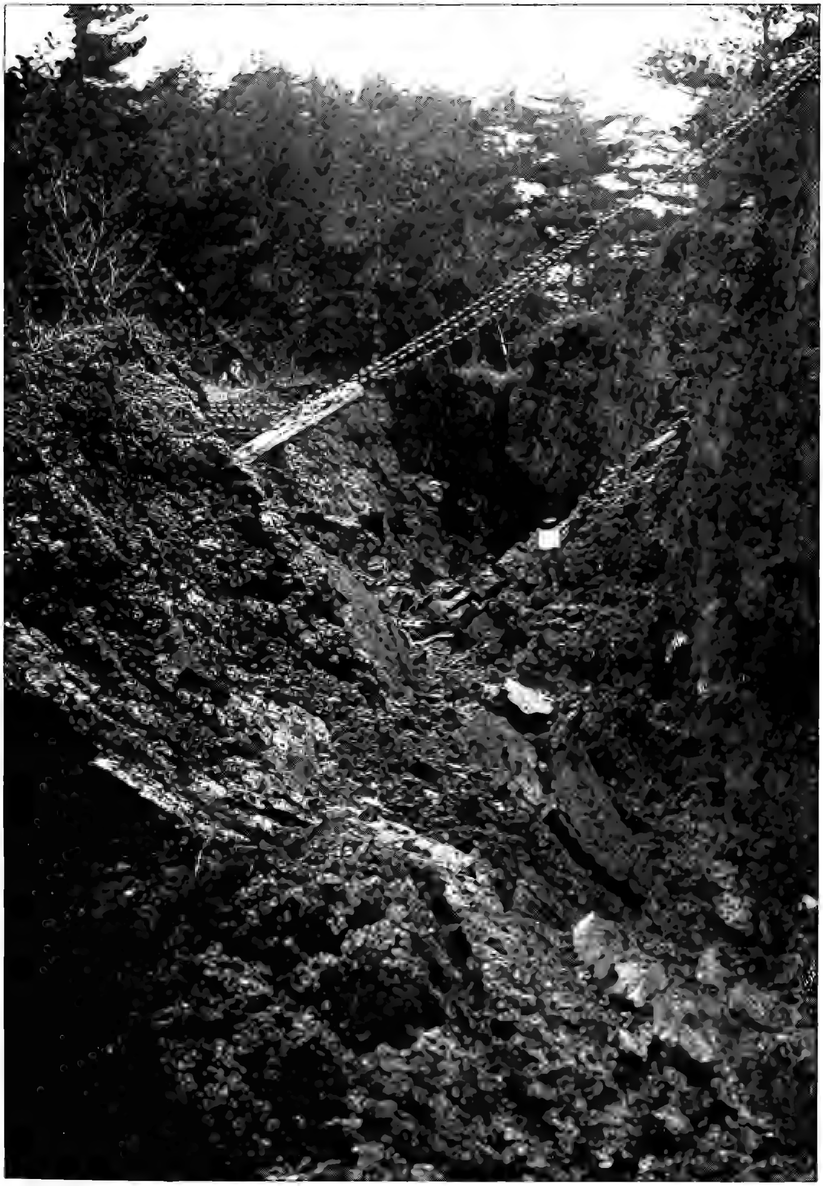
There was then a tongue of land of considerable tenacity, a few feet thick at the lower end, and 75 at the upper, resting upon a very mobile and smooth clay; the erosion of a shallow channel at the creek, afforded a passage for the exit of this clay; and the great and principal force which caused the fracture was, in my judgment, one acting in a perpendicular direction, as shown from the fact, first, that the fracture is a sharp, perpendicular well-defined line, and not the ragged, irregular sloping line usually seen where the soil has been simply drawn down a declivity; second, that immediately after the fracture, the thickest and heaviest portion did sink and forced the blue clay before it, outward, and upward, at the lower levels; its own lateral motion being very small.

Stockport. The occurrence of a landslide near Stockport, Columbia county, on March 6, 1908, was communicated to the State Geologist by Mr C. R. Van de Carr of that place, and the writer was detailed to make an inspection of the conditions which, from the details supplied, appeared to be rather remarkable. An account of the disturbance was published in the Report of the Director of the New York State Museum for 1908, from which the following abbreviated description is taken:

A section of the bank of a small tributary of Stockport creek that empties into the latter opposite Columbiaville, with a vertical elevation of from 60 to 75 feet, forming part of the 100-foot terrace at this point, cracked along two parallel planes about 50 feet apart as a maximum, and the included mass dropped down about 40 feet, measured on the outer fractured plane. This plane had a slope of 80° toward the ravine. Its appearance and the adjacent margin of the faulted block is shown in plate 3. The walls of the second fracture, about half way down the slope, were inclined away from each other owing to the tilt of the sunken block toward the bank and the uplifting of the abutting clay beds in the bottom of the ravine. A gap fully 15 feet wide was thus produced (see plate 4). The uplifted section included the stream bed that in this way was so obstructed as to cause the waters above to form a pool.

The clay beds exposed to view were little broken up by the movement; in fact they behaved much as solid rocks might have

Plate 4



H. P. Whitlock, photo

Stockport slide. Open fissure between the downthrown and upraised blocks. Soft clay in bottom extruded from below.

acted in similar circumstances. The main scarp was clean-cut and the sunken block held together in a body.

The cause of the disturbance was ascribed at the time to the presence of a layer of water-soaked liquid clay which came to the surface in the very lowest part of the ravine and upon which the upper bed rested in a state of delicate equilibrium, ready to be precipitated by some impulse. It was thought this may have been supplied by the weakening of the structure through cracking, as it was noticed that a longitudinal crack had developed along the bank shortly before the disturbance occurred, which was during the night. With increase of pressure upon the liquid layer the latter sought escape at the lowest outlet, whereupon the whole block came down at once. The sudden exertion of pressure upon the liquid layer upraised the beds in the ravine but not to an extent that could be considered proportionate to the volume of the subsidence which was estimated at from 4000 to 5000 cubic yards. An interesting circumstance, of no significance probably with respect to the cause of the disturbance, was the occurrence of a heavy earthquake in Mexico, the vibrations of which reached Albany at 6.10 p. m., the same date.

The vicinity of Stockport bears evidences of having been the scene of numerous slides of the terraced clays. Another section of the same bank is reported to have subsided since the occurrence here described.

Hudson. A disturbance of serious proportions took place August 2, 1915, on the property of the Knickerbocker Portland Cement Co., just outside the city of Hudson. In some features it was the most remarkable of the recorded landslides in the Hudson valley, as it undoubtedly has been the object of more thorough inquiry than any previous disturbance in this section. Although many employees of the company were within the zone of disturbance at the time (shortly before 6 a. m.), few, if any, could give a connected account of the succession of events, so rapid and overwhelming they appeared to the senses. The company immediately instituted an investigation into the causes of the catastrophe, which in addition to large property damage involved the death of five workmen and injuries to many more, most of whom were caught in the wreckage of the power house.[1]

[1] For description of the general effects of the slide, see the Engineering Record, August 7, 1915. An account of the geological and engineering features was published by the same paper in the issue of August 28, 1915.

The disturbed ground consisted of bedded blue and brown clays of the normal Lake Albany type, with sands and silts distributed unevenly over the top. The surface was quite level except for a slight slope toward Claverack creek, and represented part of the terrace flat which here is about 150 feet above tide. The accompanying cross section, prepared by R. W. Jones of the Museum staff, shows the general situation. On the south the clay terrace terminates abruptly against the steep edge of Becraft mountain, an uneroded remnant of Siluric-Devonic limestones, only slightly disturbed, which rest upon the upturned edges of the metamorphosed Hudson river (Ordovicic shales). The limestones and the Pleistocene clays form the basis of the cement mixture. The most marked depression within the area previous to the slip was the trench of Claverack creek, perhaps 7 or 8 feet deep and 50 feet wide, the bank of which was about 120 feet above tidewater. The slope from the base to the main buildings to the creek was 30 to 40 feet in a distance of 300 feet or more, or about 1 in 10, but somewhat irregular.

The clays with the surface silts or sands have a thickness in this part of from 75 to 100 feet. They rest upon morainal gravels of considerable thickness, which in turn lie upon the uneven surface of shale and, on the southern end, of limestone. The glacial gravels or bottom moraine no doubt increase in thickness toward the side of Becraft mountain and tend to smooth out the irregularities of the rock contours.

In its character, the slide was typical of the unbalanced-pressure class in which equilibrium is sought by subsidence of the heavier load and uplift of the lighter, the adjustment taking place through a confined substratum of wet clay. The subsided area included the section between the river and the line of break west of the latter; the break was defined by a nearly vertical bank of the freshly-fractured clays up to 20 feet high. This bank described a broad curve open toward the creek, with its center about 225 feet from the stream channel; it was traceable for a distance of about 1200 feet. The vertical displacement amounted to 25 feet as a maximum, and was greatest in the southern half of the belt, decreasing to the north and also toward the creek. Along the creek itself the conditions were reversed, the channel and the adjoining area to the east being upraised, so that for a distance of 600 feet the former bed was left high and dry and the waters above were ponded back until a new channel could be opened through the clays. The new channels follows a much straighter course, as it cuts off the bends shown on the map.

Plate 5

R. W. Jones, photo

View of part of the subsided area near Hudson. Pile of crushed stone spread out in foreground and wrecked power plant in middle. The line of trees to right of power house marks the former course of Claverack creek, now abandoned.

Plate 6

R. W. Jones, photo

Looking north along main fracture in central part, Hudson slide. The exposed edges of clays and sands formed a vertical wall 20 feet high.

The disturbance came suddenly, without any warning that was sensed by those on the ground so that they could secure their safety, and was over probably in a couple of minutes from its start. Accounts of the eye witnesses are conflicting as to details; but there seems little doubt that the first distinct manifestations of the disturbance were at the creek bed. One of the witnesses whose attention was turned in that direction, saw the waters rise and rush out of the channel in a great flood, of which abundant evidences were to be found for a long time afterward in the leveled appearance of the adjoining fields. So quickly were the waters discharged that fish were stranded on the bottom. The upheaval was accompanied by tremors and settlement of the higher land to the west, the ground rocking as if it were in the throes of an earthquake. The subsidence was effected in blocks or strips, elongated, in a north-south direction, the blocks being uniformly tilted toward the west, probably as the result of the drag of the wet clay below in its flow toward the creek.

With the rupture of the surface clays at the creek by their upthrust of 20 feet or so, a way of escape was opened for the lower fluid layer which under pressure then flowed out onto the flats east of the old channel. The clays exposed in the dry creek bed were turned on edge; they consisted of tough, coherent brown clay little softened by their continuous contact with water. The flowed clay on the other hand was of blue color, very wet and greasy, without the definite lamination that it shows when in place; or else with the lamination much contorted.

It is apparent from the features already set forth that the creek channel constituted a zone of weakness and was one of the essential causes of the disturbances. There was little evidence, however, to indicate material deepening of the channel by erosion just previous to the event, although it was a time of heavy rains and high waters. It was noticed that the clays were

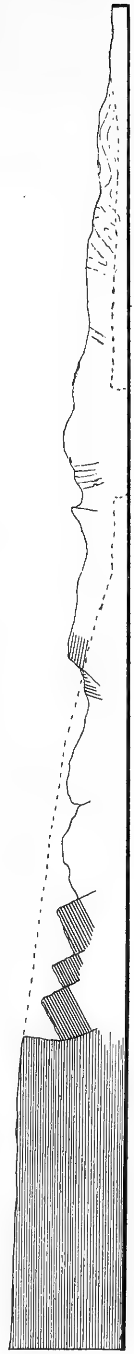


Fig. 5 Subsidence of August 2, 1915, near Hudson. The broken line shows original contour of surface; the depression at right of center marks bed of Claverack Creek which here was upraised by the unbalanced load on the fluid stratum below.

honeycombed with worm borings which hardly would have been the case if they had been subject to any considerable cutting by the stream.

The most important element in determining the character of the slide, no doubt, was the saturated substratum of blue clay. For some distance below the contact with the upper brown clay the blue clay was thoroughly water-soaked, containing upwards of 50 per cent of water, and had become soft and greasy. It behaved under the load of the higher ground exactly as a fluid, transmitting the pressure horizontally and overcoming the resistance offered by the thin crust of brown clay under the creek bed, which it lifted bodily in the air, as already described. Test borings showed that the condition of water saturation varied considerably from place to place, and apparently the supply of water came not so much from surface seepage as from lateral infiltration along the beds. The extreme of wetness was encountered just beyond the northeast point of Becraft mountain in near vicinity to the line of break, and it would appear likely that there was an underground circulation of water from that part of the mountain toward Claverack creek, perhaps following a fissure or a brecciated zone in the limestones.

The period immediately preceding the slide was one of unusually heavy rainfall, the July precipitation, reported by the Albany weather station, amounting to 5.05 inches. The wet zone was doubtless raised above the normal level by the excess of rain, while the thickness of the overlying coherent layer was by so much diminished and the structure thereby weakened.

The coherent brown clay which acted as a load upon the wet substratum measured from 10 to 30 feet thick, increasing toward the higher ground. To its weight should be added the artificial load represented by the buildings and the stock pile of crushed stone, this latter amounting to about 25,000 tons. Altogether, however, the artificial load was a mere fraction of the natural load represented in the upper clay layers and to the writer hardly appears to have been an appreciable factor in the precipitation of the slide.

Newburgh. The existence of early slides in the clay terraces of this vicinity is inferred from the disturbed condition of the beds revealed in some of the banks worked by the brick plants. Mather[1] mentions the occurrence of a fault at a point one-half or three-fourths of a mile below the city on the river shore, made noticeable

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[1] Geology of First District, p. 156. 1843.

Plate 7

R. W. Jones, photo

North end of the upraised section of Claverack creek, adjoining the undisturbed part in which the water stands.

Plate 8

R. W. Jones, photo

Flow of wet blue clay onto flat, east of old creek bed. It was the escape of this substratum along the cut made by Claverack creek that started the slide.

by the occurrence of sand on one side and gravel on the other of a vertical line, and both covered by beds of coarse gravel evidently deposited after the fault had been formed. Features of somewhat similar nature are described by W. B. Dwight[1] as present in the clay beds at Clark's Dock Station 3 miles northeast of Newburgh.

Haverstraw. The brickyards at the north end of the town were the scene of an earth slide on January 8, 1906, that was accountable for extensive damage and the loss of 20 lives. It is one of the few examples of an artificially produced disturbance of catastrophic proportions on record in the Hudson valley. The cause is ascribable to the overdeepening of a cut in terraced clays, the latter belonging to the series of clay beds which front the river in this section but of somewhat different character than those of Lake Albany. The clays had been worked back from the river until the bank, about three-fourths of a mile long, had approached close to one of the village streets. The cut, apparently, was made vertically down into the beds and did not leave any sufficient mass to resist the thrust from the higher ground which had the additional weight of the street and buildings to maintain. Shortly before the slide a crack developed at some distance from the edge of the cut that seems to have been regarded by a few of the dwellers as warning of the impending trouble, for they moved out of the zone of danger. The other inmates of the houses mostly were unable to effect their escape, as the movement began suddenly in the night and, once started, proceeded rapidly until so much earth had slid into the pit that a condition of temporary stability had been attained. Eleven houses altogether toppled over into the pit as the result of the first movement; they were completely wrecked and in many cases set on fire, while the safety of many others was so endangered as to necessitate their abandonment.

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[1] Vassar Bros. Inst. Trans, v. 3, p. 86–95. 1884–85.

ALBANY MOLDING SAND[1]

BY DAVID H. NEWLAND

This paper deals more particularly with the features of molding sand as exhibited in the field. Its scope will be restricted to the description of the deposits in the Albany district, one of the better known sources of sands for general foundry use in the East and in some respects, perhaps, typical as an illustration of their occurrence in this section.

The study of molding sands from the present standpoint does not seem to have engaged much attention heretofore. There are one or two state reports of relatively recent issue, but aside from these little information may be found in regard to the distribution of the resources, their geological association, extent of available supplies and other matters that have direct relation to the productive industry and that in the future may develop critical importance. In view of the wide interest that has been manifest of late in the investigation and appraisal of the supplies of other natural materials that have engineering or technical value, the lack of information upon this subject seems the more striking and prompts the inquiry whether any real incentive for such study has been forthcoming from those who should be mainly concerned — the foundrymen themselves.

General Features of the District

Albany molding sand is the product of a single district, but has a more extended distribution than the name might suggest to one unfamiliar with the conditions. The district includes a stretch of about 100 miles on the meridian and takes in both banks of the Hudson river from near Glens Falls on the north to Kingston on the south. Albany lies near the center of the area, but by itself is not an important factor in the industry, although good sand is found within the city limits.

The deposits occur here and there over the distance mentioned, but usually are restricted to a very narrow section within close proximity of the river. From Kingston to Albany county they do not reach back usually more than a mile or two from either bank. With the expansion of the valley near Albany through the entrance

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[1] This paper was presented before the American Foundrymen's Association, Atlantic City Meeting, 1915.

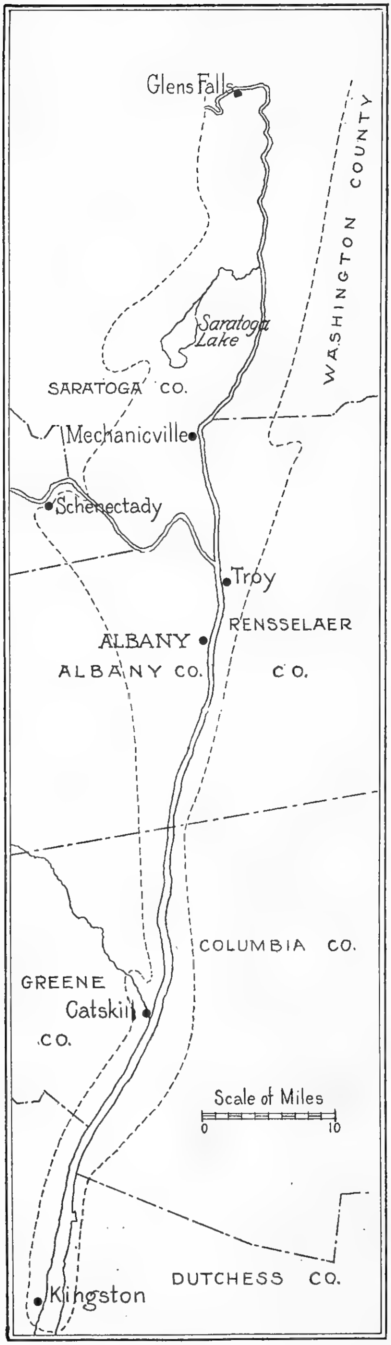


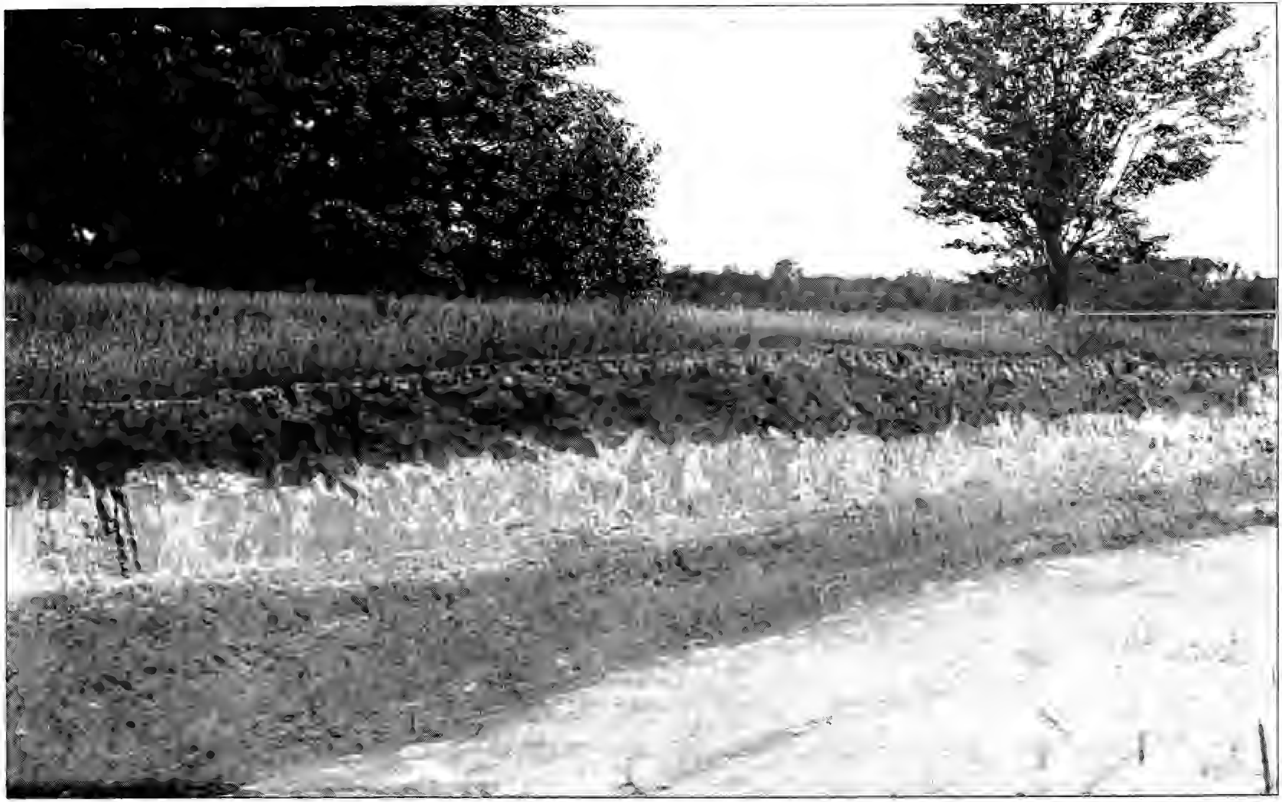
Fig. 1 Map of the Albany molding sand district

of the Mohawk, which occupies a broad valley that extends westward for over 100 miles, the sands attain a much wider devolopment and are traceable on the west bank as far as Schenectady. North of the Mohawk the district again narrows perceptibly, but for a considerable interval it is still broader than the average of the southern section.

In its limits as thus indicated the district conforms with certain geological conditions which need to be set forth before the discussion of the sand deposits themselves is taken up.

The present Hudson valley is an open, well-rounded excavation in shales and sandstones that belong to the so-called Hudson river formation of Ordovician age. These rocks seldom come to the surface within the lower ground, as they are mantled by unconsolidated sediments — clays, sands and gravels — which evidently were deposited ages ago but still rather recently as geological time is reckoned. The latter beds attract the notice of visitors to the region owing to their being arranged in terraces, which rise abruptly from near the river to summits that for long distances are flat and preserve a uniform height. The terraces attain their greatest height in the north and also on the west edge of the district near Schenectady where their upper surface is about 400 feet above sea level. The general level of

Plate I



Normal occurrence of molding sand. The succession from top to bottom of the bank is soil, molding sand, open sand, and clay.

those in the middle and southern section is from 180 to 200 feet, but there are still lower ones in the south.

The sands and clays were laid down in standing water and their deposition dates back to late Pleistocene time when the Hudson, instead of flowing freely to the sea as now, was held back or imponded so that its waters reached the higher levels marked by the terraces. The sediment swept into this temporary lake by the Mohawk and other tributaries was deposited layer upon layer until the accumulations attained an elevation of 400 feet or more above the old river bottom and extended from side to side of the valley depression. With the later lowering of the outlet the waters were drained off and the river began cutting down a channel through the soft beds which it now occupies.

The clays and sands retain their original stratified arrangement for the most part; the former especially show a division into longitudinal layers or seams just as they were first deposited.

The clays occur mostly in the lower and the sands in the upper part of the series. The latter were laid down in the closing stages of the history of Lake Albany, as the flooded valley is called, and originally formed a mantle over the whole district. It is these surface sands that are of present interest.

Distribution and Occurrence of the Sand

At the present time the sand deposits are by no means continuous over the whole district. Lying at the surface they have been subjected to erosional influences which over some areas have effected their complete removal. In general, they are not very thick, 15 or 20 feet being about the maximum, except where they have been heaped up in ridges and dunes by the work of the winds. The action of the wind has a prominent part in the present arrangement and distribution of the sands, and they are still being shifted about wherever they are not anchored by a mantle of soil and vegetation. The area covered by the old Mohawk delta contains tracts occupied by live dunes that are in course of continuous change as to form and position. Frequently the topography bears evidences of similar wind work, although the surface may have been protected from it for a long time.

In consequence of this working over by the winds the sand now occupies no definite position in the series, but is distributed over the surface from near sea level to several hundred feet above. Its contact with the clays below may be seen in places to be quite irregular, although originally the sands were deposited on a level platform.

Another influence of the same agency is to be found in the evenness of texture which characterizes the sand; the first sorting by the water may have produced a fairly even grain, but no doubt this feature has been further promoted by the sifting action of the wind. The uniformity of texture does not obtain over long distances, but only within rather narrow limits, as the same layer may be seen to change gradually to a coarser or finer condition when traced along the surface. Some banks of a few acres extent may produce two or three commercial sizes. The coarsest grain seldom approaches that of fine gravel, the latter material being rarely met with among the molding sands.

The drift sand from the bare wind-swept areas has the same textures as the sand that lies under sod, but differs from the latter markedly in appearance and in other features. It is an incoherent aggregate running readily on slopes under slight propulsion, and has no strength, to speak of, when moistened. Its color is grayish from the admixture of dark grains of shale and sandstone with those of white or transparent quartz. On the other hand, the sand taken from under an old soil has a brownish yellow or ochreous color and contains enough clay usually to show good bonding power. Banks of the latter will stand vertical for a long time unless thoroughly dried out by removal of the protecting cover. This yellow, loamy sand in depth usually grades over into a sand of looser more " open " nature which resembles more or less the drift sand.

It is rather evident from the associations that these variations reflect different stages of weathering and decomposition after the sand was deposited. Wherever the sand has been held down by soil for a long period the shaly particles have disintegrated so as to form clay and at the same time some of the iron has been released and oxidized. The change has proceeded from the surface downward under the influence of moisture, frost and probably the acids of the soil.

The Molding Sand Layer

The molding sand represents a very small fraction of the whole accumulation of sand. Its occurrence is quite without rule, except that when present it is always the layer directly below the soil. In many places this layer may lack the necessary qualities of texture or cohesiveness to constitute a good sand, and there is no way of determining the conditions except by actual exploratory tests.

Plate 2

Albany sand lying upon eroded surface of clay

The unsodded drift sand, as already stated, has little bonding power, although in texture it may resemble the commercial material.

The thickness of the molding sand layer ranges from a few inches up to 4 or 5 feet, which represents about the maximum for the thoroughly weathered layer. In the usual run of the bank the thickness probably is not much more than 18 or 20 inches. Its limits above and below are defined quite sharply, but less so in the latter direction where it shows gradation rather quickly, that is, within a few inches, into grayish open sand. The sod cover with the soil usually amounts to 10 or 12 inches.

The continuity of the layer shows no interruption as a rule from minor irregularities of the surface; but the sand is cut off by stream depressions and never extends far down the sides of steep banks. The product comes mainly from the upland flats, 200 feet or more above sea level.

Composition and Textures

The commercial molding sand consists almost wholly of quartz grains bonded by clay. Examination of numerous samples evidences its very simple mineral composition. Some unresolved shale or sandstone, an occasional particle of feldspar, chlorite or other silicate constitutes about the only variation that may be noticed. The quartz particles, when freed from the attached coating of clay, are seen to be tinted a faint yellow by limonite which adheres to their surface and lends the ochreous color to the sand as seen in the mass.

The ratio between granular aggregate and clay bond varies of course in the bank within rather wide limits. In the usual run of commercial sand of the finer sizes, the latter amounts to about one-third or one-fourth by weight of the whole process.

A feature of the sand that comes out prominently when viewed under the microscope is the angularity of the individual particles, even down to the very finest that can be seen. This is no doubt of practical significance since it has been shown that angular particles do not pack so closely as round ones and therefore should have increased permeability to gases. The angularity is evidenced by wedge-shaped forms and concave surfaces which are characteristic of quartz sands comminuted by crushing under pressure rather than by attrition or abrasion. Such sand is formed by glacial erosion. The deposits of sand and clay in the Albany district represent the finer residue of the load of rock debris which the Pleistocene ice sheet carried along in its sweep from the north and in its later retreat left scattered over the country as moraines. The morainal accumulations within reach of the waters that drained into Lake Albany were worked over and the finer parts carried off to be deposited in the well-sorted beds which are seen today. Later abrasion by wind has not materially changed the character of the quartz grains.

Although several different grades or sizes of sand are obtained, it is the finer sizes which constitute the more typical material commonly associated with the name Albany sand. The grading by the shippers, as will be explained later, is not based on uniformity of practice and does not always lead to closely similar results; but in general the sands are graded from no. 0, the finest, to no. 4, which is the coarsest that is commonly shipped. Mechanical tests of no. 0 sand from different banks show that in the average from 95 to 98 per cent of the whole, inclusive of clay, will pass the 100 mesh screen, or in other words is finer than .147 mm (.0058 inches). An average sample from a stock pile of this grade, to give an example, showed 96.64 per cent as passing the 100 mesh, while all but .71 per cent passed the 80 mesh sieve. There are few molding sands elsewhere comparable in fineness and uniformity of grain, so far as evidenced by published data.

The Methods of Extracting the Sand

The methods employed in the production of the molding sand for the market are simple and in view of the large quantity that is shipped from the district, they may appear at first as somewhat crude. The conditions, however, are such that mechanical methods can not well be adapted to the purpose. These conditions pertain particularly to the variable thickness of the layer as it is traced from place to place, ranging from a few inches to 2 or 3 feet, and to the rather abrupt changes of texture which occur and which require that constant attention be given lest the grades become mixed.

The entire operation of removing the sod and excavating the sand is carried out with hand shovels. The usual practice is to work the ground in sections, according to the number of grades that may be present in the land. The first work is to take off the sod, carefully cutting down to the lower limit of the soil, from a strip a few rods long and about 3 feet wide. The sod and soil after the first strip is worked are placed on the excavated ground, which practice is followed throughout so that at the end the land

Plate 3

Method of stripping sod and soil for removal of the molding sand. The exposed layer of the latter as shown is about 18 inches thick.

may be returned to agricultural use without material decrease of fertility. The bank of molding sand which is thus exposed is shoveled into wagons, care again being necessary not to extend the cut below the layer into the open sand. The sand is then hauled to the nearest siding for shipment, or is placed in stock pile for loading in the future.

The business for the most part is in the hands of regular dealers who carry on operations in several places and are able to supply the various requirements of the market. The individual land owner seldom has enough familiarity with the grading of sand to enable him to undertake the business. The right of digging the sand on a parcel is sold under contract, the shipper paying either a lump sum or on a tonnage basis with the agreement that he shall have a certain term of years in which to complete the removal. The amount that is paid depends altogether on circumstances which vary with each particular tract, such as the grade of the sand, thickness of the layer and distance to railroad siding or to the river.

The crop obtainable is placed roundly at 1000 tons for each 6 inches of thickness, a 30 inch layer thus yielding 5000 tons to the acre.

Haulage is one of the largest items in the cost and one that can not well be reduced; it is likely rather to increase as time goes on and the more accessible lands are exhausted. About 5 miles is the maximum limit of haulage at present.

The methods of production are the same as were employed in the beginning of the industry in the district, but it is doubtful if they can be materially improved as to mechanical features. The absolute need of personal contact with and supervision of the operations is a bar to any great change in that respect.

The weakest feature of the practice, in the writer's estimation, is the lack of positive standards for the grading of the sand in the field. As conducted at present, the grading is a matter of rule-of-thumb tests dependent for their value upon the skill and experience of the practitioner and consequently involving an indeterminable personal factor. In such circumstances it could hardly be expected that uniformity of grading would obtain between different producers; on the other hand, the way is opened for considerable variation not only as between different producers but also with regard to separate shipments from the same source.

Just how far-reaching the results of such lack of precision in grading molding sand may be is not within the writer's knowledge, and is a matter which the foundrymen themselves can best answer.

The methods alluded to are in general use throughout the industry, not peculiar to the Albany district by itself, so that the same conditions probably hold with respect to sands of different origins.

Any plan for improvement of the practice would seem to have its basis in the introduction of physical tests in line with those employed in laboratory work, but not necessarily so refined or comprehensive as the latter. The Albany sands show a degree of constancy in many features that makes for simplicity in the testing operations. They are all quartz sands of high purity, at least the weathered surface portion that is the source of practically the whole output, and the constituent grains are of similar physical development, differing only in size. The bond is also of similar nature throughout. Consequently the features upon which the varied properties of the sands in use depend are, first, the relative grain sizes and, second, the clay percentages. A method for comparison of these features that is readily applicable in the field should not prove difficult to find, in fact may be said to be already at hand. The examination for size is merely a matter of screening with a set of standard sieves, as explained in an article by Mr Karr.[1] The estimation of the percentage of clay bond is performed by rubbing a moistened sample in the fingers to secure disintegration and then shaking it well in a graduated glass cylinder with sufficient water; the contents are then allowed to settle, when the clay will form a distinct layer above the sand. The volumes of each may then be read directly from the scale. This method is not very precise, but sufficiently so probably to serve the purpose of field classification.

Production and Supply

The present output is obtained from numerous localities that altogether cover pretty well the whole district. By far the largest share, however, comes from the central section, that is within a stretch of 20 miles or so north and south of a line drawn between Schenectady and Albany. Among the more important localities for the shipment of the sands are Elnora, Round Lake and Mechanicville, Saratoga county; Albany, Wemple, Selkirk and Delmar, Albany county; South Schenectady and Carmen, Schenectady county; Rensselaer and Van Hosens, Rensselaer county; Coxsackie, Greene county; Rhinecliff and New Hamburg, Dutchess county; and Kingston, Ulster county.

[1] A preliminary report on molding sands. Amer. Foundrymen's Ass. Trans., v. 24. Cleveland, 1916.

Plate 4

Molding sand in stock pile awaiting shipment

The annual production ranges from 300,000 to 500,000 tons a year. The following statistics represent the aggregate production of molding sand in New York State for the years 1908–14 as collected by the State Geologist's office. They may be regarded as practically equivalent to the output of the Albany district, for the industry outside is very small.

Output of molding sand

YEAR	TONS
1908	312 819
1909	468 609
1910	471 351
1911	476 014
1912	469 138
1913	504 348
1914	310 727

A production of 500,000 tons a year means the exhaustion annually of about 125 acres of a 2 foot layer, based on an estimated yield of 1000 tons for each 6 inches of sand on an acre, which is said to be about the rate of yield. On this basis, a square mile of territory is worked over every 5 years.

There is no doubt that the supply has been appreciably diminished by past operations which have been conducted on an extensive scale probably for the last 50 years or more. This is shown by the fact that the sand is now hauled from more distant points than formerly. Yet there is a large amount of unworked territory, sufficient probably to meet the demand for a long time to come, but at somewhat increased costs. The supply of the finest grade is likely to give out first, since it is not so plentiful as the others.

The production of artificial molding sands to compete with the finer grades of Albany sand does not appear possible, so long as the latter can be obtained at moderate cost.

To grind such a tough material as quartz to a similar degree of fineness is expensive and there are physical difficulties which may prove insurmountable so far as practical operations are concerned. One of these is the close attachment or adhesion between the clay and the quartz, which no doubt is promoted by the slightly corroded or roughened surfaces of the grains and their film by iron oxide. Furthermore, it would probably be very difficult to obtain an even distribution of the bond comparable as in the natural sand of which every particle is separately coated by clay.

ON THE GENUS URASTERELLA WITH DESCRIPTION OF A NEW SPECIES

BY GEORGE HENRY HUDSON

Many fossil forms are imperfectly understood because of lack of complete and accurate descriptions of material already preserved in museums. The type of study that should be given such is well exemplified in Bather's "Studies in Edrioasteroidea" appearing in the Geological Magazine at various dates from 1898 to 1915 inclusive and now privately published (October 1915) by the author at "Fabo," Marryat Road, Wimbledon, England. The writer of the present paper has endeavored to pattern after so good an example and he hopes that the more intensive study given to three American specimens of Urasterella has revealed much that is new and of profound import.

Bather's studies also emphasize a second need, and that is for more material. Collectors must come to realize that perfect specimens are by no means the only ones desired. Well-weathered fragments may often reveal anatomical detail not heretofore suspected and any fragment may prove of great value if used as material for sectioning. Certain collectors, after examining some indication of "a find" often decide that the fragment is worthless as a cabinet specimen and many times it receives a parting blow, thoughtlessly given with the face of the hammer. This condition of things is not imaginary and in certain choice hunting grounds has doubtless led to serious loss. In many localities all weathered surfaces have been fairly well stripped. The value of, and desire for, fragments of rare forms should be made widely known.

The studies to be presented here will illustrate also another hinderance to understanding, and that is that our systems of classification and group definitions in many cases serve to cloud our vision and not only lead us to insist on the presence of structures where they do not exist but also to deny the reality of structures truly present. For instance, the idea that species of Urasterella were asteroids has led students and authors for over fifty years to give them arm cavities containing ampullae and double rows of podial openings through the floors of their food grooves. Even so keen and experienced an observer as Schuchert (1915) has both specified and illustrated podial openings for this genus.

That they do not exist is amply shown by our plates 3 and 9. This author, on the other hand, in his definition of paxillae (1915, page 16) expresses a paleontological article of faith when he adds " None are known in Paleozoic genera." In his plate 30, however, he gives camera lucida drawings (figures 1 and 2) of structures which he refers to on page 298 as " articular spines and probable paxillae." We shall take pleasure in adding more evidence for this remarkable discovery and in making that word " probable " unnecessary in this connection. Our plate 4 shows paxillae with three spinelets each; shows the spinelets in open and in closed positions; and shows also the articular faces of the pedicels. We are all under the influence of preconceived ideas which make us hold the false as true and the true as false and we are lucky indeed when we succeed in freeing ourselves from a single one of these many bonds.

Intimately associated with classification is terminology, which is also often a stumbling block in the way of both student and expert. Urasterella gives us a good example.

Gregory, in 1900, page 250, placed Urasterella under the Phanerozonia, not because it had large marginals but because, when the arm was preserved in open condition and viewed from the oral side, its adambulacrals covered the marginals and hid them from sight. He says (loc. cit.) " The adambulacral plates are large and act as marginal plates." He then immediately confuses his nomenclature and makes marginals and adambulacrals synonymous terms. Speaking of the adambulacrals he proceeds to say, " The axes of the marginal plates are parallel and the rays petaloid (as in Stenaster), or the axes of the marginal plates are convergent "; etc. The latter statement must be confusing to the student who would like to retain the idea that the two terms apply to radically different elements. It will be seen later that the first statement quoted from Gregory contains a serious error of fact, for the adambulacrals do not function as marginals but rather as cover plates for the food groove (see our plates 8 and 9). True marginals are present and perform their own essential functions with relation to the plates of the food groove.

Schuchert has a much more accurate conception of the structure of the genus and in 1915, page 172–73, makes a new family for it (Urasterellidae) and places it under the Cryptozonia of Sladen. Even here it can rest but a short time, for in its anatomical structure are certain details which it shares with many other Palaeozoic sea stars, which will necessitate the formation of a new subclass of Asterozoa. Spencer in 1914, page 47, says, "In fact, careful analysis discovers that the true Asteroidea were represented in early Palaeozoic times by but few genera and species." Again, on page 52, he says, "The number of divergent branches of the Asterozoan stock can not be expressed by the present dual division into Asteroidea and Ophiuroidea — a classification which, it must be remembered, is merely based on knowledge of the recent survivors of many ages of experiment and trial."

While writing my description of Protopaleaster narrawayi I had before me the types of Urasterella pulchella (Billings) and Stenaster salteri, Billings. An examination of a portion of a food groove of U. pulchella, to reveal the exact location of the supposed necessary podial openings, demonstrated the fact that such pores were not present where we find them in Asteroidea. There remained only the possibility, suggested by the relaxed condition of certain arms such as that shown in plate 11, figure 2, that the podial openings formed a single medial series, a conclusion apparently verified by my belief that in Protopalaeaster narrawayi I was viewing the oral surface of the specimen.

Here then appeared to be a new type of food groove and one apparently also shown by Palaeaster niagarensis Hall, and Mesopalaeaster (?) parviusculus (Billings). True ambulacra appeared to be absent and therefore in my definition of the new order Eostelleroidae (1912, page 5) I used the term adambulacra as synonymous with floor plates where ambulacrals were believed to be lacking. The form, in my definition, requiring the double row of podial openings was Stenaster salteri, which seemed to show but one double row of plates inside true marginals. Had I excavated but a single one of these apparent podial openings I should have been forced to the conclusion that here at least was a form absolutely without such structures. Spencer's studies of hundreds of specimens had already led him to the belief that none of the oldest fossil sea-stars had developed podial openings. Had I possessed his grasp of these older conditions, the fact that P. narrawayi showed a medial line of pores would have been used as evidence that the plates between which they passed could not be floor plates. Of course, the most conclusive evidence as to whether I mistook the apical for an oral aspect in my description must come from the additional evidence given by the six species classed by Schuchert under Hudsonaster[1] or perhaps more properly from the three good specimens which he refers to P. narrawayi, for he suggests (1915, page 59) that these specimens are perhaps generically distinct from the other species of Hudsonaster and that Protopalaeaster (accepted by Spencer in 1914) may have to be revived. My studies of the holotype (1912, 1913*a*, 1913*b*) will show that the four good specimens now referred to this species should receive more detailed analysis.

No attempt will be made to redefine my proposed new order of sea stars, for Spencer's careful work certainly should make this field his own, but I shall enter here a protest against the use of the terms ambulacra and adambulacra in any class of echinoderms save the Echinoidea. Whether the plates there designated by these terms are homologous with the plates so named in Crinoidea or Asteroidea we do not know, but we do know that in the last two cases they are applied to plates having entirely different origins. The terms are intrinsically meaningless so far as their application to echinoderms is concerned and they are both cumbersome and confusing. Their use will therefore be abandoned here and the terms floor plate and cover plate, as used by Bather in his "Studies in Edrioasteroidea," accepted in their place.

Urasterella clearly shows that the food groove is an organ apart by itself, with a cover plate for every floor plate, and this organ shows also an utter disregard for the serial arrangement of the inframarginals. The presence of a food groove similarly constructed is as apparent in Blastoidocrinus as it is in Edrioaster and is also found in Blastoidea, Crinoidea and Cystidea. So primitive and fundamental a structure and one so essential to alimentation in most echinoderms should have a truly descriptive terminology, and one so applied to all forms retaining the food groove as to assist in keeping the homology in view.

Raymond (December 1912, plate VI) figured a specimen of Urasterella from the Museum of Comparative Zoology, Cambridge, Mass., to show that a fossil sea star might be so weathered as to lose most of its apical skeleton and reveal the apical surfaces of its floor plates. Doctor Raymond, afterward, very kindly loaned me this specimen for study. It shows much that is new to our present

[1] The six species of Hudsonaster will probably be reduced to five, for according to Bather (1915, p. 425–26) he and Spencer are agreed that in H. batheri, Schuchert mistook an apical aspect of Tetraster wiville-thompsoni for an oral aspect of a new species.

conception of the genus and also represents what the writer believes to be a new species.

Urasterella medusa, new species

(Plates 1–6)

Peristomial ring heavy. Axillary inframarginal prominent, its long axis parallel with the ring. First floor plates (peristomial) with radial diameters equal to the sum of those of the three following floor plates. Arm marginals with long axes set parallel with the ray. Supramarginals and axial columns consist of prominent plates. All plates of the apical skeleton bear paxillae. Inframarginals and cover plates also bear paxillae but those of the latter plates are small and delicate structures with short or modified pedicels.

In U. pulchella (Billings), to which this species is most closely allied, the axillary inframarginals have their long axes placed radially; the first floor plates have radial diameters but twice as great as those of the following floor plates; and the inframarginals are placed with their long axes perpendicular to the ray. Other differences will be noted in the more detailed description and comparison which follow.

Raymond's figure (loc. cit.) and those here given are of the holotype. The specimen was collected by Dr C. D. Walcott from the Trenton limestone at Trenton Falls, N. Y., and is now in the collection of the Museum of Comparative Zoology, Harvard University.

Description of the Preserved Structure of three American Fossil Sea Stars Referred to the genus Urasterella, McCoy

Floor Plates of the Peristomial Ring

These plates are oppositely placed. In U. medusa (plate 2, figure 1, apical aspect) their average radial length is 1.2 of their transverse diameter (measured along the edge of a distal face) and the exposed edges of their inner (common) faces is 1.15 of their outer. In U. pulchella (plate 10, oral aspect of plesiotype) the average radial length of these plates is but .8 of their transverse diameter while their inner edges are 1.5 the length of the outer. As the width of the floor of the food groove is practically identical in the two specimens, and as the plates measured in the plesiotype (those next interradius *d*) were cut down to about half their thickness and allowance also made for overlap of the following floor plates, these differences can hardly be attributed to either age or difference in aspect. U. pulchella seems to be the more primitive form and one in which the peristomial floor plates could move slightly inward and function as jaws. In U. medusa the ring seems to be too solid to allow such movement and the projecting ends of these jaws were therefore partially lost.

In plate 10, radii A to D inclusive, portions of the oral surface of these plates which are still buried in sediment suggest podial openings. With the permission of former Director R. W. Brock, interradius (*d*) was gradually cut down and a series of stereograms made of it during the process. Our plate represents the last of these. This cutting involved two peristomial floor plates. The floor plate of arm D has lost the distal excavation seen in other plates but still shows a portion of the proximal excavation. In arm E the further cutting down of the plate next interradius (*d*) has demonstrated the fact that these pits were not podial openings. The proximal pit seems to have served as a muscle pit for an adductor which assisted in drawing inward the first or interradial pair of cover plates. The latter are seen to have formed a very effective outer jaw (note particularly interradius *a*) for retention, crushing, or thrusting captured specimens into the oral cavity. This specimen shows an oral armature of both types, floor plate and cover plate. The latter is of course the more primitive form.

Turning now to plate 2, figure 1, it will be noted first, that the evidence against podial openings is conclusive. Regarding the projection of medial toothlike processes, the upper left corner of this plate seems to show a projection 1.21 times the outer face of the plate but the arm is here viewed more from the side and plate 1, figure 1, shows some displacement of this pair of floor plates.

The proximal faces of a pair of peristomial floor plates are shown in plate 2, figure 2. The outer edges of these faces measure about .6 of their long or lateral diameters, while their inner faces, due to thickening of the oral surface, measure .8 of this diameter. The oral surface of each plate appears to have a shallow radially placed channel. In plate 1, figure 1, the left channel of arm C contains an apparently pear-shaped ossicle which, as it lies between a pair of spines and the plate and seems to fit the excavation, may belong to the specimen. The exposed end of this ossicle shows longitudinal striae (or cleavage planes) and a suggestion of a central, axial pore. It presents an appearance somewhat like that which Schuchert gives for the madreporite of Petraster speciosus (Miller and Dyer) in 1915, plate 27, figure 3, only it is much smaller.

Schuchert[1] (1915) mentions no heavy first floor plates for any species of Urasterella. In his plate 27, figure 7, he presents a camera lucida drawing of part of the proximal, oral area of a ray of U. grandis (Meek) of which he says (page 298) "The complete oral armature is preserved." The first floor plates, as here represented, are no heavier than those which follow them and instead of together forming a medial toothlike projection, they present a very marked concavity next the oral aperture. Schuchert's plate 28, figure 5, presents the first floor plates of U. girvanensis Schuchert, as no larger than others in the same ray and (in the long arm) recessed next the oral cavity. Spencer (1914, plate I, figure 4) gives essentially the same form for these plates. These facts should be sufficient excuse for the details here given. The markedly different character of the peristomial floor plates, shown in our figures, and the essentially different form they give to the border of the oral cavity may be generic characters.

Arm Floor Plates

The arm floor plates are placed with their inner ends thrust toward the mouth and they are also imbricated. Near the peristomial ring the proximal face of each plate, when viewed orally, slightly overlaps the distal face of its older neighbor. This condition is well shown in plate 1, figure 1, arm A. In plate 2, figure 1, the apical aspect of the second floor plates, or those next the peristomial ring, would indicate that the overlap was confined largely to the inner ends of the plates. The majority of the floor plates, however, are tipped the other way and slightly overlap their younger neighbors when viewed orally. See plate 1, figure 2, and plate 6, figure 1.

In U. pulchella (plate 10, ray *e*) the seven and one-half floor plates, following the first, form a line 3 mm long and the long axes of these plates measure 1.3 mm. In U. medusa (plate 2, figure 1) there are but six floor plates in a similarly placed line,

[1] As Schuchert's important recent work (1915) must be accepted as a standard, we shall make frequent reference to it. Our dissection, gum mounting, photomicrographs and stereograms have revealed much that is new concerning the genus Urasterella. In some instances it will make necessary a modification of Schuchert's description of this genus; in others it will corroborate certain very important deductions of his.

while the long axes of the plates measure but 1.2 mm. As the cover plates, when in open position, rest partly on the outer beveled faces of the floor plates (plate 1, figure 1, arm A) our measure of the long axis of the latter in U. pulchella may be slightly under the true length. If we increase this length, however, we but increase the difference in form in the two species. We may then safely say that the oral faces of these plates in U. pulchella are more slender than in U. medusa. We should note also a change in form as we pass to more distal portions of the arm. In plate 3, figure 1, the sum of the radial diameters of plates 2 to 8 inclusive is 3.4 mm, while plates 9 to 16 measure 4.1 mm. With this slight increase in radial diameters there goes a decrease in transverse diameters and a marked thickening of the floor apically. This thickening is already apparent in the third floor plate of the left row in figure 1. In both figures of our plate 3, this thickening is seen rapidly to bring about a marked convexity of the apical surface of the arm floor. This thickening and the concomitant convexity is still more manifest in the last floor plates shown in plate 1, figure 2.

Turning now to the holotype of U. pulchella (plate 9, figure 3) we find that at the sixteenth floor plate the medial thickening of the floor has given the inner faces of these plates a length equal to that of their oral faces. These sections of arm A of the holotype reveal the fact that at this distance from the mouth the apical skeleton was in contact with and fitted the apical surface of the arm floor. As evidence of this condition note, in the figure referred to, the curve where the supramarginal at the left fits the floor plate. In plate 5 the radials and supramarginals conform closely to irregularities of the floor plates and pits left by the loss of two plates of the radial series may be clearly seen. Both figures of plate 3 show other decided imprints of apical plates and in figure 1, in the region of the fifth and sixth floor plates, a single radial is still present in its pit and a similar pit lies over the inner ends of the third and fourth floor plates. Plate 1, figure 1, shows the solitary radial viewed somewhat from the side. From the evidence given above we must conclude that the viscera did not extend into the arms beyond the second floor pieces.

The evidence given is also against the assumption that the genus possessed internal ampullae and podial openings. The exposed apical surfaces of the floor plates in our figures of U. medusa give positive proof that such was not the case. U. medusa is, however, not alone in yielding this evidence. In 1915, plate II, a view of a portion of arm D of the holotype of U. pulchella was given. The flooring plates there shown had lost a portion of their oral surfaces by exfoliation. They display close sutures on all sides and no trace of podial openings.

The oral aspect of the floor plates differs very markedly from the apical. In plate 11, figure 2, floor plate no. 23 of the right row shows a broad inner end (in imbricated position?) from which a narrow transverse ridge of uniform diameter runs to and abuts against an inframarginal. This ridge, near the middle, bears a marked angle projecting orally. It will be seen that the cover plates, three of which are shown in the lower right corner of figure, rest against the outer side of this angle when the arm is open. Between these ridges and over the line of plate contact there is thus left a groove with parallel sides, which is usually shown filled with sediment as in our figure. In this condition the outline of a single plate resembles that of a round-headed tack. This seems to be the appearance Schuchert had in mind when he stated of this genus (1915, page 174), " Each plate is excavated laterally, along a proximal edge, leaving a more or less long, slender podial opening between adjoining plates." The floor plates of the left row on our figure have lost more of their oral surfaces and present an aspect somewhat like that figured by Schuchert (1915, plate 30, figure 3) to show the podial openings of Urasterella grandis (Meek) and of which he says (page 298), " The podial openings are situated laterally between the thinner ends of the ossicles." The only other species of which Schuchert mentions the pores is his U. girvanensis. His figure is in part copied from Nicholson and Etheridge and shows somewhat diamond-shaped openings (see his plate 28, figure 5).

If now we examine plate 12, figure 2, we may clearly see a linear series of comparatively large, black circles lying between the left floor plates and their cover plates. These would most assuredly be taken for outlines of podial openings by most students, but they are truly the remains of organic structures lying wholly on the oral side of the floor plates. It must be noted that the two apparent pores nearest the twentieth cover plate seem to have double inner walls. Here and elsewhere there are two distinct half circles which, if completed, would cause the circles to intersect. We must interpret these features as sections through the thin and more or less crumpled walls of external ampullae or podia. This plate affords another interesting example of the preservation of soft, organic structures and of the value of the gum damar mounting in revealing the same. From these circles or parts of such there runs a channel which becomes less wide and deep and which crosses diagonally from one plate to the next one on the proximal side. On the latter plate the channel is soon lost. Between the convex (in section) inner ends of the floor plates there is a preserved mass of organic fibers, most of which run parallel with the axis of the arm. We are here probably dealing with a portion of the radial branch of the water-vascular system and the more delicate side branches have been lost by weathering. At this level the inner ends of the floor plates seem to be separated, and this appearance led me at first (1914, page 5, lines 3–4) to assume that here at least was a line along which a single row of podial openings might have found exit. A similar aspect doubtless led Schuchert (1915, page 174) to give as a character of the genus Urasterella that "Medially the columns loosely adjoin." In plate 9, figure 3, the great depth of the inner sutures of the floor plates and their close contact would seem to negative such an assumption. So also would the position of the median water vessel clearly shown in cross section in figure 2 of this plate. The delicate lateral branches of this vessel had to pass over the oral surface of the floor plates to reach the position of the podia and podial sacs already noted. For further evidence of close suture at the inner ends of the floor plates, see our plates 2 and 3 and the photomicrograph, X20 dia., given in Hudson, 1915.

Another detail of the floor plates requires attention. In plate 2, figure 1, the second, third, fourth and sixth floor plates of the upper row have had their outer faces vertically channeled to correspond with similar channels on the inner faces of the inframarginals. The pores so formed have a diameter (measured on plate 4, third floor plate) of .05 mm. From many of the outer arm faces these channels are decidedly absent. Papulae were numerous on the apical surface of the genus as shown in Schuchert's drawing of the apical surface of a young U. ulrichi (1915, plate 30, figure 6). We have in U. medusa an example of a fringe of papulae issuing between the inframarginals and the covering plates. When the food groove was closed these papulae would appear on the oral surface; when the arm was open they would appear on the apical surface. In plate 3, figure 1, floor plates 6, 12, and 13 of the right column show small pores penetrating the outer end of the plates. These are seen also in the right column of figure 2, floor plates 2 and 5, and elsewhere. Note also what appears to be a pore passing between floor plates 8 and 9 of this series and in still other places in our figures. With apical plates in contact with floor plates, there must needs have been passages for flow of coelomic fluid, for nerves, etc. The study of other well-weathered material, even fragmental, or of series of sections must be undertaken before any decided opinion is expressed concerning the nature of these apparently irregular passages.

The arrangement of the flooring plates in U. medusa is for the greater part an alternate one. Those oppositely placed being those of the peristomial ring and a few following them; arm A has nine pairs oppositely placed, arm B but two pairs and arm C apparently but one pair. In U. pulchella, however, in both holotype and plesiotype, the arrangement so far as seen is an opposite one. Only confusion can come from persisting in using this character, of alternate or opposite arrangement of floor plates, in our definitions of genera or larger groups of paleozoic sea stars. In Blastoidocrinus, the blastids, and all forms in which the growing arm tip rests against bibrachials, radials or terminal plates, the flooring plates are developed alternately. When one has become well grown and stiffened with stereom it takes up the thrusts against the growing arm tip and leaves a space on the opposite side, practically free from compression, where the embryonic new plate and its concomitant structures may assume their proper positions. The subsequent arrangement of these plates is due to other factors and they may be found alternately placed in one arm while oppositely placed in another of the same individual.

Cover Plates

Schuchert (1915, page 174) calls these plates "coin-shaped" but the term is rather misleading. Plate 1, figure 1, lower left, shows the proximal and outer surfaces of one of them. The form here approximates that of a parallelopiped. The apical face rests against an outer beveled portion of the oral surface of a floor plate. The opposite or oral face is roughly semicircular and bears a median crest. It is this part of the plate alone which suggests the coin shape when the arm is in closed condition. The apical faces of fifteen cover plates are shown in figure 2. These faces are ridged or grooved transversely and show remains of muscle fibers. The outer surface (as viewed in cross section) is either flat or convex and the form taken seems to be due to the manner of meeting the inframarginals. The last inframarginal on the right shows one of these contacts which here gives a convex outer surface to the cover piece. The portion of the inner surface next the apical end of the plate bears a central ridge showing an acute angle on cross section, the oral portion of the inner surface is ventricose and between these ends the plate seems to be rather deeply excavated. The character of the outer surface of a series of six is shown in plate 6, figure 1. Note that the apical ends where they meet the floor plates may be either flat or convex. Each cover plate meets two floor plates, one by its apical face and one by a portion of its proximal face. The plates are thus set alternately with the floor plates. They are also imbricated with the oral face tipped toward the mouth. Figure 2 shows four of the same plates from an apical aspect.

That these plates, though bound together serially, could still act as cover pieces is shown in plate 8, where the food groove is presented in open, partially closed and completely closed positions. The closing of one side of the arm may be also seen in plate 11, figure 1. This plate shows a distal, somewhat central concavity in the last cover plate in the lower corner of figure 2, and the same concavity is also revealed in the upper half of the right column in figure 1. Sections revealing sigmoid flexures are to be seen in the greatly relaxed position of the upper plates of the left column of figure 1, and throughout the left column in figure 2. Note particularly the form of the ends where contact is shown with the floor plates as in figure 2. The twist of this portion of the plate apparently allowed each cover piece to rest diagonally across two floor plates and so prevent injury to tissues lying in the transverse cavities of the latter. The extremely relaxed condition shown in this plate is in part due to the beginning of disintegration. This is shown in figure 2 by the displaced floor plate in the upper portion and the appearance of what seem to be two plates of the apical skeleton in the lower part of the figure. It is difficult to believe that the inner faces of the floor plates in this plesiotype had the same depth of those shown in the holotype. It will be easily seen that decay of an open arm in a form like the holotype, if lying oral surface up, would tend to drag apart the oral portion of the inner faces, of the floor plates and press their apical portions together.

In plate 10, arm E, disintegration has still further opened the food groove and scattered some of the cover plates. Their alternate arrangement is, however, well demonstrated in the upper margin of arm D and we shall be able to demonstrate that for every floor plate there was one cover plate and one alone, even at the very beginning of the development of the arm. In interradius *c* we have numbered one series of these plates and in interradius *e* two others. The oral armature is therefore very primitive. The first floor plates have been modified by a marked increase in size and their acute proximal angles form a well-marked inner jaw. The form of the interradial cover plates is also modified to form a very effective outer jaw. We must note particularly the pair shown in interradius *a*. While situated over a large axillary inframarginal (see section shown in interradius *d*) they maintain close contact with each other and yet show distinct contact with a central transverse ridge on the first floor plates. Their attachment to both the axillary inframarginal and the first floor plates is also shown in plate 1, figure 1.

Interesting sections of more distally placed cover plates are shown in plate 9. In figure 1, the right cover piece shows a portion of its distal central pit. In figure 3 the section passes close to the narrow, transverse ridge which runs from the position of an inner oral spine to the middle of the outer surface of the plate. It appears here to be an easily detachable surface feature of the plate. Several of these ridges are seen in the upper left of this figure and also in figure 2. It is these ridges which present the coinlike appearance so manifest in plate 8, figure 1. The spines borne by these cover plates are of exceptional interest, but we shall better understand their nature if we postpone their consideration until after the spines of the remaining arm plates have received our attention.

The Inframarginals

In U. medusa, plate 1, figure 1, we are viewing two axillary inframarginals at an angle which shows both their proximal and apical faces. The proximal faces are concave and show the impression of plates of the apical skeleton. In plate 2, figure 1, the aspect is purely apical. Unlike the arm inframarginals, these plates bear no horizontally placed spinous processes but are markedly concave distally. There can be no doubt therefore that the radial diameter of the plate is here fully shown. That we have also the full lateral diameter will be seen if we note that these plates, in their apical aspect, overlap both the first floor plates and the arm marginals next to them. The radial diameter here is but .64 times the transverse diameter. In plate 10, interradius *d*, the overlap of the first floor plates has been largely cut away and the horizontal section of the axillary inframarginal is roughly circular in outline, with a proximal concavity. The holotype, however, (plate 7, figure 1, interradius *c*) shows a very different outline and again arouses a suspicion that the plesiotype is perhaps specifically distinct from the holotype. The radial diameter here is 1.2 times the transverse diameter.

Of these plates, Schuchert says, in his description of generic characters in Urasterella, 1915, page 174, " In none of the mature specimens have been seen well-developed or larger axillary inframarginals or interbrachial marginal plates." From the great thickening of the first floor plates in two of the specimens under study, it would seem reasonable to assign an approach to maturity in the specimens here under study.

If the axillary inframarginals were spine-bearing, this spine must have arisen from the oral surface. In plate 10, we find what appears to be a cross section of such a spine. It lies between the second and third pairs of covering plates of interradius *a*.

In turning now to the arm marginals we shall describe first of all the new revelation which U. medusa makes concerning the " articular spines and probable paxillae " which Schuchert (1915, page 298) feels he must credit to Urasterella grandis (Meek) though, following a universally accepted opinion, under his definition of paxillae (1915, page 16) he says " None are known in Paleozoic genera." In U. medusa, however, we have forms preserved which are strikingly like the paxillae of Hymenaster perissonotus Fisher (1911, plate 115, figure 1*a*), only the plate bases are not so deeply incised and the pedicels are more nearly perpendicular to these bases. In fact, the three long and slender articulated spinelets borne on the projective pedicels of the inframarginals of U. medusa and the certainty that all the apical plates bore similar pedicels with similar spinelets, almost leads one to infer that this ancient species possessed a nidamental membrane. The paxillae we are about to describe are without doubt homologous with those of recent forms, but they show peculiarities well worth careful study.

We will first examine plate 4. The fourth marginal of arm B shows two of its spinelets turned distally at an angle of a little more than 45 degrees with the axis of the pedicel. The upper of the two spinelets is slightly separated from the pedicel and shows its concave articular face. Both spinelets are longer than the pedicel and plate thickness combined. The head of the same pedicel shows an articular face from which a spinelet has been lost. The seventh marginal of the same arm shows two spinelets turned in opposite directions but still remaining in close contact with the head of the pedicel. The space occupied by their bases indicates room for a buried third spinelet. In arm C the fourth and fifth marginals each show the basal diameters of single spinelets still practically in contact with their respective pedicels. These diameters are such as to allow the pedicel heads to possess three articular surfaces for such spines, and three only. The gum mounting shows that the spinelets and pedicels are built of an alternating series of light and dark discs. The dark discs indicate the former presence of organic tissues, the white discs the presence of more open or spongy stereom formation. The writer would interpret this appearance as indicating that the spinelets were increased in length by a series of tissue extensions at the tips, these extensions becoming consecutive centers of stereom formation which, however, did not completely join one another. The spines seem also to have been formed in the same manner and the whole structure is of a very primitive nature.

Such a structure must not only have kept the spinelets from becoming very rigid bodies, but it must also have allowed them to fall apart, like a broken string of beads, in decay. Plate 2 presents evidence to corroborate both suppositions. The upper half of figure 3 shows three spinelets thus falling apart; the middle one is long and contorted. The length of this spinelet must have been at least 15 times its basal diameter. Near the lower part of the figure we find the partially filled mold of a spine of approximately the same length.

This figure shows that the pedicels also became separated from the plate bases during decay and, like the spinelets, broke up into similar but more robust beads. In the upper right corner of figure 3 are seen two pedicel beads, the upper showing a concave face and the lower an apparently convex face. Not far below this pair is a larger portion of a separated pedicel. Its left face is convex and either represents the face to which the spinelets were attached or the outer face of the joint just under the head of the pedicel.

In plate 5 we will notice first, near the upper left corner, a bent portion of a spinelet breaking up into discs. In the arm margin, above the thirteenth floor plate, the pedicel of an ambital plate is separating into discs. The ambital, seen in side view, immediately at the left of this is crossed by white bands. A separation at these bands would break the pedicel up into four parts. The head of this pedicel is covered with black tufts in the calcite which represent the muscles moving the spinelets; near the lower left of this pedicel other "heads" are seen bearing similar tufts. Immediately below the white-banded ambital the base of another is seen. The latter has lost its pedicel and distinctly bears a white ovate scar with acute tip. Immediately above the thirteenth floor plate is one of a series of larger apical plates which Schuchert calls the supramarginals. This plate bears also a similar white scar indicating loss of its pedicel at one of the white division planes. The separate plate of the radial column, set over the inner ends of floor plates 14 and 15, possesses also a whitened central area. Similar indications of loss of pedicels from other plates should be noted, as Schuchert's description of the genus states (1915, page 173) that all the apical plates of the arm "excepting one or three middle columns, are drawn out into more or less long, blunt, stout, erect, nonarticulating rods." In plate 3, figure 1, a single plate of the radial series is preserved but this still shows the base of a pedicel. In plate 6, figure 2, just below the middle of the figure, there are two supramarginals, one each side of the median line, which still retain their pedicels while others distinctly show the whitened area denoting planes of separation. That the pedicels broke up into "beads" is also shown near the lower right corner of this figure.

Two large spines or spinelets are to be seen in plate 1, figure 1, near the beginning of arm C. Their position indicates some displacement. If they belonged to the axillary inframarginal at the left, its orally directed pedicel (indicated in plate 10) bore at least two heavy spinelets. These may be simple spines borne at the ends of the first cover plates, but a comparison with the tips of the latter, two pairs of which are also shown in this figure, would indicate that these spines are rather too large to be assigned to such an origin.

In comparing the horizontal outlines of the inframarginals of U. medusa and U. pulchella, we shall omit the pedicels and measure only the plate bases. In plate 2, figure 1, the longest horizontal axis of these plates has the proximal end tipped in a little toward the ray and the plates at the same time are imbricated with the proximal apical ends slightly overlapping the plate nearer the oral cavity, as in the fourth marginal of this figure. A long axis, as near as we can measure, appears to be .75 mm long. The diameter at right angles to this measures about .45 mm. In U. pulchella, on the other hand (plate 7, figure 1; fourth, fifth and sixth marginals of arm C next interradius *d*), these marginals have a radial diameter of but .5 mm or one-third less than in U. medusa, while their diameters perpendicular to the ray measure at least .75 mm or one and one-half times greater than in U. medusa.

We turn now to spinous processes which assuredly belong to the cover plates. In plate 1, figure 1, arm A, we see a single spine projecting from the inner, oral, proximal corner of a preserved third cover plate. This spine is .08 mm in diameter and shows .3 mm of its length. It is probable that it was one of a pair attached to the inner edge of the coinlike medial ridge of the plate. In plate 2, figure 1, the area from which the floor plates were lost shows a diverging pair of spines which apparently belonged to the inner, oral end of cover plate 10. The right-hand spine is seen to fork and show two very delicate spinelets which were bent inward by the soft mud of the bottom and now show cross sections appearing like minute white specks terminating the branches of the fork. These pedicels, for such it seems we must call them, had diameters of but .06 mm and a length (shown by the neighboring pedicel) of at least .22 mm. In U. pulchella, plate 9, figure 3, we find an inner spine about .09 and having a length of .4 mm. This spine is on a fifteenth covering ossicle and yet is very markedly larger than the pedicels in a similar position on a tenth cover plate in U. medusa. This appears to be a simple spine but may also be one of a pair.

In plate 7, figure 2, upper left, we see several of the medial oral coinlike ridges of U. pulchella. These are in the vicinity of the thirtieth cover plate and where the arm begins to turn over and show its apical surface. The transverse diameter of the ridge on the uppermost cover plate, near its inner end, is .15 mm. This end of the ridge is angulated and bears two articulated spines .08 mm in diameter. The following cover piece shows also the same outer angle with one of a pair of spines still attached. From the evidence we should be inclined to credit each cover piece with an inner, oral pair of articulated spine bases, bearing two spinelets each.

Turning now to indications of spines on the outer, oral edges of the cover plates, we find them first in plate 1, figure 2, where the members of a consecutive series (in upper left of figure) show a single spinous process each. This process is close to one end of the medial, coinlike ridge which we have seen in U. pulchella and may be but the end of that ridge. If these processes are pedicels, their position is also such that the bottom muds would turn back their spinelets. Both the twenty-third and twenty-fifth cover plates show a pair of cross sections of such spinelets. Additional white dots along the margin of this arm indicate the presence of others. Both pedicels and spinelets seem, so far as size is concerned, to be very like those already seen on the inner oral edges of the cover plates of this specimen. A study of the uncovered outer faces of the cover plates shown in plate 6, figure 1, is indicative of similar conditions at their oral edges but the outer face itself seems to negative the idea that these plates bore additional and larger paxillae, in pairs, on more apical portions of this face, such as Schuchert credits to U. grandis. The three specimens here under study show no evidence for any spines or paxillae on the cover pieces save at the inner and outer ends of the medial, oral ridge.

We are in a position now to note that if these specimens are to be retained under Urasterella, the description of the genus must be somewhat modified. Let us quote simply Schuchert's description of the cover plates (1915, page 174): "Adambulacral plates very numerous, coin-shaped, and arranged on edge with the actinal surface pustulose. Each plate on its actinal surface bears two or three short thick spines, and on its ambulacral side there is a similar spine. Along the outer edge of these plates toward the abactinal side there is another row of spines, in pairs, which are long and slender, flat and longitudinally grooved on two sides. The adambulacral columns terminate in small triangular plates of the oral armature. In the young of U. ulrichi five very stout, short, pointed spines (tori) are inserted inside of the plates of the oral armature."

None of our specimens show the actinal surface "pustulose," but such structures are often easily removable. In plate 7, figure 2, the spaces between the raised medial ridges of the cover pieces are seen to be packed with fragments, suggestive of ova, which may be removed pustules or separated beads of spines. In plate 12, figure 1, these ovoid blackened beads appear to be attached to both *vertical* faces of the median, oral ridges and to have grown therefrom in a form resembling minute puffballs. Traces of these structures are also seen in figure 2 of this plate.

The "two or three short thick spines" credited by Schuchert to the oral ("actinal") surface of these plates, seem to be represented in our specimens by the single outer, oral pedicels bearing two spinelets each, in U. medusa.

On the inner oral edge or, perhaps more properly speaking, in an excavated corner involving a part of the inner (ambulacral) face, there appears to be a single spine in U. pulchella. In U. medusa, however, the similarly attached spines seem to be minute paxillae, each pedicel bearing two spinelets.

Plates 1 and 6 offer proof positive that in U. medusa there were no spines on the outer faces of the cover plates. These are the faces Schuchert evidently designates as abactinal. A portion of these faces are covered by the marginals and the uncovered portions are "abactinal" only when the arm is open. The true actinal face is here called the apical and this, as we have seen, is articulated with the floor plates. The spines which Schuchert credits to the "abactinal" side of the cover plates in U. grandis (1915, page 181) and illustrated in his plate 30, figures 1 and 2, would seem to belong to the marginals. Figure 1 of this plate is very suggestive of such an origin. The longitudinal grooving of these spines here shown is doubtless a line of contact of two spinelets. These spinelets (as measured from the figures) were nearly .8 mm long and the pedicels about .13 mm in diameter. This diameter is but slightly in excess of the .12 mm which we gave for the pedicels on the marginals of U. medusa. An examination under gum mounting would probably more clearly reveal the character of the articulation of the spinelets with their pedicels.

Figure 7 of Schuchert's plate 30 shows three of his "five very stout, short pointed spines (tori)" which "are inserted inside of the oral armature." If these are spines, as represented, this specimen can not be congeneric with the plesiotype of U. pulchella. I should interpret these as simply the paired first cover plates as seen in our plate 10.

Schuchert's figure seems to show a detached pedicel whose origin was from the axillary inframarginal in upper right interradius. We also saw evidence for such a piece in our plate 10. Similar spinous processes are shown in the interradii of Schuchert's figure of U. girvanensis. Here, however, their relation to the first paired cover pieces is more clearly shown.

Beyond noting the loosely imbricated arrangement of the ambitals, an adaptation allowing of the opening and closing of the cover plate columns, we shall in this paper have nothing more to say concerning the apical skeleton of Urasterella. It may be of interest, however, to compare briefly our conception of this genus with Protopalaeaster as known to us through P. narrawayi. Schuchert includes Protopalaeaster under Hudsonaster and says of the genus (1915, page 40) "In Hudsonaster we have the most primitive known starfish." Spencer, on the other hand (1914), separates a new genus "Eoactis" from the Urasterella group and believes that it shows one of the simplest of mouth frames. We shall here give only some of the more interesting differences between these genera. For this purpose we shall accept the interpretation of

Spencer and Schuchert that P. narrawayi presents an apical instead of an oral aspect.

In U. pulchella, the inner ends of all floor plates meet the median lines of the rays and are closely joined to those of the opposite column. The first pair in each ray is greatly increased in size and forms a very definite radial jaw, the proximal inner edges of the plates projecting into the oral cavity. The following floor plates (with the exception perhaps of the second and third pairs) are thickened apically to a remarkable degree and retain impressions of the surfaces of the radials and supramarginals against which they developed. The floor plates are set with their inner edges a little nearer the mouth and form a very thick floor, flat on the oral side and strongly convex on the apical.

In P. narrawayi the inner ends of the first three pairs of floor plates can not reach those of the opposite column, but they run along the curved, apical, inner border of the axillary inframarginals and become interradial in position. If we assume that for every cover plate there was a floor plate, then the first floor plates form the "secondary jaw" of this species (see my former papers for quoted terms), the second floor plates form the interradial pairs of "suboral epineurals" and the third floor plates are those I formerly designated as "second epineurals." One may pass around the inner apical margins of the great axillary inframarginals and find no break in the series of floor plates. Though the first members have moved toward the oral surface, the second members have joined each other on the interradius and cover the first pair apically. The axillary inframarginal is excavated on its inner, apical surface to receive the divorced second pair of floor plates. This condition is shown in Hudson 1913, figure 1. The floor plates of the arm are not thickened vertically. Those preserved in one arm have their inner ends nearer the mouth; in another arm they are tipped away from the mouth. The floor is built like a long and steeply angled roof with the ridge placed apically. There was no marked vertical thickening of the plates, no evidence for an arm lacking viscera, no convex apical side of floor with impressions of the radials and inframarginals, though some deformity may be due to this cause. Orally the floor surface seems to have lacked the transverse grooves and other complex features found in Urasterella. Unlike the latter genus, the double series of floor plates formed the weakest elements in the structure of the arm.

In Urasterella the cover pieces could be thrown back far enough to hide the inframarginals and the latter could be crowded over nearer the supramarginals. They were set slightly in advance of the floor plates to which they belonged and each, viewed orally, slightly overlapped the next proximal floor plate. The first cover plates met over the single axillary inframarginal to form an interradial jaw. The members of these " mouth angle plates " were not so highly specialized as to hide their origin, but their movement was in arcs of circles lying in vertical axillary planes. They could thus very effectively thrust captured material into the mouth.

In Protopalaester the opening and closing movements of the cover plates was very limited. They were set alternately with the floor plates but viewed orally, each slightly overlapped the next distal floor plate. This form of imbrication, save for arm tips in a few cases, is unique and requires explanation. The interradial pairs were heavier than the others and also apparently less free in their movement than in Urasterella.

So far as the peristomial ring and plates of the food groove are concerned, Urasterella is the more simple and primitive of these two forms. The floor plates begin where the groove begins and the cover plates arch over the mouth. The rigid parts of the ring consist of but fifteen pieces, ten cover plates and five axillary inframarginals. This ring is strong but allows a small, radial gliding motion of the floor plates, which enables the first pairs to function as radial jaws. The first cover plates become slightly modified mouth angle plates and function as interradial jaws. Urasterella is then a very generalized form having both types of oral armature.

In Protopalaeaster there is no oral peristomial ring. The axillary interradials are braced by the supramarginals and radials. radials. The first, second and third floor plates are parted from their opposite members and swung over toward the interradii. The strong elements of the jaws, visible from the oral face, are the first cover plates which no longer rise and arch over the opening. On their apical surfaces rest the paired and weakened first floor plates. Thrust over these again are the second floor plates. Are these first and second floor plates vestigial or do they really serve some important function? On the supposition that he was viewing the oral face of P. narrawayi, the author recognized the remarkable similarity in arrangement between what he took to be epineurals in this genus and the undoubted cover plates of Urasterella. It was an easy matter also to conceive of a function for these "secondary jaws" and "suboral epineurals." On the supposition, however, that P. narrawayi presented an apical aspect, these plates presented much difficulty, for, so far as known, this type specimen is the only fossil sea star showing two pairs of floor plates one over another and with their common faces meeting in the same interradial vertical plane as those of the first pair of cover plates or between what is commonly called the "adambulacral jaw" and the apical skeleton. The apparent direction of their movements would seem to aid in thrusting food out of the oral cavity, not into it. They may have become double chains of ossicles connecting the apical surface of the axillary interradial with the first cover plates and, by means of muscular attachments, serving to draw the latter apically, but whatever function we assign them (and their form hardly allows us to regard them as vestigial and functionless) we must admit that they no longer represent a primitive condition.

Although Schuchert (1915, page 34, figure 1) gives a ventral view of a "Theoretic Phylembryo of Stelleroidea. . . . Based on Hudsonaster," he pays no attention to the peculiar features noted above but draws his first floor plates as he finds them in Urasterella girvanensis. If Hudsonaster is at all like Protopalaeaster, only four floor plates could be seen beside the first six cover pieces drawn. The latter also in both Hudsonaster and Urasterella are never set exactly opposite the floor plates but slightly nearer the oral aperture.

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——— 1913*b* Does the Type of Protopalaeaster narrawayi Present an Oral or Aboral Aspect? Ottawa Naturalist, v. 27 (Oct.)

Raymond, P. E. 1912 On the Nature of the So-called "Covering-plates" in Protopalaeaster narrawayi. Ottawa Naturalist, v. 26, p. 105–8, pl. 6 (Dec.)

Schuchert, C. 1915 Revision of Paleozoic Stelleroidea. U. S. Nat. Mus. Bul. 88 (March 20)

Spencer, W. K. 1914 A Monograph of the British Palaeozoic Asteroidea. Pt 1, p. 1–56; pl. 1.

Plate 1

Page 141

Urasterella medusa new species

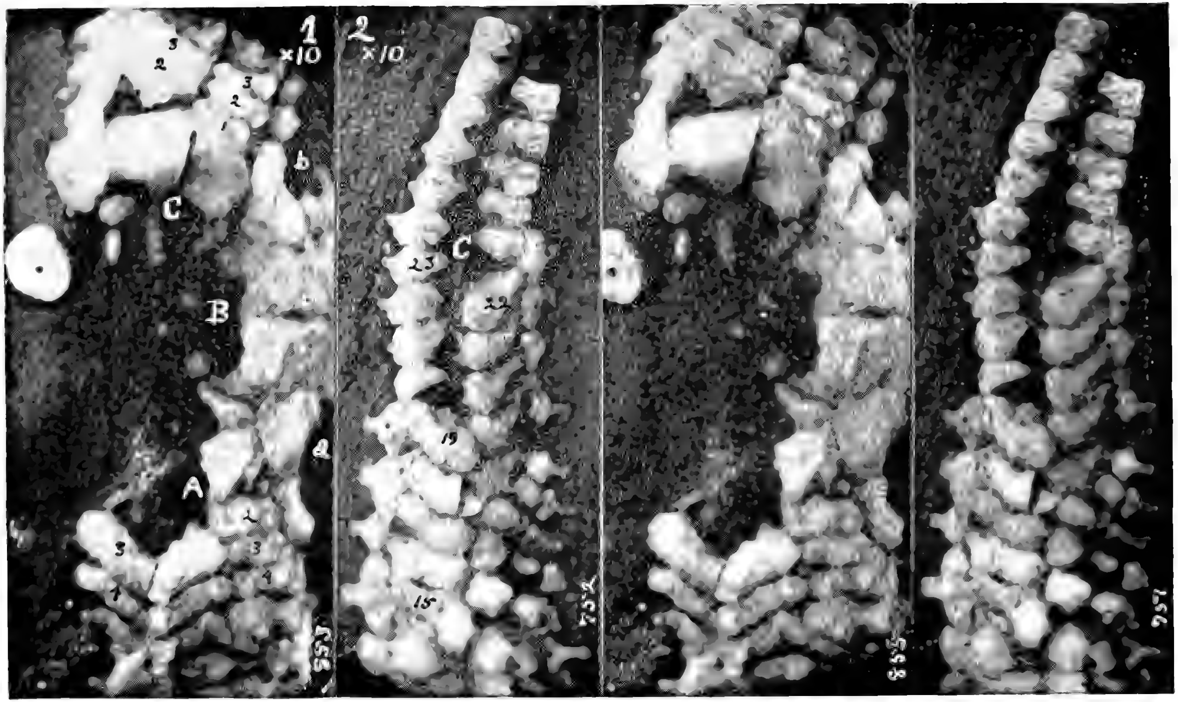
Trenton limestone. Trenton Falls, N. Y. Museum of Comparative Zoology.

Details of holotype under gum mounting. Apical aspect.

The amplification of the photomicrographs forming these plates is marked in white on the upper portions of the figures and near the figure number. The original negative numbers (near the lower margins of the figures) and the letters arbitrarily chosen to designate radii and interradii are also in white. The numbers used to designate the members of a series of ossicles are in black. Some of the important features of these plates will not be seen unless a stereoscope is used as suggested by the author in 1913*a*, page 104.

Figure 1 of this plate shows a part of the remarkably heavy peristomial ring not hitherto recorded or figured for Urasterella. Arm B is viewed at an angle from the perpendicular which shows the manner of attachment of the first cover plates (mouth-angle plates). A few scattered spines are seen. These appear to have been built up of alternate black and white discs. One of the spines belonging to the third cover piece of arm A is still in normal position and shows a slightly bent base. In this figure note particularly how the single radial remaining on arm A influenced the shape of the floor plates to which it is still attached. Pairs 3 and 4 of the floor plates of this arm show the imprint of a radial since lost.

Figure 2 reveals the remarkable apical thickening of the slightly imbricated floor plates which of themselves made necessary a strongly convex apical surface of the arm, and this without the aid of any visceral cavity. The view of the double row of cover plates, in the upper part of the figure, with their articular faces bearing traces of musculature and their buried, single outer spine bases and cross sections of small reversed spinelets, is particularly interesting. Note also the loose arrangement of the ambitals and their channels for papulae.



To be viewed through a stereoscope

Details of holotype of *Urasterella medusa* n. s.

Plate. 2

Page 143

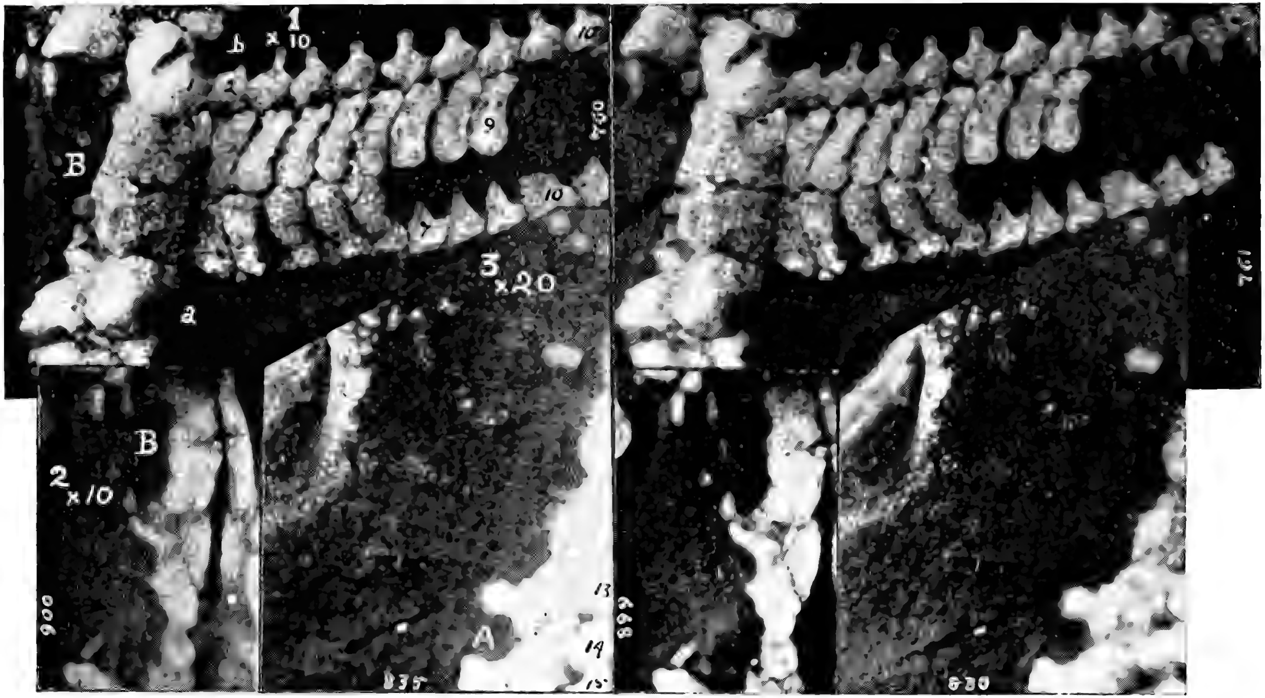
Urasterella medusa new species

Details of holotype under gum mounting. Apical aspect.

In figure 1 a part of the peristomial ring is seen in more nearly vertical view. Note particularly in upper left, that the first floor plates make a radial (" ambulacral ") jaw. The floor plates are seen to fit closely to each other, to show no podial openings whatever and no definite articulative pegs. The outer ends of a number of these plates are vertically channeled, and the faces of the marginals next them likewise, to form small tubes for papulae which made their exit between the inframarginals and the cover plates. In the open right portion of this arm are seen two small spines apparently diverging from the tenth cover plate. The right spine is seen to fork and bear two spinelets.

Figure 2 was introduced to show the thickness of the first floor plates. The apical surface is seen reflected in the cover glass.

In figure 3 we have a number of spinelets which were borne on the pedicels of the inframarginals. Here we need to notice that these spinelets could be bent and that on decay they broke up into separate discs. The pedicels themselves were detached and broke up into beadlike portions. A little over two-thirds up the right margin of this figure a detached and slightly bent pedicel is seen and in the upper right corner of the figure there are two parts of a pedicel, one showing a convex and one a concave articular face. We shall get a better knowledge of these exceedingly remarkable structures from plates 4 and 5 but the evidence of parting or breaking up into fragments on decay, here shown, is very important.



To be viewed through a stereoscope

Details of holotype of *Urasterella medusa* n. s.

Plate 3

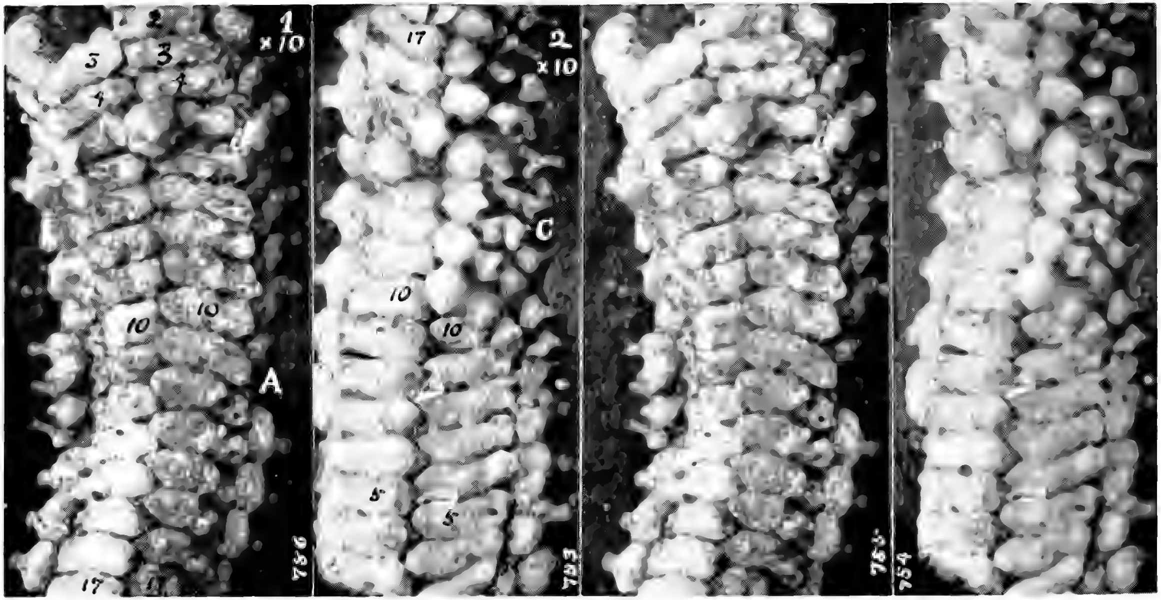
Page 145

Urasterella medusa new species

Details of holotype under gum mounting. Apical aspect.

This plate shows additional portions of arms A and C to emphasize the absence of podial openings; to show more of the impressions made on the floor plates by lost radials and supramarginals; to show whitened apical faces on the latter, due to loss of pedicels; to show further curious penetration of outer ends of floor plates; and (in figure 2) to present the surroundings of an area which we are to view under greater magnification in plate 5.

The channels cut down the outer faces of the floor plates, or in places through a part of their substance, should be looked for in other paleozoic sea stars for these openings may originally have functioned as did similarly placed pores in the Edrioasteroidea, in Blastoidocrinus and the Blastoidea. In the last two groups, which were plankton feeders, these tubes served to drain away surplus water and thus allow concentration of the living content in the material moving toward the mouth. The fixed position of the Edrioasteroidea would indicate that they were also plankton feeders and that their pores near the outer ends of the floor plates served a similar purpose. In our plates there is an irregularity about these structures which is puzzling. For instance, in figure 2 one of these pores appears to pass through (or into) the floor between the eighth and ninth floor plates of the right row. This plate may well serve the purpose of calling attention to a new field of investigation and one of no little promise.



To be viewed through a stereoscope

Details of holotype of *Urasterella medusa* n. s.

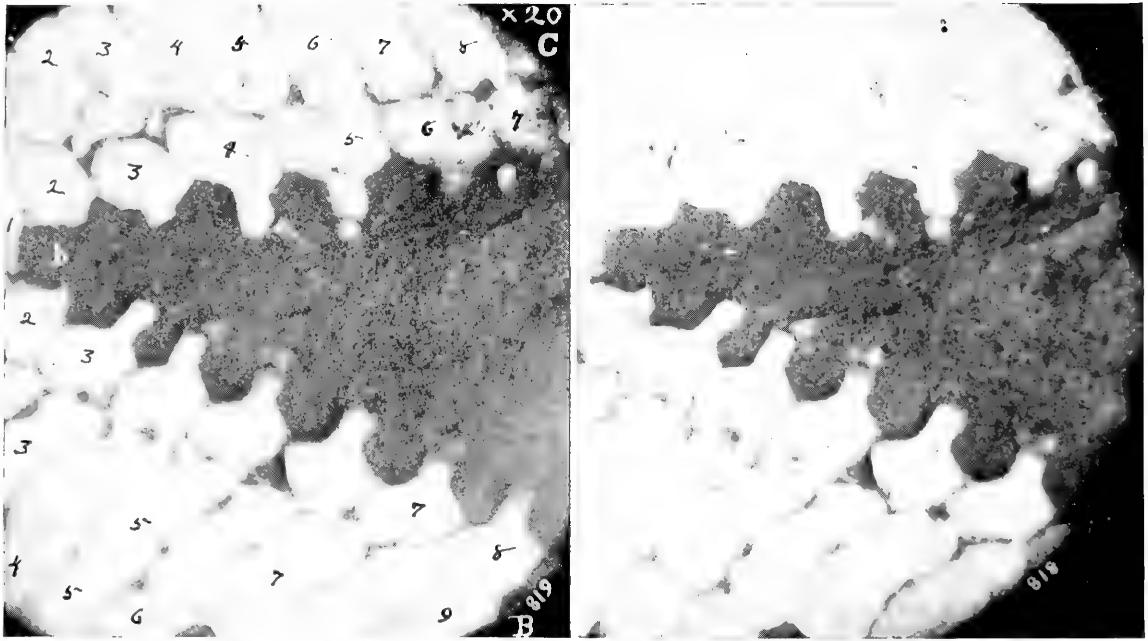
Plate 4

Page 147

Urasterella medusa new species

Details of holotype under gum mounting. Apical aspect.

In this plate the pedicels of the paxillae consist of dark discs separated by thinner white discs (arm B, marginals 4 to 7 and arm C, no. 4–6). The structure of the spinelets is similar. Most of the latter have been more or less detached from their pedicels but marginal no. 7 of arm B shows two widely opened spinelets still articulated with the dark head of the pedicel. The fourth marginal of this arm retains two of its spinelets, bent away from the axil, and, on the pedicel, an articular face for the attachment of a third. That the marginals bore pedicels which supported three long, slender, articulated and movable spinelets each is here demonstrated beyond the least doubt. While Schuchert (1915) gave two figures showing probable paxillae in *U. grandis*, the details shown were not complete enough to carry conviction to all conservative paleontologists. We have here, for the first time, evidence so complete in its details that all must accept his interpretation and admit the presence of paxillae in paleozoic sea stars.



To be viewed through a stereoscope

Details of holotype of *Urasterella medusa* n. s.

Plate 5

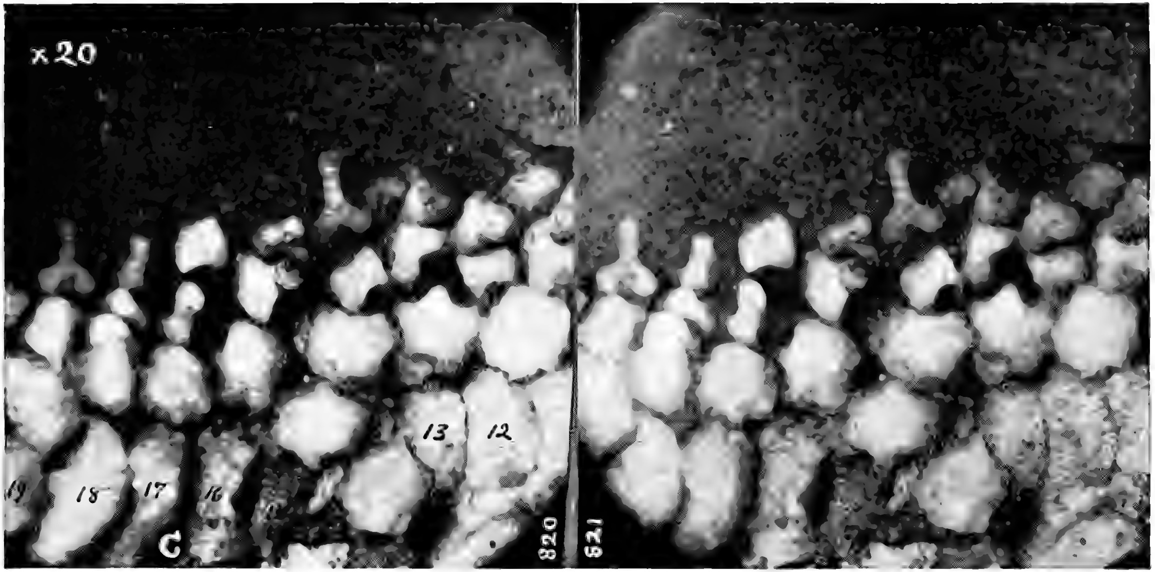
Page 149

Urasterella medusa new species

Details of holotype under gum mounting. Apical aspect.

This plate shows a bent and disintegrating spinelet near the figure indicating the amplification. On the arm margin above the thirteenth floor plate one of the ambitals is having its pedicel break up into discs. The ambital at the left of this distinctly shows a head containing indications of muscle attachments and distinct white planes along which the pedicel separates into beads on decay. Immediately below this is an ambital that has lost its pedicel but still retains the characteristic outline of one of the white planes of separation. At the right and a little below this is a supramarginal bearing a similar scar with its apex toward the upper edge of the arm. Still attached to the thirteenth floor plate is a supramarginal of the other column with a scar, its apex this time directed to the lower edge of the arm. The radial just above and to the left of this also bears a scar. These evidences for attached pedicels (there are also others in the figure) would carry the implication that all the apical plates bore paxillae.

We should also note in this figure the evidences of tufts of muscle fibers on the ambitals at the lower left of the banded ambital previously noticed. The impressions on the floor plates left by the lost radials and supramarginals are also well worth examination.



To be viewed through a stereoscope

Details of holotype of *Urasterella medusa* n. s.

Plate 6

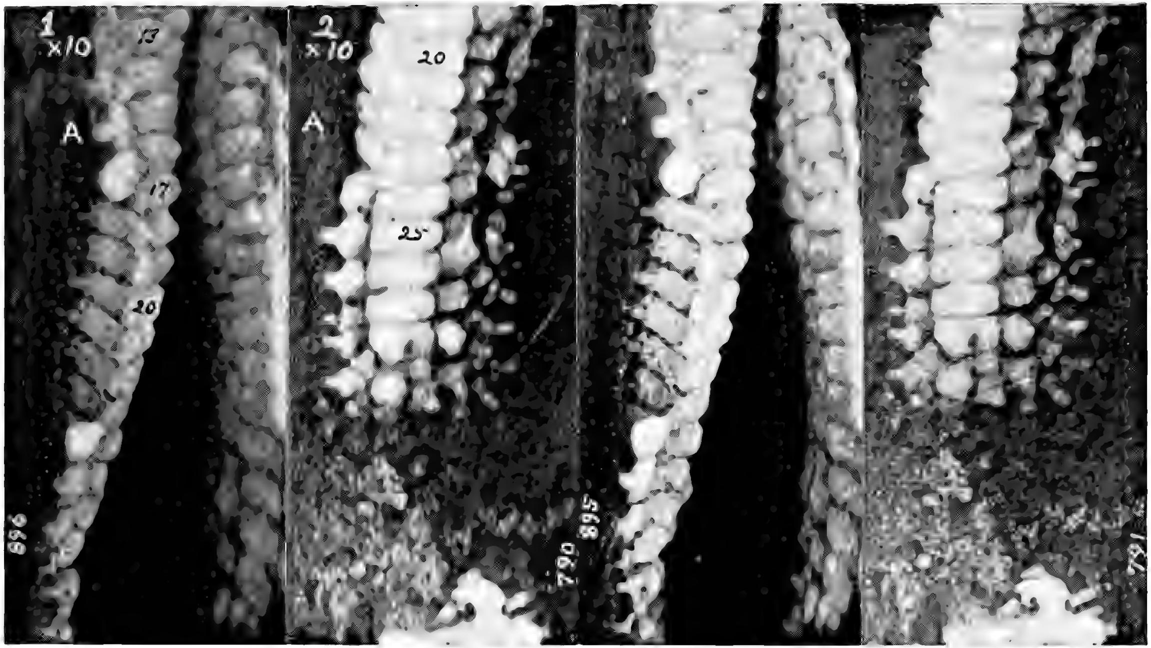
Page 151

Urasterella medusa new species

Details of holotype under gum mounting. Apical aspect.

In figure 1 is shown practically a side view of part of an arm. Between the seventeenth and twenty-third floor plates the marginals have been recently lost. This permits a view of the outer surface of six cover plates which have lost little from weathering. The oral ends of the plates (the left ends) show each a single pedicel with traces of spinelets. The character of the outer faces of these plates offers clear proof that no more apically placed row of paxillae, two to a plate (such as Schuchert credits to U. major) could have been present in U. medusa. The outer faces of these cover plates have weathered so little that they still retain the remains of tufts of muscle fibers. The oral ends are seen to fit closely against the floor plates and to be also in slight alternation with them. So marked is this arrangement between the seventeenth and twentieth floor plates that we might properly speak of them as placed alternately. This tendency of the cover plates to advance proximally and to tip their oral ends in the same direction is not only a primitive character but one almost universally present in sea stars. In this figure the floor plates are seen mirrored in the cover glass at the right.

Figure 2 is introduced to show supramarginals still bearing pedicels with muscle tufts in their heads, a sure indication that they bore spinelets. The beadlike breaking up of certain pedicels is seen in lower right of this figure.



To be viewed through a stereoscope

Details of holotype of Urasterella medusa n. s.

Plate 7

Page 153

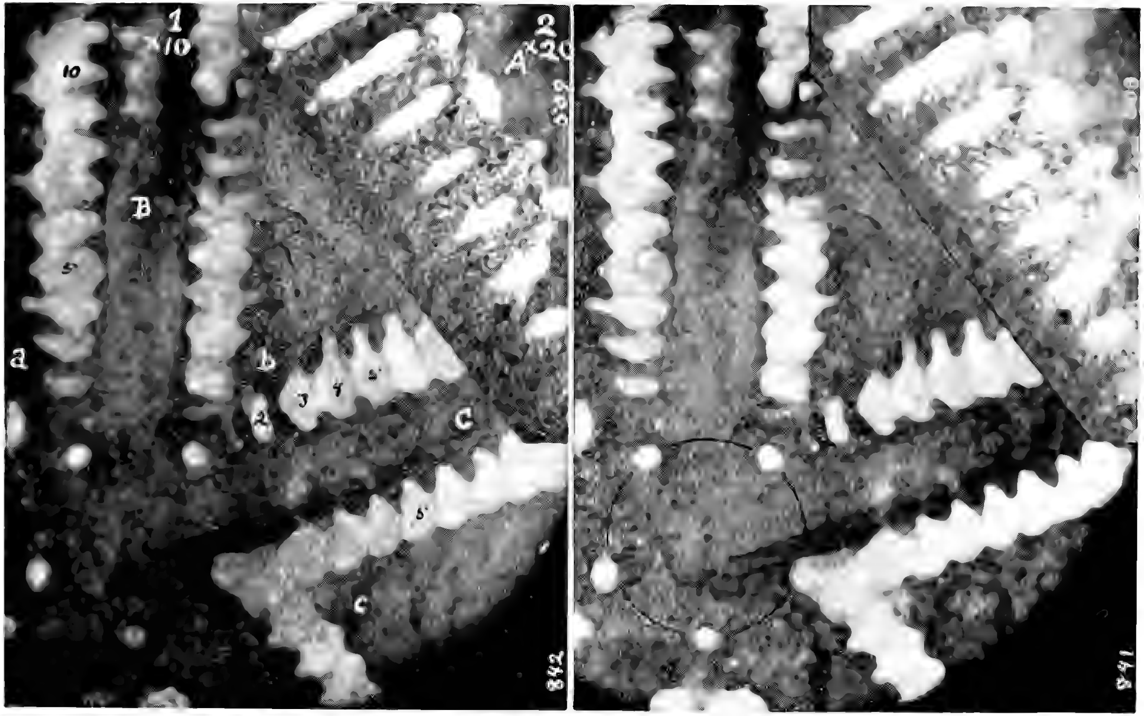
Urasterella pulchella (Billings)

Canadian Organic Remains, Decade III, p. 79, pl. 10, fig. 2. Trenton limestone, Ottawa, Can. Victoria Memorial Museum no. 1397 a.

Details of holotype under gum mounting.

Figure 1 (oral view) is introduced to show form of axillary inframarginal (interradius *c*) and arm marginals (4 to 6 of arm C next interradius *b*). The forms presented here differ very markedly from those already shown in plates of U. medusa. The holotype of U. pulchella has lost much of its central oral surface through exfoliation or frost work. Most of the cover and floor plates have been thus carried away. The four small oval interradial pieces seen in the same circle with the proximal end of the preserved axillary inframarginal are shown by the stereoscope to belong to the oral skeleton. They were either elevated bosses situated on the proximal ends of the axillary inframarginals and with which the first cover plates articulated (see plate 1, figure 1, interradius *a*) or they were small accessory plates having the same position. In interradius *b* the distal end of the axillary inframarginal is seen and the apparently buried condition of the plate would indicate that the transversely oval fragment was some distance from it and in a shaly portion of the matrix likely to be lost if an attempt to uncover the plate was made. Some excavation was made along the proximal end of radius C but without encountering any plates of the apical skeleton.

Figure 2 is introduced to show that the coinlike, raised, oral ridges of the cover plates bore either two spinelets or two pedicels on their inner ends. The arm is here turned over a little toward the left, bringing the inframarginals into view. The raised ridge itself seems to act like a pedicel and the two processes, in upper left of figure, are distinctly articulated with it. In U. medusa, however, (plate 2) the evidence seemed to be for two pedicels on this edge of the plate, both of which bore two spinelets. The mass of fragments packed in the hollows between the ridges undoubtedly belonged to the specimen (as will be seen in plate 12, figure 1) and are perhaps detached tubercles. Their diameters are too large to allow them to be associated with the articulated spinelets shown in the same figure. Note also in this figure (particularly in left half of stereogram) the indications of small tufts of muscle fibers on the exposed surfaces of the coinlike ridges.



To be viewed through a stereoscope

Details of holotype of *Urasterella pulchella* (Billings)

Plate 8

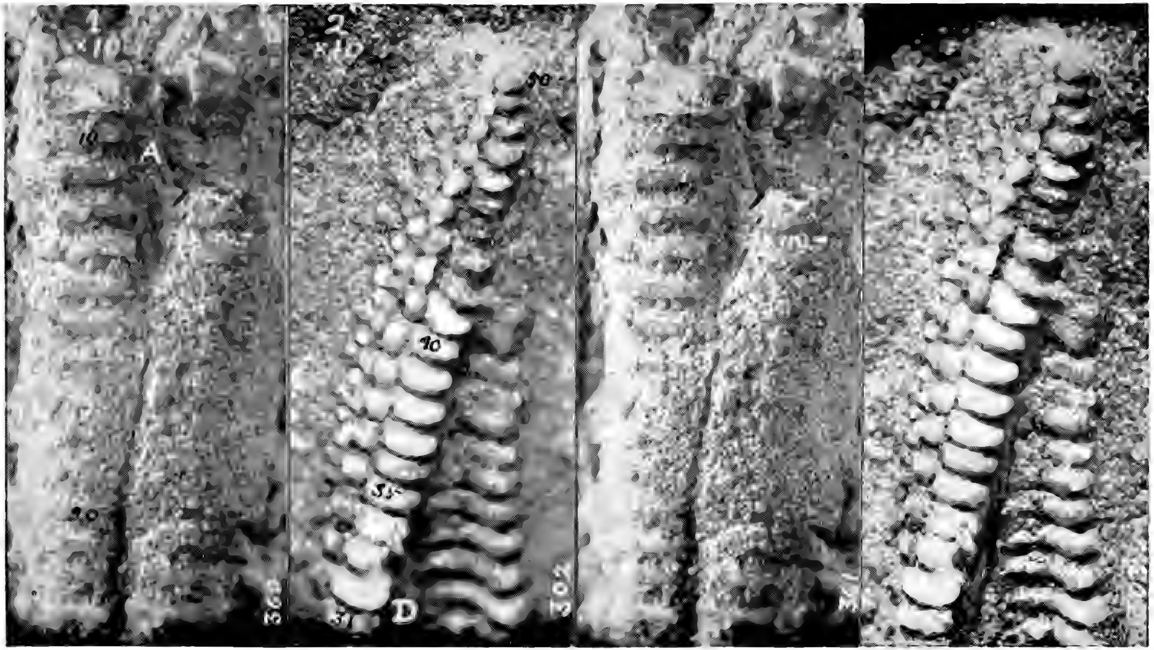
Page 155

Urasterella pulchella (Billings)

Details of holotype without gum mounting. Oral aspect.

In figure 1 the arm is slightly open in upper portion, but below this the cover plates are completely closed over the food groove. In figure 2 the arm is open at the thirty-first pair of cover plates and gradually closed toward the tip. The function of the cover plates is very clearly shown in these figures.

Figure 2 also shows other details of interest. The thirty-ninth cover plate of the left column shows distinct vertical dark striae .09 mm apart on the side next the fortieth cover plate. On the oral face of the coinlike portion of the fortieth cover plate of the opposite column similarly spaced lines cross the ridge but appear to be connected along its margin. These marks are commensurate with the dark shell-like fragments seen in plate 7, figure 2, and probably show attachment edges of tubercles. This plate shows also one column of inframarginals and it must be noted that back of this column is another with plates nearly as large (see particularly the region of the forty-third cover plates). The transverse diameters of two of these plates taken together would here nearly equal the length of the ridge on a cover plate. We shall have occasion to refer to this in the study of plate 9.



To be viewed through a stereoscope

Details of holotype of *Urasterella pulchella* (Billings)

Plate 9

Page 157

Urasterella pulchella (Billings)

Details of holotype under gum mounting. Oral aspect.

The three figures given here show cross sections of a portion of arm A of the holotype. A small piece was taken out by permission of Director R. W. Brock and to him we are indebted for the knowledge of the remarkable structure of the arm here revealed. Figures 2 and 3 show the two ends of the cut as left on the specimen. The arm fragment will be further developed by grinding down and making a series of stereograms at measured distances.

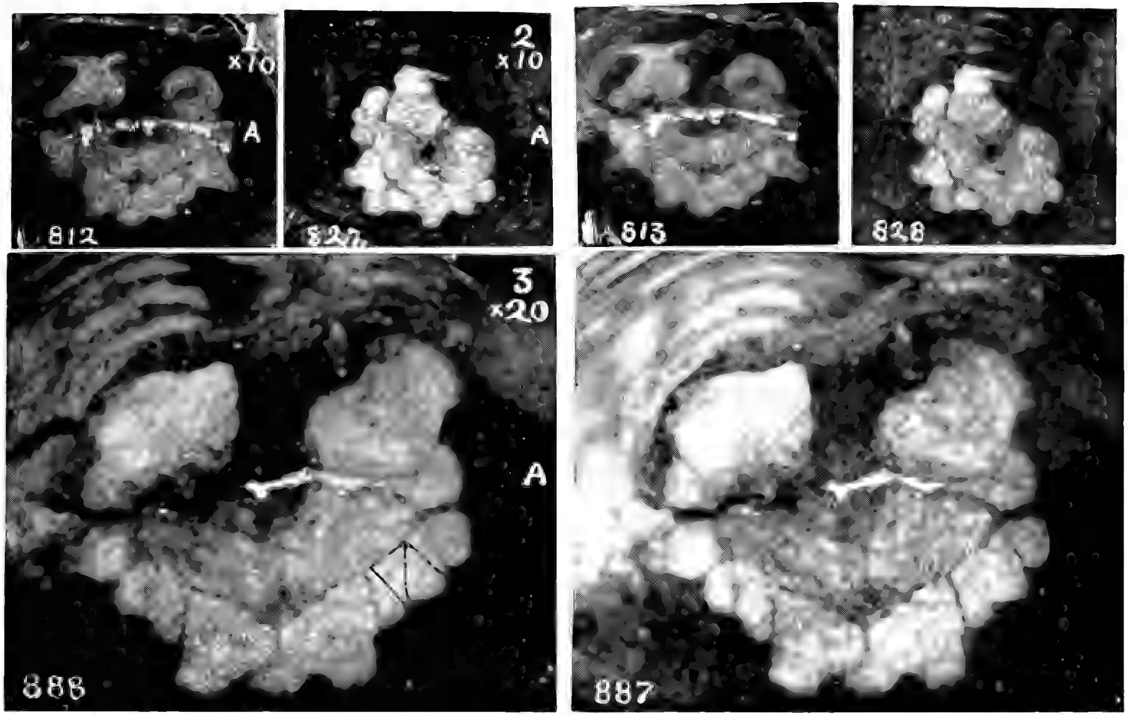
When the cut was made a little white paint was used to mark the proximal end of the fragment before removal. This paint passed a little way into the horizontal exfoliation fissure which caused so great a loss of the oral surface of this specimen. In our figures it serves to mark the proximal views.

Figure 1 shows a cross section made in the region of the fifteenth cover plate of arm A. The paint line forks at the right and its lower branch separates an inframarginal above from a large plate below. We should identify the latter as a supramarginal were it not for the two columns of large plates situated next the radials. On the floor of the food groove note the central and two lateral ovals outlined in black, each with a dark dash along its primary axis.

Figure 2 also suggests the presence of a double series of marginals in contact with each other. This figure gives an interesting view into the radial canal.

Figure 3 gives a view of the region shown in figure 1 as it appeared after a little grinding of the surface. It will be noticed that the apical portion of the arm is but slightly altered, but in the oral portion (on right cover plate) a spone and a medial ridge are now shown. The outer part of this ridge appears to be marked off as a distinct and perhaps separable portion of the plate and its inner end to show a shorter and smaller spine than the one first noticed. The arm here seems to show 15 columns of plates besides the remarkably large cover plates and floor plates. Outlines of two of the smaller of these plates have been intensified in the left half of the stereogram. As in figure 2 of plate 8, the first two columns outside of the cover plates have together a width equal to the length of the raised ridge on the cover plate.

The shape of the floor plates in these figures and their perfect contact with the apical skeleton demonstrates the utter absence of both viscera and internal ampullae. The finer dark lines on these cross sections are in part growth lines and in part sections of the water vascular and other systems. While the finest of these lines will be lost in reproduction, it is hoped that much of their interesting detail will be preserved.



To be viewed through a stereoscope

Details of holotype of *Urasterella pulchella* (Billings)

Plate 10

Page 159

Urasterella pulchella (Billings)

Trenton limestone, Ottawa, Can. Victoria Memorial Museum, no. 1397

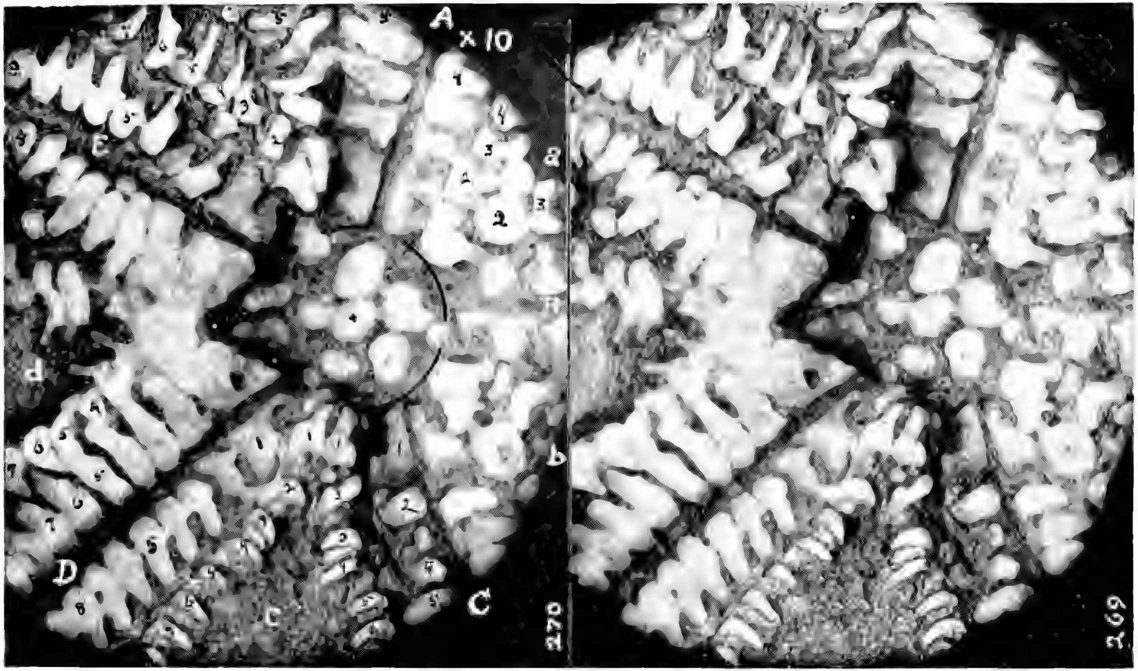
Details of plesiotype under gum mounting. Oral aspect.

Billings did not have this specimen when he wrote his description of the species, but it bears a label in his handwriting. This is the specimen figured by Schuchert in 1915, plate 28, figure 3. The lowest arm in that figure is our arm E.

The oral cavity has here been excavated until it now reveals a portion of the aboral skeleton. Interradius *d* was also cut down by degrees and a series of stereograms secured, of which the one here presented was the last.

The first covering ossicles are seen to possess arched and projecting distal ends and to meet to form a very effective interradial outer jaw (see interradius 2). This jaw was drawn inward by adductors which had their origins on the first flooring ossicles. Next to interradius *d*, one of these muscle pits was partially removed and the other completely so, in order to show that these pits were not pores.

The first flooring ossicles are very heavy and the radial pairs terminate orad in projecting ends that apparently could act as crushers for such larger shelled organisms as were thrust into the oral cavity by the external jaw. Many of the other floor plates show what appear to be small articulating pegs projecting proximally, but sockets are not so apparent and the " pegs " may be simply raised bars separating the inner from the outer plate depressions. The appearance of great libertv of motion seen here is negatived by our plates 2 and 3.



To be viewed through a stereoscope

Detail of plesiotype of *Urasterella pulchella* (Billings)

Plate 11

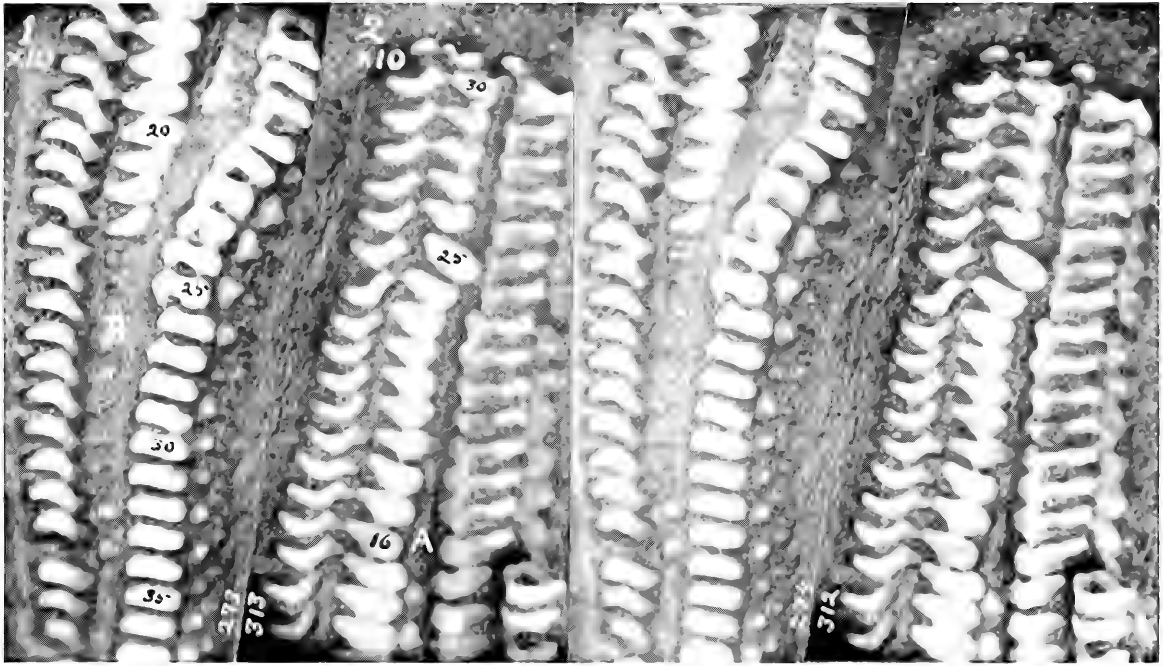
Page 161

Urasterella pulchella (Billings)

Details of plesiotype under gum mounting. Oral aspect.

In figure 1 various aspects of the cover plates can be seen. The left column shows that the apical ridge was supported by a narrow portion of the plate and that the outer edge and the spaces between were thickly covered by tubercles containing much organic matter. On being detached or broken open they appeared to be shell-like as shown in plate 7, figure 2. The cover plates of the opposite row show sections across pits (one of which was seen in plate 9, figure 1) on their distal faces which, as articulating pegs are not shown, were muscle pits.

In figure 2 (lower right) one of these distal concavities is better seen. The floor plates of the right column show their true oral surfaces and the angle against the outer face of which the cover plates rested when open. A stereoscope must be used to see the elevation. The proximal "peg" is here seen to be situated next the inner ends of the plates. In the upper part of the left column the loss of plate surface has shifted the "peg" toward the outer end of the plate. At plates 15 and 16 the loss of surface has carried the "peg" to the middle of the plate. This feature then represents a bar running diagonally across the proximal face of the plate and caused by an excavation on either side, these excavations not reaching the apical border.



To be viewed through a stereoscope

Detais of plesiotype of *Urasterella pulchella* (Billings)

Plate 12

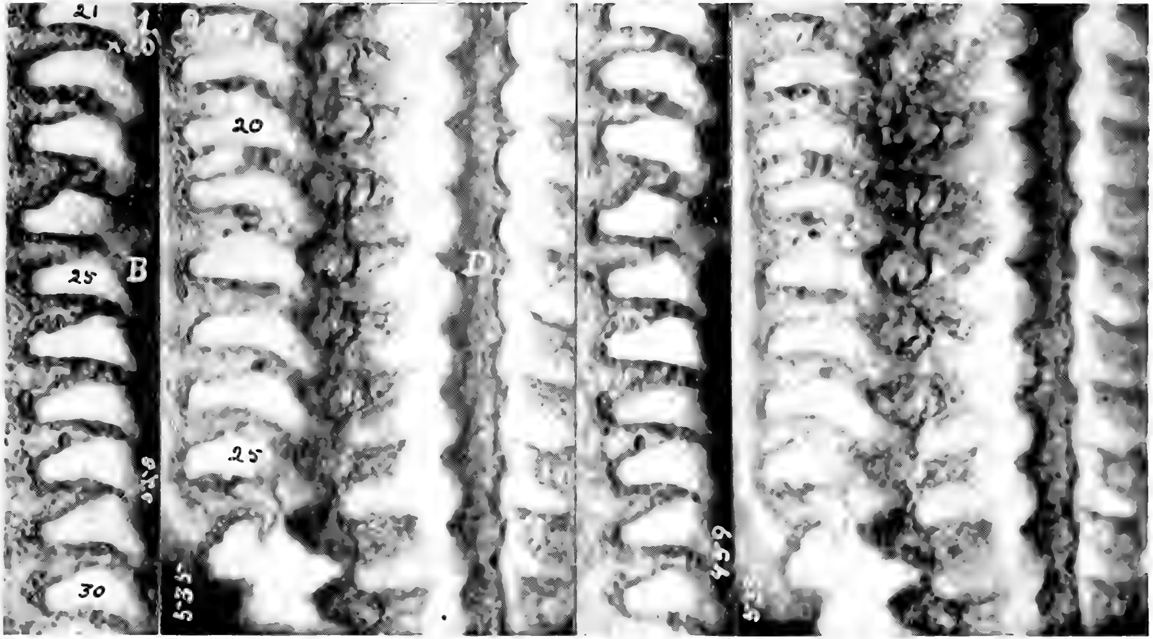
Page 163

Urasterella pulchella (Billings)

Details of plesiotype under gum mounting. Oral aspect.

In figure 1 of this plate the pustules, which cover so much of the surface of the cover plates, are more highly magnified.

In figure 2, a few of these pustules are also seen and between the twenty-first and twenty-second plates there is one that appears to have connected the plates by a muscle process. The important features here shown are the dark circles or arcs of circles over the outer border of the floor plates and the shallowing channel running diagonally inward from these and ending on the next proximal plate. These are the remains of ampullae and perhaps of podia. The former were situated in excavations not yet passing through the floor of the food groove and were further protected by the cover plates. Their diameters as here preserved are a little more than twice that of the radial canal as seen in plate 9, figure 2.



To be viewed through a stereoscope

Detais of plesiotype of Urasterella pulchella (Billings)

ANCIENT WATER LEVELS OF THE CROWN POINT EMBAYMENT

BY ELMER EUGENE BARKER

1 INTRODUCTORY STATEMENT

The observations recounted in this paper are offered in the hope that the attention of geographers and geologists may be attracted to a locality whose postglacial physiography is of great interest in connection with any critical study of the general glaciation of the Champlain region.

The writer has mapped and attempted to describe and interpret in some detail a part of the phenomena of this locality. He has used local place names where necessary to insure exact identification to possible future investigators in this field. It is his purpose here to show that the evidence they furnish falls in line with the phenomena observed by other investigators in this region, and tends to substantiate their theories concerning its postglacial history.

In making these observations a field map was used. It was enlarged from the United States Geological Survey map of the Ticonderoga quadrangle. On this map were then charted the various moraines, beach terraces, shore lines, wave-beaten cliffs, and the like, as they were found. These were then correlated along their proper lines and compared with the theoretical expectation as to the altitudes and places where such phenomena should be found.

Many observations were made with an aneroid barometer, but it was found to vary so from day to day and to be so inaccurate that data taken with it were discarded wherever those on the United States Geological Survey map could be used.

The theoretical expectancies for the locality here studied were calculated on the basis of Prof. J. B. Woodworth's postulated altitudes of the postglacial Champlain water bodies [1] (Woodworth 1905).

2 PREVIOUS WORK IN THIS REGION

Among the first men to study the postglacial physiography of this region were S. P. Baldwin [2] (1894), G. K. Gilbert [3] (1896, p. 59) and C. E. Peet [4] (1904). Of these, Peet studied particularly the

[1] Citations in parentheses refer to bibliography at end of paper.

[2] Baldwin, S. P. Pleistocene History of the Champlain Valley. Am. Geol., 13:170–84. 1894.

[3] Gilbert, G. K. U. S. Geol. Survey, 18th Ann. Rep't, 1:59.

[4] Peet, C. E. Glacial and Post-glacial History of the Hudson and Champlain Valleys. Jour. of Geol., 12:415–661. 1904.

physiography of the Hudson and Champlain valleys with special reference to changes in altitude and drainage since glacial times. All three men found evidence that bodies of water had occupied this region just subsequent to the disappearance of the continental ice sheet, and that the level of these bodies had not remained constant during the whole time of their duration.

The epochs of the several bodies of water which have occupied this region in the time since the retreat of the ice from the Brooklyn-Perth Amboy moraine were designated by Peet (1904, p. 661) as follows:

1 Hudson-Champlain
2 Higher glacial Lake Champlain
3 St Lawrence-Champlain
4 Marine Champlain
5 Present Lake Champlain

All three believed the earlier and higher bodies of water to have been glacial lakes, and that the latest and lowest of the ancient water levels was marine.

G. K. Gilbert in 1896 made observations at the northern end of the Champlain valley in the vicinity of Covey hill. His unpublished notes were available to Woodworth (1905, p. 67).

Between 1900 and 1903 Prof. J. B. Woodworth of Harvard University, as a member of the New York State Geological Survey, studied this region and attempted to solve the problems of its glaciation and subsequent alterations. His conclusions were that, pari passu with the retreat of the ice sheet in the Hudson-Champlain valleys, a glacial lake occupied the uncovered portion of the region; and that when the ice finally left the northern end of the valley the ocean came in by way of the St Lawrence valley converting the Champlain valley into an estuary. At different times these waters stood at different levels, and these stands are marked by clearly defined shore line phenomena. Professor Woodworth has correlated these isolated shore line phenomena along continuous lines, and thus has been able to trace the outlines of the ancient lakes at each stage of their existence.

More recently (1910–12) Prof. H. L. Fairchild of the University of Rochester has revisited the region in the service of the State to continue the researches of Professor Woodworth. His conclusions are stated in a preliminary report in the Annual Report of the State Geologist for 1912 (Fairchild 1913). He believes that all the ancient shore lines are due to marine waters rather than to waters of glacial lakes; that the impounded waters following the retreating ice front formed a long inlet from New York bay. "As the ice front melted back the ocean followed it and flooded the valley. The waters were at first the Hudson inlet; later, the Hudson-Champlain inlet; and finally, the Hudson-Champlain strait (Fairchild, 1913)."[1]

The studies of the present writer were based chiefly on the work of Professor Woodworth (1905). His correlated lines of ancient levels (as given on his diagram, plate 28 of reference cited) were accepted as a working basis and the phenomena about Crown Point were found to accord with them. No evidence has been noticed, however, either in support or disproof of the marine origin of the ancient shore lines in this vicinity.

3 SPECIAL CORRELATIONS OF THIS PAPER

AS TO LOCALITY

The topography of Crown Point, N. Y., and its location in relation to Lake Champlain are shown on the map of the Ticonderoga quadrangle of the United States Geological Survey.

The locality dealt with in this paper forms an embayment of the main Champlain valley extending inward in a southwesterly direction about four miles, and with a width of two to three miles, roughly speaking. To the north lies the bulk of Bulwagga mountain which presents its steep southern flank to the main valley, and a precipitous southern face to the embayment. Its western limits are the slopes of certain hills and Buck mountain, while its southern boundary is the slope of Breed hill with its lower shoulder, Sugar hill.

The writer continued his observations around the eastern face of Breed hill and Dibble mountain, and southward from the embayment through the pass between Buck and Dibble mountains to include the Sawyer hill moraine terrace in the Ticonderoga region.

AS TO EVIDENCE

This locality has strongly marked evidence of vigorous glaciation and subsequent modification by action of static waters. All about the bases of these mountains lie great moraines of rubble, and just south of the Vineyard pass is a massive lateral kame terrace of gravel built up by the marginal torrent that debouched through the pass (Peet, 1904, p. 463, 622, 623, and Woodworth, 1905, p. 154–156, 195).

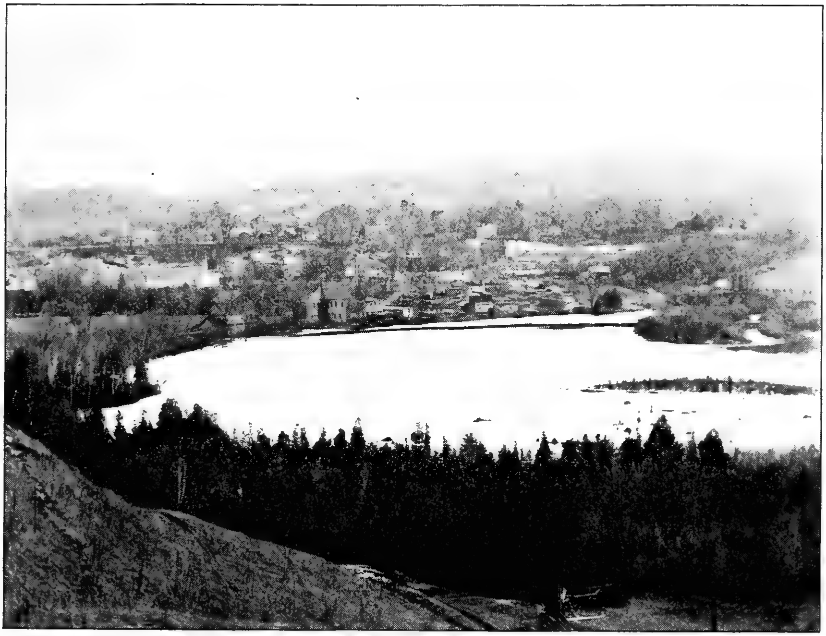
[1] Loc. cit.

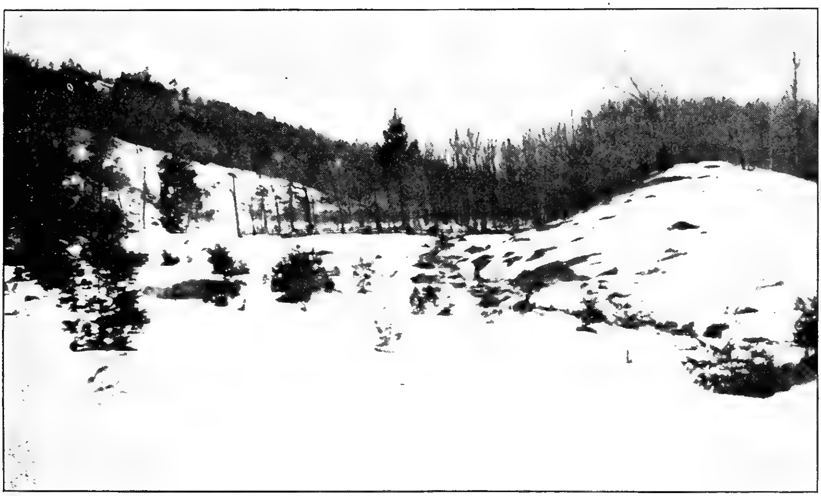
Into the sides of these moraines, shore lines have been cut at definite levels, usually defined by cobble beach terraces. Steep, exposed eminences have been washed bare of soil at the levels of the ancient lake, and at such places they present rugged cliffs. In more sheltered situations the action of the waters formed gentle lines of sandy beach, or in the lee of reefs and islands built up shoals and sand bars. The streams, too, at the levels where they emptied into the ancient water body built deltas great or small, according to their own size. Bottom deposits, also, were formed and now give decisive evidence as to the extent and nature of the water body in which they were laid down.

4 GENERAL FEATURES OF THE CHAMPLAIN GLACIATION

At the end of the Pleistocene Glacial Epoch the latest or Wisconsin stage was closed by a dwindling of the continental ice cap. It shrunk from the mountain tops and higher areas where it had been thinnest and came to occupy only the valleys and lowlands between them. At that time a tongue of ice occupied the Champlain valley and extended through the defiles of Lake George and Wood creek and down the Hudson valley to the sea. Its retreat has been detailed by Professor Woodworth in the paper mentioned above. During the advancing and maximum stages of this Wisconsin ice sheet practically all traces of former ice invasions were obliterated, as well as the marks of its own advance. Thus we have left at its disappearance only the phenomena made by the most recent occupation in its waning stage. The scouring, striae and grooves in the bedrock were usually buried beneath a blanket of till. Its slow retreat was marked by retreatal and marginal moraines. In the stagnant lobes at its end, rivulets from the melting ice fell into crevasses and bored potholes at the bottom of deep moulins (Barker, 1913 and Woodworth, 1905, p. 228). Where the rock walls at the sides of the valley reflected the sun's insolation the ice melted fastest, and here along the edges of the ice tongue flowed glacial streams laden heavily with silt and stones from the melting glacier. These streams flowed partly over the ice and in part cut their channels into the valley wall leaving scourways. At favorable places these streams widened out into marginal lakes whence the impounded waters escaped to the next lake of the chain at a level slightly lower. These marginal streams carrying their loads of debris deposited some of it along the edge of the glacier, which became lateral moraine terraces after the

Plate 1





Upper figure. Looking toward Sugar hill and Breed hill from the top of Indian ridge. Crown Point village is shown on the 180 foot terrace. The intervening valley, where lies Bly's millpond, has been excavated by Putnam's creek in the 180 foot delta plain since the invasion.
Lower figure. Marginal channel at base of Burk mountain (from the breach in the moraine) showing morainic ridge to the right

disappearance of the ice, and some of it in the beds of the glacial lakes forming small lacustrine deposits.

In the Champlain valley all these phenomena, till sheet, terraces, marginal moraines and lake beds, have been modified subsequently by the wave action of the body of water that occupied the basin between the Adirondacks and the Green mountains. This extinct body of water is known as Glacial Lake Champlain or the Lake Vermont of Woodworth. At this time the end of the glacier must have extended right across the valley, a splendid ice cliff from which huge bergs were continually breaking off into the great body of water that it held in as a dam from mountain wall to mountain wall. Over this expanse floated the bergs, sometimes dropping scattered boulders from their mass into the bed of the lake.

5 GENERAL FEATURES OF THE LOCAL GLACIATION

The main valley glacier pushed a subsidiary lobe into the Crown Point embayment. Without sufficient momentum to force itself up over the western hills, its progress was blocked by their massive bulk, and retarded here by friction against the mountain barriers, its load of rock was dumped from the edges in gigantic moraines that now lie heaped against the mountain sides. The retreatal moraines that the ice tongue left behind it as it withdrew from the embayment have been greatly modified by the subsequent action of waves, by lacustrine deposits, and by more recent stream erosion. Into the sides of these moraines the waves of each glacial lake cut shore lines at the level of its altitude. Between these water levels the original topography, untouched by movement of the surface water, remained unaltered by wave action. But it was modified somewhat by bottom deposits of silt brought in by two drainage streams from the mountainous region to the west. Although recent erosion has dissected these bottom deposits, they are still distinctly recognizable as such.

At the highest stage of the glacial lake Sugar hill was entirely submerged, and the waters extended to the higher hill behind it (see map 1). Subsequently, at a lower level of the glacial lake, its summit formed an island connected with the mainland by a sandpit in its lee (maps 2 and 5). At this stage of the lake Sugar hill was not entirely submerged. Only the highest portions rose above the surface of the waters, including that portion south of the fork of the road that runs southward from Crown Point village, and also, probably, some bare ledges of rock on the extreme eastern end.

Between these outlying reefs and the larger island was a shallow bottom over which the waves from the north rolled clear to the base of Breed hill. Wave action truncated and smoothed the till covering of this portion of the hilltop.[1] In this shoal was a shallow lagoon or pool. Its location is still marked by two small wet basins in which cat-tail flags and other aquatic vegetation find habitat.

6 SPECIAL PHENOMENA OF THE CROWN POINT EMBAYMENT

MORAINES

Ground Moraine

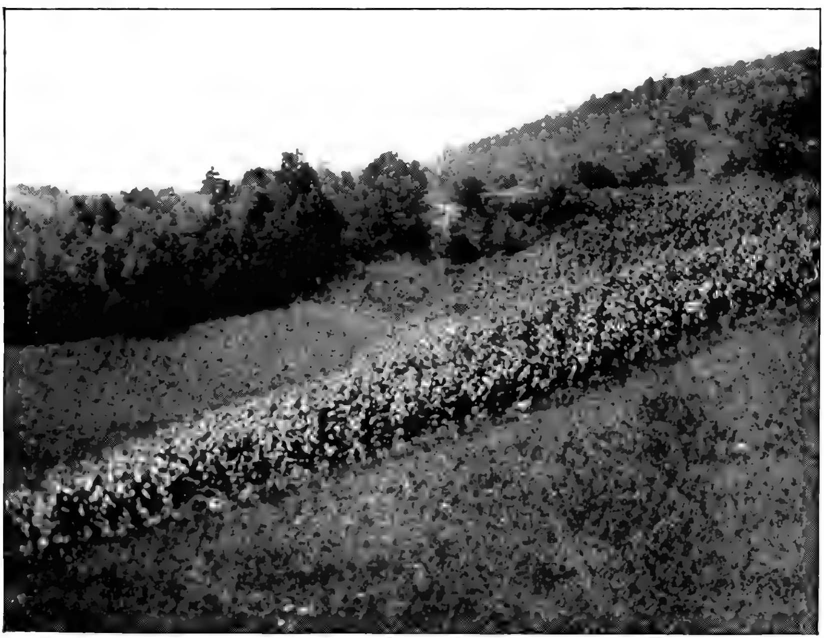
The whole valley is probably lined with a ground moraine or till sheet of blue clay, although it is concealed in many places by later deposits of alluvium. This clay has become oxidized to brown in places where it is exposed. It contains great numbers of irregular boulders which represent all the kinds of rock that occur to the north in the glacier's line of flow. This till sheet covers the surface of Sugar hill from its base just above the loam flat where Crown Point village stands, up over its top and well over the top of Breed hill. In the southwestern and western part of the embayment it is exposed wherever the streams have cut deeply enough through the overlying alluvial deposits to reach it. It covers also the area north of Putnam's creek and east of Bulwagga mountain. In the lowest part of the valley, west of Bly's mill pond the creek has exposed a bed of heavy blue clay along its south bank, and stony moraine east of the mill.

Lateral Moraines

Morainic deposits are a well-marked feature of the glaciation of the Crown Point embayment. Marginal moraines mark the outline of the ice tongue that pushed into the embayment from the main valley. These moraines are of coarse material — usually mere heaps of rubble — and skirt the bases of the mountains along the northwest and southwest sides of the embayment at an altitude of between six and eight hundred feet. None occurs on the south side, but here the till sheet lies exposed. In the pass between Buck and Dibble mountains are morainic heaps of rubble with deep kettle holes in them (plate 2). They extend well out into the open

[1] A well bored on the top of Sugar hill passed through about 50 feet of unmodified till before penetrating bedrock.

Plate 2



Upper figure. A kettle hole in the top of Sawyer hill marginal moraine. Notice the figure of a man in the apex of the kettle hole.
Lower figure. Portion of a kettle hole in the Sawyer hill marginal moraine

region to the north where the pass widens out. There they become obscured by the overlying deposit of alluvium.

Phillips Moraine

At the southern end of Bulwagga mountain there are moraines on its eastern face. An old and little used road between the George Gage place and the Phillips house skirts the base of a gigantic moraine. This moraine consists of erratics of all sizes from smallest pebbles to immense boulders. It arises from the 340 foot terrace of sandy loam. At 438 feet (A. T.) there is a wide slanting terrace covered with small stones. At the back of this terrace the moraine rises again with a steep, rocky ascent and forms a ridge extending northeast by southwest at an altitude of 720 feet (according to the United States Geological Survey map). It lies against an outlying spur of Bulwagga mountain, for its southwest aspect shows outcropping ledges of gneiss. Upon this spur as a core the moraine was built up — a huge pile of transported stones. West of it lies an open, upland valley. The northern side of this valley is formed by the precipitous face of Bulwagga mountain. This valley may well have held a small marginal pond at one time. Even now, its lowest part is wet and ill drained, but the remainder of the valley floor is covered with a sheet of sandy till which is very heavily interspersed with boulders. Many of them are Potsdam sandstone, and many are blue Ordovician limestones such as occur the length of Lake Champlain. There can be no doubt that the ice pushed up into here from the main valley bearing with it these erratics, and that it did not come from the Adirondacks to the north and west. The northern side of this little valley shows other piles of morainic rubble which slope upward onto the granite ledges of the mountain itself. Here a little moraine of sand forms a very pretty crescent on the valley floor, with concave face to the northeast, and is evidently the terminal moraine of a tiny ice lobe. Its top is at 655 feet (A. T.).

Russell Street Road Moraine

On the road known as Russell street between the Port Henry road and White Church, some great rubble moraines are to be found (see map 5). They lie just above that part of the road that skirts the base of Bulwagga's southern spur. About one-half of a mile east of White Church, and just west of the house occupied by Mr Hayford, the moraines on the mountain side show a profile as outlined in the diagram (figure 1). The moraine presents a series of five horizontal ridges, most of them small but well marked. Between the fourth and fifth ridges is a ditch about 20 feet deep. Behind this, the largest ridge rises with a steep face about 70 feet above the bottom of the ditch. The top is 758 feet (A. T.) and here it merges into the general slope of the mountain. A short

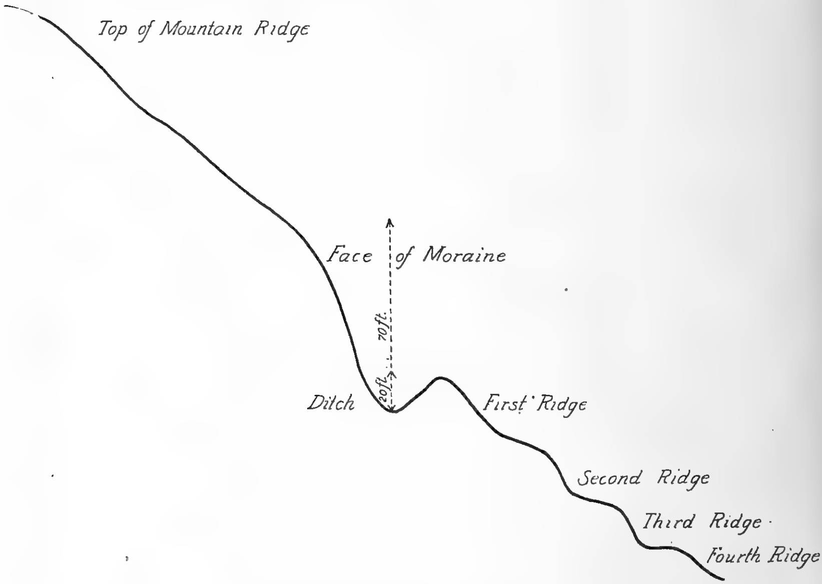


Fig. 1 Profile of morainic mountainside above the Russell Street road east of White Church.

distance farther east, just at the southeast angle of Bulwagga mountain, is another moraine of boulders. There is a ditch 5 to 20 feet deep separating it from the mountain wall. Into its side at 520 feet has been cut a flat terrace about 100 yards wide, the surface of which is composed entirely of cobblestones. Below this again, is a narrow slanting terrace.

Petty Hill Moraine

On the Petty Hill road above the 520 foot sand terrace the road climbs over a large moraine, then descends slightly through what may have been a marginal channel up again over the slope of the hill itself. This moraine begins a little to the north of the road but lies mainly south of it. An outcrop of gneiss on the face of one of its eastern lobes indicates that it may be founded on a core of solid rock. From the northern end it rises and becomes broader toward the south where it ends abruptly in a very steep face, dropping suddenly to the creek far below. It is highest at the extreme south end where it takes the form of a crescentic ridge with concave face to the west, superimposed on a less perfect crescent. The altitude here is given as 660 feet on the United States Geological Survey map. The hill presents a steep, sharp-sided lobate face to the northeast, east and south. Its surface is marked with kamelike depressions and hummocks, and supports a scant growth of grass and polytricum moss, with pine trees at the south end. It is too stony to permit the entry of a soil auger.

To the south, across Putnam's creek gorge, is another morainic deposit. A very level-topped terrace extends southward from the highway called locally the "Middle road." Its top is outlined by the 600 foot contour line and its outer edge is lobate. Below this level top the surface takes on the rounded, hummocky appearance characteristic of unmodified morainic topography. This terrace has at its back two ridges, the more northerly of which is a tectonic ledge of gneiss. The other is a moraine into the face of which the terrace has been cut. Both the moraine and terrace are ended abruptly to the south by the Amy Hill brook. Overlooking the brook, and about 15 feet lower than the terrace top, is another terrace. It is about 50 yards wide with a flat stony surface, and runs northeast by southwest. It was formed, probably, by the brook as it cut its way down.

Buck Mountain Moraine

On the eastern base of Buck mountain is another moraine. It is west of the road running west from Crown Point Center to Ticonderoga, and opposite the place where this road is joined by the road coming westward from Sugar hill (see map 5). Just west of the road is a field of fine sandy loam sloping up to the base of Buck mountain. It contains pebbles and small stones of smoothly rounded shapes. At the edge of the woods (500–520 feet altitude according to the United States Geological Survey map) the ascent becomes steep, very rough with huge rough boulders, and appears like a wave-swept shore line. One ascends 40 or 50 feet up this steep, rocky slope onto a stony, sloping terrace about 50 to 75 feet wide. This in turn is terminated at 664 feet (A. T.) against the ledges of the mountain itself.

Following this terrace northward, it is seen to become level-topped where it emerges from the woods into an open space. Here at its north end it is composed of irregular and rounded stones, and is unmistakably of morainic nature. The boulders are such rocks as occur in native ledges to the north, gneisses, Paleozoic limestones, and so forth. Angular pieces of Potsdam sandstone were noticed.

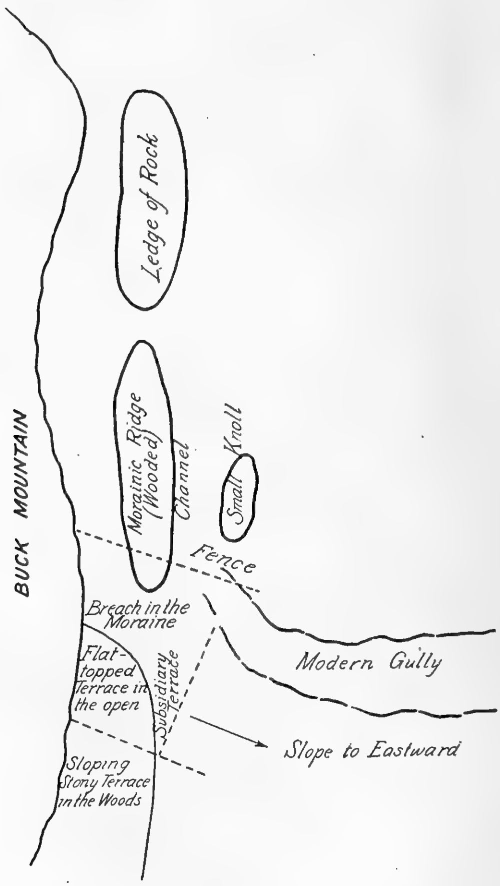


FIG. 2. Diagrammatic sketch of the area adjacent to the base of Buck mountain, showing morainic ridge and terraces and marginal channel

These do not indicate, necessarily, transportation by berg or pan ice, since outcrops of this sandstone occur as near as a mile away, about Crown Point Center, and if these pieces did come from such nearby sources, their transportation in the glacier would not have sufficed to wear off their edges and corners. The moraine terrace is interrupted here by a breach about 75 yards wide (figure 2 and plate 1, lower figure). North of this breach it is continued as a morainic ridge distant 100 yards from the mountain wall. Its top is 20 to 30 feet higher than the depression between it and the mountain. This morainic ridge continues northward rising slightly, and is narrow on top. At its north end it slopes down again to meet the south end of a tectonic ledge that continues northward along the same axis at a like height. Along the outer face of this ledge and moraine is to be seen a wave-beaten line of large, exposed rocks.

Between the ledge-moraine ridge and Buck mountain is a depression of varying width, but of unvarying depth (figure 2, and plate 1, lower figure). Its northern portal is from a terrace of stony loam at an altitude of between 560 and 580 feet (United States Geological Survey map) just south of where the old Crown Point Iron Company's railroad bed crosses the highway, and a short distance east of Enos Dudley's house. Its floor is wet and mucky and is clothed with sedges, ferns, hummocks of sphagnum moss and other moisture-loving vegetation. This depression was evidently a marginal channel, and at the breach mentioned above, it broke through the moraine into a marginal lake. Prior to this, and while the ice still lay against the northern portion of the moraine, the marginal stream may have swept over the southern end of the moraine, which, as we have seen, is flat on its top just south of the breach. This portion is slightly lower than the north end of the channel. When the ice had receded somewhat from the moraine, the marginal stream broke through it, and sweeping between the ice and the moraine's southern end, it formed a subsidiary terrace there. At this level the marginal stream may have flowed both sides of the ridge, uniting at the breach with the portion that flowed in the channel between the ridge and the mountain. This breach in the moraine lies at the head of a modern gully that runs eastward and crosses the highway between the Brooks and Bradford houses. Passing down this gully, the right-hand bank is seen to be composed of heavy morainic stones, while on the left is exposed a cut of gravel, evidently unstratified.

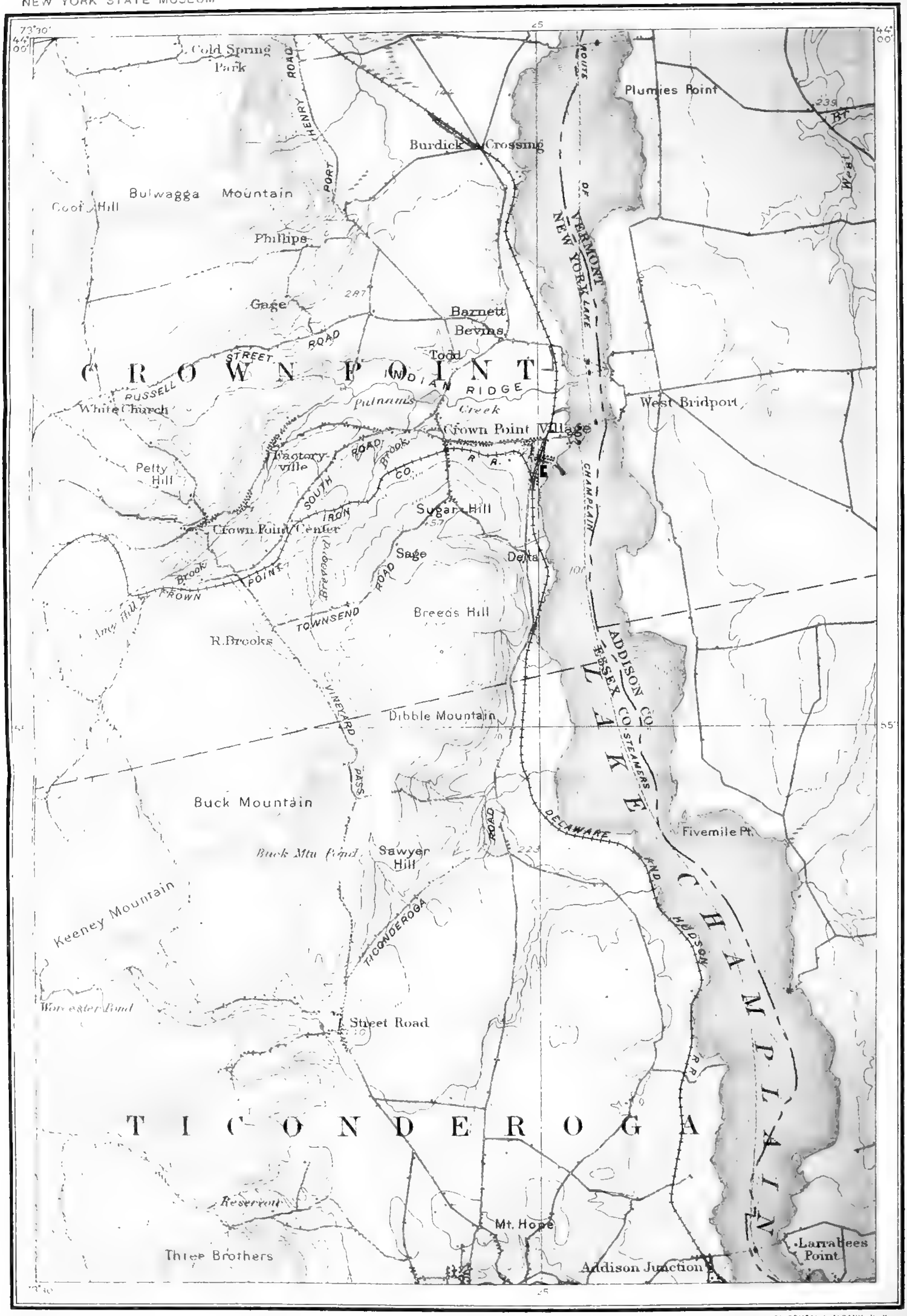
Gillette and Factoryville Moraines

In the central part of the embayment occur moraines at a lower level. The Gillette moraine is a knoll lying to the north of the so-called " South road " a short distance east from Renne Corners (see map 5). It is shown on the contour map with a top rising to over 500 feet. Its south side is skirted by a gentle shore line at the 450 foot contour. Its northwest face shows no shore line, but descends to the bed of Putnam's creek in a typical, hummocky kamelike slope. Its western base is composed largely of small, rounded cobbles in matrix of gravel, and a soil sample from its top showed coarse sand. To the northwest it drops abruptly to the Putnam's creek valley.

Not far to the northwest of this, the road through Crown Point Center climbs a hill from a lower to a higher level. The road ascends by a dugway with Putnam's creek below on the left-hand and a bank of gravel and cobblestones overhanging on the right. This bank is evidently of morainic origin also. It forms the south end of a ridge of hills that extends northeasterly for almost a mile overlooking the villages of Crown Point Center and Factoryville. This whole ridge is probably of morainic origin. Originally, no doubt, the Gillette moraine formed its southern end. The latter has been isolated and cut off from it by the creek.

Sawyer Hill Moraine

The Sawyer Hill moraine occupies a critical place among the localities that have been studied in reference to the ancient water levels of the Hudson and Champlain valleys. This moraine was formed against the side of the great valley glacier by the marginal stream that flowed between the ice and Buck mountain as it issued from the Vineyard pass. Because of its location, and because of certain features that it exhibits, it has afforded important data for the formation of several hypotheses regarding the postglacial history of this region. These are described and discussed on pages 21–24. It occupies all that triangular area south of Dibble mountain and east of Buck mountain that is bounded by the Vineyard road, the Crown Point–Ticonderoga lake road, and a cross-road that runs east and west connecting them (see United States Geological Survey map, Ticonderoga quadrangle). It is composed of sand, gravel and cobblestones. There seems to be a core of tectonic rock running for some distance south from Dibble mountain underneath its highest portion. Its top contains several ice-block or kettle-holes. The southern portion of the moraine is a wide, flat-topped terrace rising 200 feet above the plain with steep faces to the east and the south. It is very level and shows no trace of any marginal channel across it. The entire width of it formed, probably, the bed of the marginal stream. On its sides at a later time have been carved shore lines.



J. B. LYON COMPANY, ALBANY, N. Y.

MAP 1. CROWN POINT EMBAYMENT

Approximate area covered by ice and water at the stage controlled by the Quaker Springs outlet.

Contour interval 20 feet

LEGEND

Marginal waters

Ice

SHORE-LINE PHENOMENA

Epochs Marked by Impounded Bodies of Water

At the close of glacial times the Champlain region stood much lower in relation to the sea than at present. It has since risen 625 feet [1] at Montreal.[2] The greatest rate of elevation has been to the north. This has resulted in a tilting of the land as one goes northward. Consequently, the old shore lines as they exist today are found to form tilted planes, and along these planes Woodworth has correlated the beaches, terraces and cliffs of the ancient body of water that occupied the Champlain valley at the close of the Ice Age.

When the Hudson–Champlain glacier retreated it was followed by a body of water that was held in by the ever retreating wall of ice to the north. Due to one cause or another, this body of water did not always stand at the same level, but dropped to successively lower levels at each of its stages. The marks made in the Crown Point region at each of these stages will be described first, leaving all discussion of their significance until later. Professor Woodworth's postulated water levels are here accepted provisionally.

LEVELS CORRELATED WITH THE QUAKER SPRINGS OUTLET [3]

(Map 1)

According to Professor Woodworth's observations, glacial Lake Champlain or " Lake Vermont " was confluent in its incipient stages through the Wood creek pass with a large body of water, " Lake Albany," that covered the area now constituting the plains about Fort Edward and southward beyond Albany to the highlands of the Hudson. This body of water received the discharge of glacial Lake Iroquois by the Mohawk river, and its waters escaped to the sea through the Hudson highlands. The northern limit of the lake was ever coincident pari passu, with the retreating ice front.

At the close of the Lake Albany stage the level of Lake Vermont may have been determined by a possible outlet just east of Quaker Springs. Professor Woodworth, in a letter to the writer, regards this outlet as doubtful, but certain evidence about Crown Point and Street road may indicate a stand of water as high as this altitude.

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[1] The altitude of upper marine limit on Mount Royal, according to unpublished opinions of Professor Goldthwaite and Professor Woodworth.

[2] The evidence of this alteration is discussed on pages 21–24.

[3] Woodworth, 1905, p. 194–96, and pl. 28, line T–U.

When ice still filled the Champlain valley as far south as Street road (Ticonderoga quadrangle), which is about 5 miles south of Crown Point village, a tongue pushed southward through the defile between Buck and Dibble mountains (here called the "Vineyard pass"), leaving Dibble mountain projecting as a nunatak (map 1). Beside and around this tongue swept the marginal stream from a chain of marginal lakes to the north. Where it debouched from this defile into the lake covering the Ticonderoga plain it deposited a large kame terrace of gravels between Buck mountain to the right and the ice mass in the main valley to the left. This constitutes the Sawyer Hill moraine already described on page 12. The defile, likewise, is choked with boulder moraines and gravel deposits, which contain kames and kettle-holes left where detached ice blocks melted out.

A line inclined at the estimated rate of tilting to the northward, if drawn through two of the highest beaches found between Port Kent and Sawyer's hill at Street road [1] on the New York side of Lake Champlain, will pass through the region of the Crown Point embayment at approximately 520 feet altitude. Evidence of water standing at this altitude is afforded by the shore line at 500–520 feet described above in connection with the Buck Mountain moraine, and also by the terrace cut into the side of the Russell Street road moraine at 520 feet. Further evidence is afforded by deposits of light sandy loams that occur in the southwestern part of the embayment up to an altitude of 560 feet.

On the western side of Breed hill occurs fine sandy loam at an altitude of 565 feet (A. T.) in the vicinity of a sugar-house on the farm of Charles Townsend, and thence southward for some distance. In the woods above the road east of his residence, the shore line itself can be discerned at 520 feet (United States Geological Survey map), and a soil sample taken there showed fine sand. This locality appears to be at the same elevation as truncated knolls and flat-topped hills of the same soil type that lie a little farther west and southwest where the area converges to the Vineyard pass. The intervening valleys are due to recent dissection. These cuts reveal an underlying till sheet of blue clay where recently exposed, or heavy brown oxidized clay where it has weathered. The clay is overlaid with a covering of light sandy loam.

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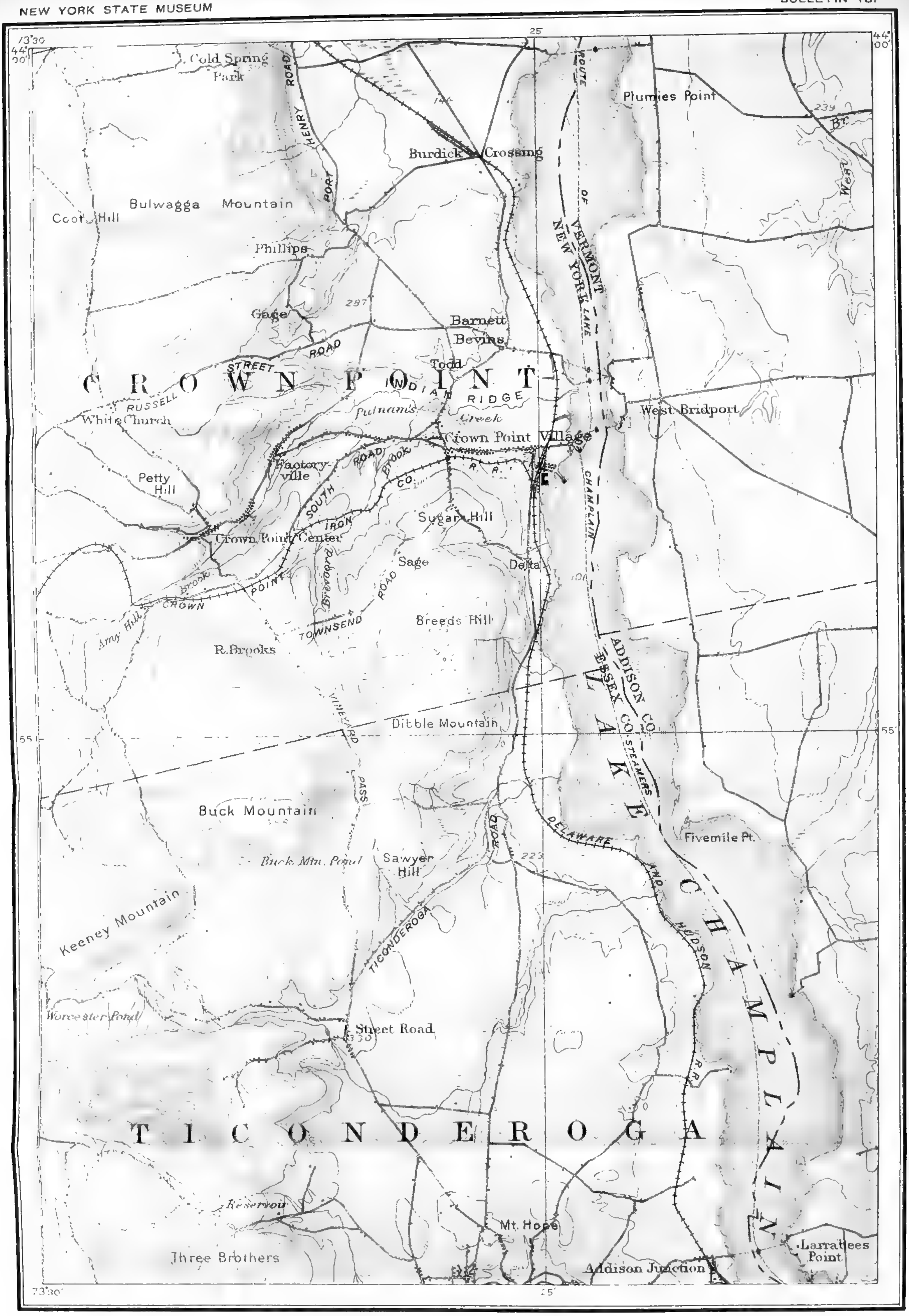
[1] Woodworth, J. B., 1905, p. 191, pl. 28, line A-B.



MAP 2. CROWN POINT EMBAYMENT

Approximate area covered by water at the stage determined by the Coveville outlet.

Scale 1/62500

Miles

Kilometers

Contour interval 20 feet

Datum is mean sea level

LEGEND

Water

LEVELS CORRELATED WITH THE COVEVILLE OUTLET [1]

(Map 2)

Professor Woodworth postulates two hypotheses for the death of Lake Albany: either it was drained off from the Albany–Fort Edward plains as its outlet through the Hudson highlands became lowered by stream cutting, or else a downward tilting toward the north at this time (of which he thinks there is some evidence) accomplished the same effect (Woodworth, 1905, p. 191–93). Lake Vermont then came into existence as such, and its outlet was by a spillway at Coveville into the old rock gorge of the Hudson river (Woodworth, 1905, pl. 11). With this stage of the waters should be correlated the shore line phenomena along his line C–D, plate 28. This line passes through Crown Point at approximately the 450 foot contour, which shows very marked evidence of a long continued stand of the lake at this level.

The approximate outline of the embayment at this stage is shown on map 2.

Evidence

At the base of Bulwagga mountain northwest of Carl Russell's house is to be seen a shore line at 440–460 feet. It is interrupted at several places by recent dissection, but from a distance its continuous line is apparent. A sample of the soil here showed fine sand. About 50 feet above this shore line is a broad rocky terrace sloping upward 20 or 30 feet to the base of the cliff. On the " South road " between Crown Point village and Renne Corners, a little to the northeast of the brick schoolhouse, is a knoll of morainic origin described above (pages 11 and 12). Around its southern face and eastern end curves the shore line of this stage of the glacial lake. Below this line is a sandy plain which is the old bed of this stage of the lake. It is now dissected by streams, and slopes gently to the east and south.

Along the southwest base of Breed hill the shore line can be discerned. South of Leon Sage's house on the Townsend road are bare ledges of rock that must have risen a little above the water level. In the lee of one of them is a small, sandy shoal deposit consisting of coarse sand with pebbles. Farther west, the flat-topped, loam-covered hills rise to near the same level.

A well-marked terrace was cut into Sugar hill on the highest portion of its southeast aspect. The summit of the hill rises as a

[1] Woodworth, 1905, p. 196–98 and pl. 11 and 28, line C–D.

knoll 10 or 15 feet above this terrace. The altitude here, as given on the contour map, is 450 feet. The terrace is stony. It falls off on its eastern face with a rocky basement. On it stands Savard's sugar-house in a grove of pine trees. At the end of this beach, in the lee of the island, was formed a little gravel beach in the sheltered cove. This gravel deposit has been utilized to build highways nearby. Farther in the cove, and in the lee of the highest part of the island, is a gravel ridge extending back to the base of Breed hill. It is a wave-heaped bar composed of gravel and beach pebbles. On the face of Breed hill across the cove from the terrace just described is a wide sloping terrace at about 450 feet (plate 4, upper figure).

(A. T.) that is about 50 yards wide, very level and flat on top, and supports a grove of maple trees. At the back of it rise the bare ledges of the mountain. Farther to the westward and about 35 feet below its level appears to be another terrace in the woods. It is about 25 yards wide and slopes to a rather abrupt face. This latter terrace may be correlated with the Fort Edward outlet, possibly.

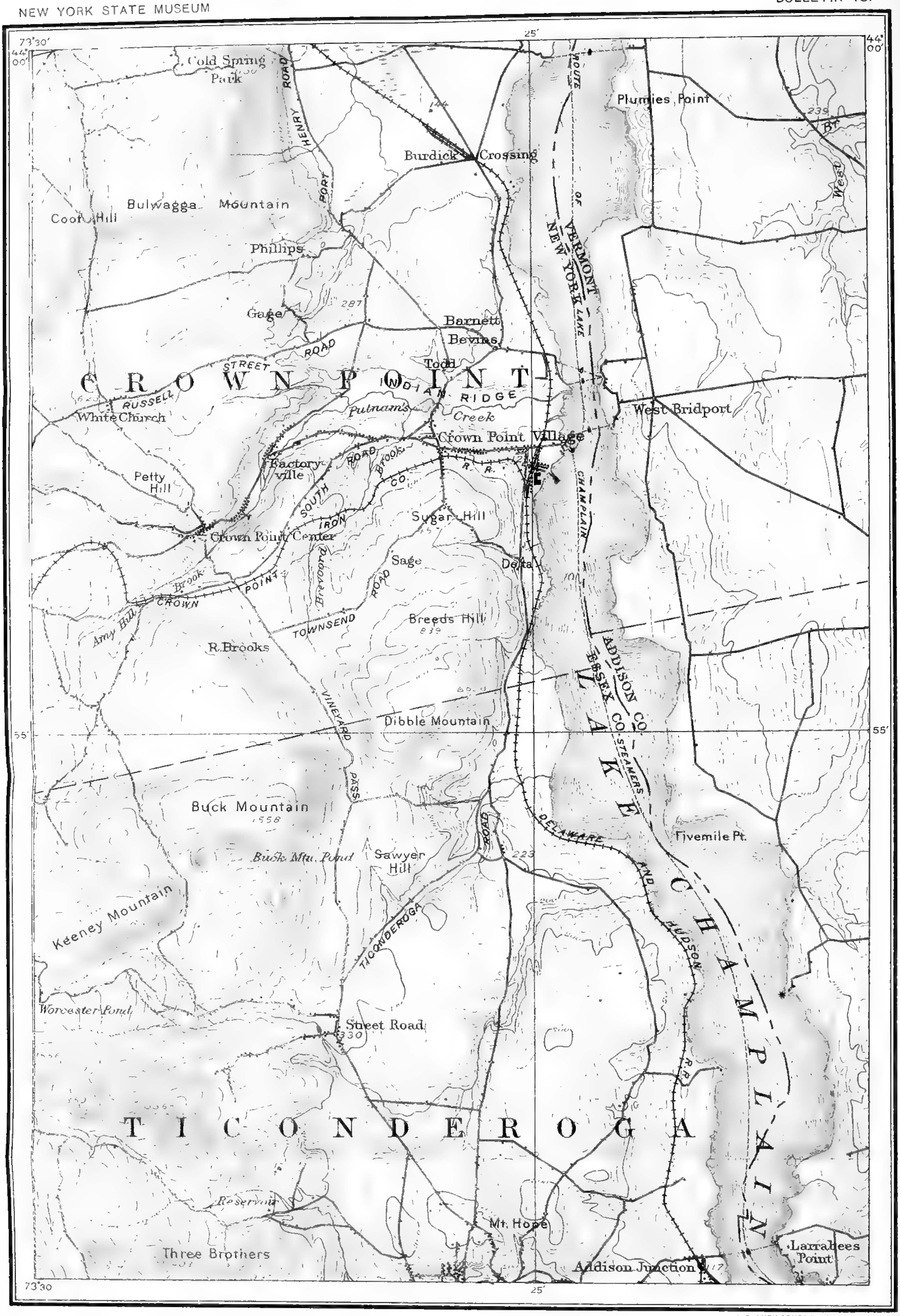
Not far from here, on the eastern side of the Sawyer Hill moraine, is a very sharply cut and distinct beach terrace cut into the hillside at this level of the lake. It is nearly level, and on the face it presents a steep basement slope while at the rear of it is another steep slope where it is cut into the side of the moraine. It is composed of earth and cobblestones, as smooth and rounded as ostrich eggs, which they resemble in shape, although they vary in size both larger and smaller (plate 3).

LEVELS CORRELATED WITH THE FORT EDWARD OUTLET [1]

(Map 3)

The extent to which the waters filled the embayment during this stage is shown on map 3. During the phase of the lake just described, its waters were discharging into the old Hudson gorge at Coveville (Woodworth, 1905, pl. 11), over a sloping waterfall nearly 100 feet high. As the old gorge was re-excavated northward beyond this point, the Coveville scourway was abandoned, and the next lower stage of the glacial lake was determined by the height of the divide in the bed of the Wood Creek channel near Fort Edward. On his diagram on plate 28, Woodworth has correlated the deltas and beaches along line E–F with this outlet. This line passes through Crown Point at about 350 feet altitude. "This

[1] Woodworth, 1905, p. 198 and pl. 28, line E–F.



MAP 3. CROWN POINT EMBAYMENT

Approximate area covered by water at the stage determined by the Fort Edward outlet.

Scale 1/62500

Miles

Kilometers

Contour interval 20 feet
Datum is mean sea level

LEGEND

Water

Plate 3

Upper figure. The 350 foot beach on the Sawyer hill moraine. Looking southward from the crossroad. The steep, stony descent of its face at the left is not shown in the picture.

Lower figure. Same beach as shown in the upper figure, a short distance farther south, showing some of the beach stones scattered about

was the lowest point of discharge to the south of glacial confined waters in the Champlain district. The marine limit seems to have fallen short of this col." (Woodworth, 1905, p. 198.)

Evidence

At the foot of the great Phillips moraine that lies against the southeast face of Bulwagga mountain there is a broad, level terrace at 350 feet altitude (United States Geological Survey). On it stand J. Phillips's house and outbuildings. This terrace consists of light sandy loam. It curves around the hill to the southward almost as far as the Gage house, which is built on the same level. Below this, to the south, lies a rather extensive plain at 300–350 feet (on the contour map). It is crossed by the Russell Street road and several farmhouses stand on it. The soil is a sandy loam, but it is underlaid by clay. This loam deposit marks the bed of this phase of the glacial lake.

The road from Factoryville to Port Henry climbs the west end of Indian ridge at a place known locally as "Leland hill." A new grade cutting on this hill, made in August 1913, between the 200 and 240 foot contours showed an instructive section. The surface of the hilltop plain at this point is composed of a layer of argillaceous sandy loam about 2½ feet thick containing a few small, erratic stones. Underneath this is a layer of stratified clay about 6 feet thick. It is devoid of stones and lies conformably on top of a stratum of stratified fine sand. The altitude here (241 feet A. T.) removes it above the range of the marine occupation. These sands and clays, then, must have been deposited on the bottom of one of the higher water bodies, since they are not, evidently, ground moraine. The till sheet probably lies at a depth of 100 feet or more beneath. The presence of scattered erratics so far from the ancient shore can hardly have been due to transportation by stream currents. They may have dropped from floating icebergs. This must have occurred, if at all, during the latest, or Fort Edward, stage of the glacial lake, as the stones lie in the top layer of soil and not in either the clay or the layers of sand beneath it.

On the hill west of Factoryville a barometric reading was taken at 331 feet where a terrace has been cut into the hill, apparently by wave action, just below its top. A sample of soil taken from this terrace consisted of fine sand; and a few small stones were found about here in the level field.

At the foot of this hill to the north the Spring brook has cut down to bedrock, which here is Potsdam sandstone.

In the central part of the embayment is a wide, level plain of sandy loam whose top is crossed by the 340–360 foot contour lines. It stretches along the side of the Brevoort Brook valley. A fill of the old Crown Point Iron Company's railroad bed crosses this valley and continues westward along the south side of the sandy deposit whose top is at 360 feet altitude (on the contour map).

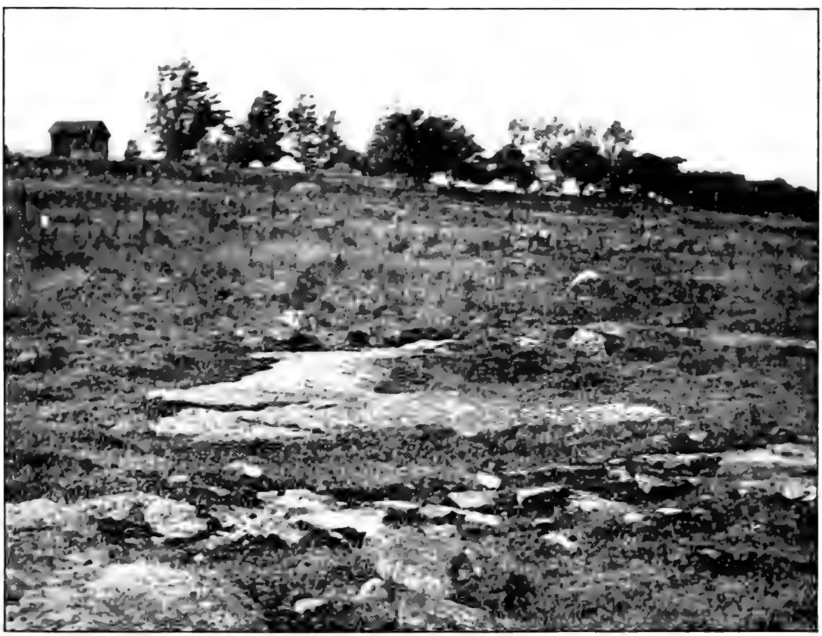
The drop of the waters to the Fort Edward level left Sugar hill a promontory in front of Breed hill. Its eastern and northeastern faces are precipitous, and the bare rock exposed there must have risen from the water as wave-lapped cliffs. The northern face of the hill felt the bite of the waves sweeping down the length of the whole valley when the ice had retreated far to the north. The evidences are strongly marked here, and extend over a great vertical distance. Above the limit of the waves rise clay knolls, and again, below the limit of their action, the uninterrupted slope of till continues downward to the marine level.

The face of Sugar hill east of the highway is marked by gneissic ledges washed bare on top, with low cliffs at their bases (plate 4, lower figure). Scattered over this slope are boulders of all sizes. In the lee of an outlying reef or island is a sandy shoal deposit. To the west of the road behind Colonel Barker's house (357 feet altitude), is a stony beach (plate 5, upper figure). This rocky beach line curves around the southwest side of the hill, and here in the more sheltered situation it merges into a gentle line of light loam devoid of exposed, wave-washed stones. It skirts the bases of clay knolls.

On the eastern face of Breed hill are ravines situated so that their north walls would have afforded a slight protection from the north winds and currents in the glacial lake. These ravines would thus have formed tiny coves at the lake level in which sandy deposits could form. Such deposits, more or less obscure, can be found here, and correspond with the various lake levels. In two of these ravines aneroid readings on such deposits gave an altitude of 347 feet. On the southeast face of Dibble mountain is a sloping terrace at 362 feet (A. T.) that corresponds in altitude with this stand of the waters.

Nearby, on Sawyer hill, is another beach terrace. The aneroid here read 332 feet. This splendidly developed terrace is in every way similar to the one described on page 16. It lies 100 feet below that terrace and parallels it throughout its whole length. The north

Plate 4



Upper figure. Looking westward into the cove between Breed hill and Sugar hill. The face of Breed hill with the Coveville outlet terrace is shown to the left, the sand bar and gravel pit to the right of the center.
Lower figure. Scene on Sugar hill east of the highway looking across the shore line determined by the Fort Edward outlet. The rocks and ledges have been washed bare by wave action.

Plate 5

Upper figure. A stony beach on Sugar hill along the level determined by the Fort Edward outlet a short distance west of the place shown on plate 4, lower figure

Lower figure. A modern stony beach on the coast of Maine. Notice similarity to the ancient stony beach shown in upper figure.

end of it can be seen from a distance of one-half of a mile from the lower Crown Point–Ticonderoga road. It is so striking in appearance that it looks like a railroad bed cut into the hillside (plate 3).

THE MARINE INVASION

(Map 4)

Until this last stage of the glacial lake was inaugurated, the ice sheet had lain against the northern base of the Adirondack and Green mountains, choking the northern end of the Champlain valley and impounding the waters behind it. They drained southward into the Hudson basin. As long as the glacier filled the basin of the St Lawrence and choked the northern end of the Champlain valley, the waters impounded behind it stood at levels relatively higher to the sea, although the land itself was much lower than now. When, however, the ice retreated from the northern base of the Green mountains, the waters were allowed to escape at the north into the St Lawrence gulf, and the level of the lake was lowered thereby. Then, when the ice was no longer a barrier, the sea came in at a lower level. Thus the Champlain valley was converted into an inlet or estuary opening to the north. The marine waters extended as far south as Benson's Landing or Putnam (Leighton, 1905, p. 629), or to Whitehall according to Baldwin (Baldwin, 1894, p. 11).

This episode is recorded by the presence of marine shells and other marine fossils in the Champlain clays which were laid on the valley floor at this time. The shells of mollusks are very common (Peet, 1904, p. 461–62). Near Charlotte, Vt., the bones of a whale were found in clay about 8 feet below the surface. It was a species of Beluga closely similar to B. leucas or to B. catodon (Dawson, 1883, and Vermont Geological Survey, 1849), species which live in the north Atlantic ocean at the present time.

Woodworth has correlated the beaches and terraces attributed to the marine epoch along his line M-N on plate 28. This line would pass the latitude of Putnam's creek at an altitude of approximately 181.5 feet.[1]

---

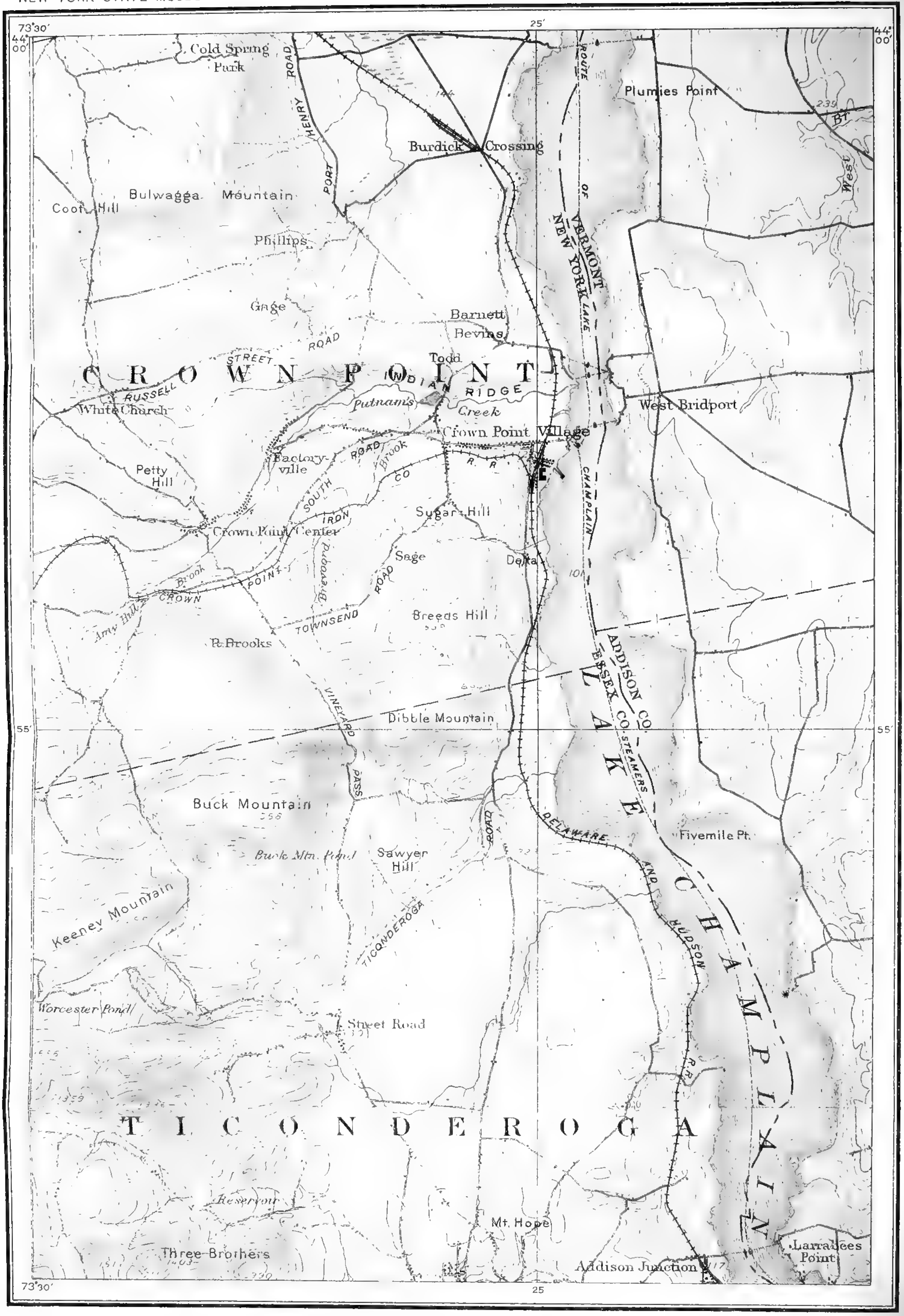
[1] Subsequent to the publication of his paper Woodworth, in company with General Lamothe and Professor Goldthwaite, found marine shells on Mount Royal at an elevation of 585 feet. Lamothe and Woodworth placed the upper marine limit on Mount Royal at 625 feet. This would make the rate of tilting along line M–N even steeper than given, that is, 4.111 feet to the mile. But it would still pass through the Crown Point region somewhere between the 180 and 200 foot contours.

The marine occupation played the least part of any of the ancient stands of the waters in the formation of the topography of Crown Point for the reason that it was able to flood only the lowest, and thus the smallest, portion of the embayment. The marine waters filled a wedge-shaped trough in the axis of the valley now occupied by Putnam's creek with the sharp end of the wedge pointing westward. They must have reached as far west as the locality of Factoryville (maps 4 and 5). To the north and to the south of this wedge-shaped area they were able to cover only a narrow strip of ground fringing the bases of the mountains. Here was deposited heavy clay — a part of the Vergennes heavy clay series — that forms the floor of the main Champlain valley throughout Vermont and a narrow strip along the New York side of the lake.

Putnam's creek entered the apex of the bay from the southwest, and Brevoort brook reached it near the middle of the south side. Both these streams were given greatly increased force by the lowering of their base level, and must have cut down rapidly through the soft alluvium of the old lake beds which had been recently exposed. Reaching the end of their course, and coming to rest in the waters of the bay, these streams deposited their heavy loads of silt over the bottom and built it up nearly to the 200 foot contour line (Peet, 1904, p. 460). This formation flared to the eastward as a broad, deltalike fan.

Before the close of the marine epoch the bay must have been a shallow, marshy area, probably largely overgrown with water-loving vegetation through which the streams meandered in shifting channels. Two of these channels can still be seen on the northern portion of this old delta. Where the Port Henry road north of Crown Point village climbs to the flat top of Indian ridge it bifurcates, and one branch turns eastward. Just south of this branch, in the pasture east of Mrs Todd's barn, is a clean-cut U-shaped channel deepening to the eastward as it cuts the old delta (plate 6, lower figure). North of this same road another ancient channel skirts the base of the clay knolls that form the higher part of Indian ridge in this locality (plate 6, upper figure). It continues eastward as far as the present lake and crosses the highway between the houses of George Bevins and George Barnett (map 5).

North of Putnam's creek this delta forms flat plains of sand and loam from the 120 foot contour on the east side near the present lake up to the 200 foot contour. Across the valley is the southern portion of this delta deposit, severed now from the northern half by the creek (plate 1, upper figure). Like it, however, it slopes up



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MAP 4. CROWN POINT EMBAYMENT

Approximate area covered by the waters of the marine invasion.

Scale $\frac{1}{62500}$

Miles

Kilometers

Contour interval 20 feet

Datum is mean sea level

LEGEND

Water

[illegible]

Plate 6

Upper figure. Upper marine limit at Crown Point. Edge of the delta plain on top of Indian ridge
Lower figure. Ancient stream channel through the marine delta on top of Indian ridge

from the 120 foot contour near the present lake shore to the 200 foot contour. The village of Crown Point stands on this marine terrace, at approximately the 180–200 foot contours.

The southern shore line of this bay skirts the base of Sugar hill near the 200 foot contour. Bare wave-cliffs are exposed behind the schoolhouse, and a gentle shore line traverses the park near the old brick store and the soldiers' monument. The three Hammond houses stand on clay knolls where the till sheet rises above the marine level, while the Congregational Church and the parsonage stand on the sandy delta terrace.

Farther west, the marine shore line can be seen where it crosses the top of Brevoort hill from north to south by Mr Barney's house.

Between Sugar hill and Breed hill a tiny brook runs eastward to the lake down the bottom of the old cove (plate 4, upper figure). It cuts the strip of marine clay to reach the lake, but between the 160 and 180 foot contours it formed a delta. This is a loamy terrace several acres in extent. It lies to the south of the present course of the brook. The state road crosses it near Joe Ross's house as it skirts the northeast base of Breed hill.

7 SUBSEQUENT MODIFICATIONS OF TOPOGRAPHY

Tilting

The shell deposits that have been discussed above give the best evidence to be had to show the extent and rate at which the land has risen since glacial times. According to Woodworth (1905, p. 205) "The marine limit of this epoch is now tilted more steeply to the south than the shore lines of the earlier water levels [are tilted] to the south. It appears to follow from the divergence of these ancient water plains that before the invasion was established the land was tilted down to the north, thus determining the extent of the submergence; since then the land has risen."

The subsequent elevation of the land to the north has raised these shell deposits far above the present sea level. At Montreal they are found at from 540–560 feet above tide, according to Spencer.[1] Professor Goldthwaite, General Lamothe and Professor Woodworth collected Saxicava rugosa on Mount Royal at an elevation of 585 feet. At Crown Point (Fort Frederick) they occur at about 100 feet. Between these two points the shells are

[1] Spencer, J. W., 1912, p. 471. "Dawson's figure of 560 feet has been corrected on the recent Canadian Geological Survey map to 572 feet from datum from Lake St Peter to mean tide at New York."

found at successively lower intervals in the Champlain valley, and an inclined plain drawn through them passes below the level of the lake at Ticonderoga (Woodworth, 1905, p. 216 and pl. 28, line M-N). This indicates a rate of tilting to the south during postglacial times of 4.111 feet to the mile.[1] These shell fish are supposed to have lived in from 100 to 300 feet of water (Woodworth, 1905, p. 215). The present writer has considered the upper marine limit at Crown Point as about 100 feet above the line of shells.[2] It would be, then, near the 200 foot contour.

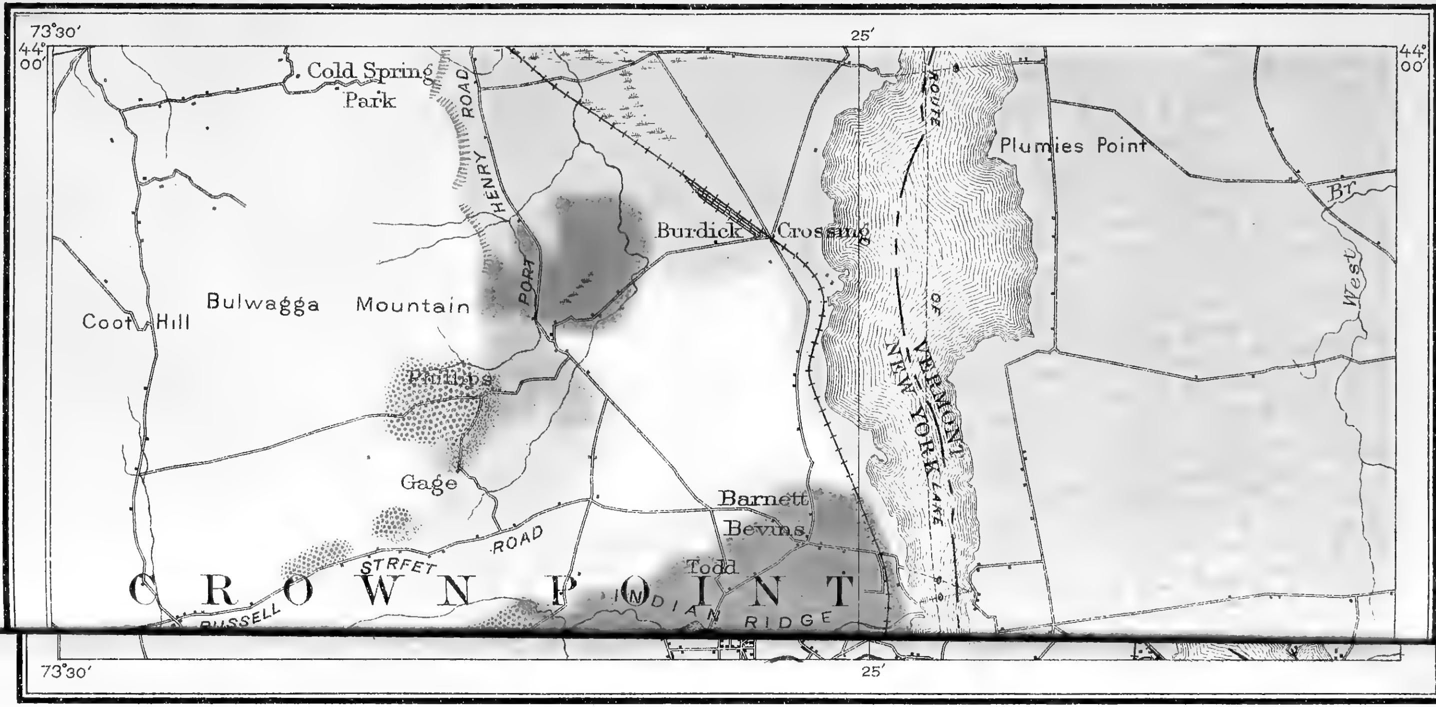
This postglacial elevation of the land has affected, likewise, the other shore lines above this so-called "upper marine limit" of Woodworth. They now lie at proper intervals above the marine shore line. Similar inclined planes have been used to correlate these lake beaches and these are diagrammed by Woodworth on plate 28 of this bulletin. He used a different set of criteria in correlating them, however, because the low altitude of the land at the time of their formation and its differential tilting since the marine invasion cause them to lie in planes not quite parallel to the so-called "marine" beaches, and they may have arisen at an accelerated rate.

The recent conclusions of Professor Fairchild at which he arrived after a reexamination of all the data afforded, and after a field consultation with Professor Goldthwaite of the Canadian Geological Survey, are opposed to the hypothesis that these shore lines above the so-called "marine" limit were formed by fresh waters. He believes, as stated above (page 2), that they were formed by waters of the Hudson-Champlain inlet. Their line of tilting is less steep than that of the later marine line. This indicates a faster rate of elevation since the marine episode than previous to it. The rate of tilting of the higher shore line is about 2 feet to the mile, while that of the lowest or marine is 4.411 feet to the mile (Fairchild, 1913, p. 24 and Woodworth, 1905, p. 191), while that of the lowest or marine is 4.411 feet to the mile (Woodworth, 1905, p. 206).

Woodworth regarded the highest and earliest of these shore lines as having been formed in a body of water south of a retreating ice cliff, or possibly in marginal lakes. Fairchild regards them as

[1] See footnote, page 19, and Woodworth, 1905, p. 206.

[2] Peet, 1904, p. 626. "The level of marine fossils falls below the marine level 60–80 feet at the north and not far from that amount at the south. At Montreal the upper marine limit on Mount Royal is 40 feet above the highest deposit of marine shells yet observed."



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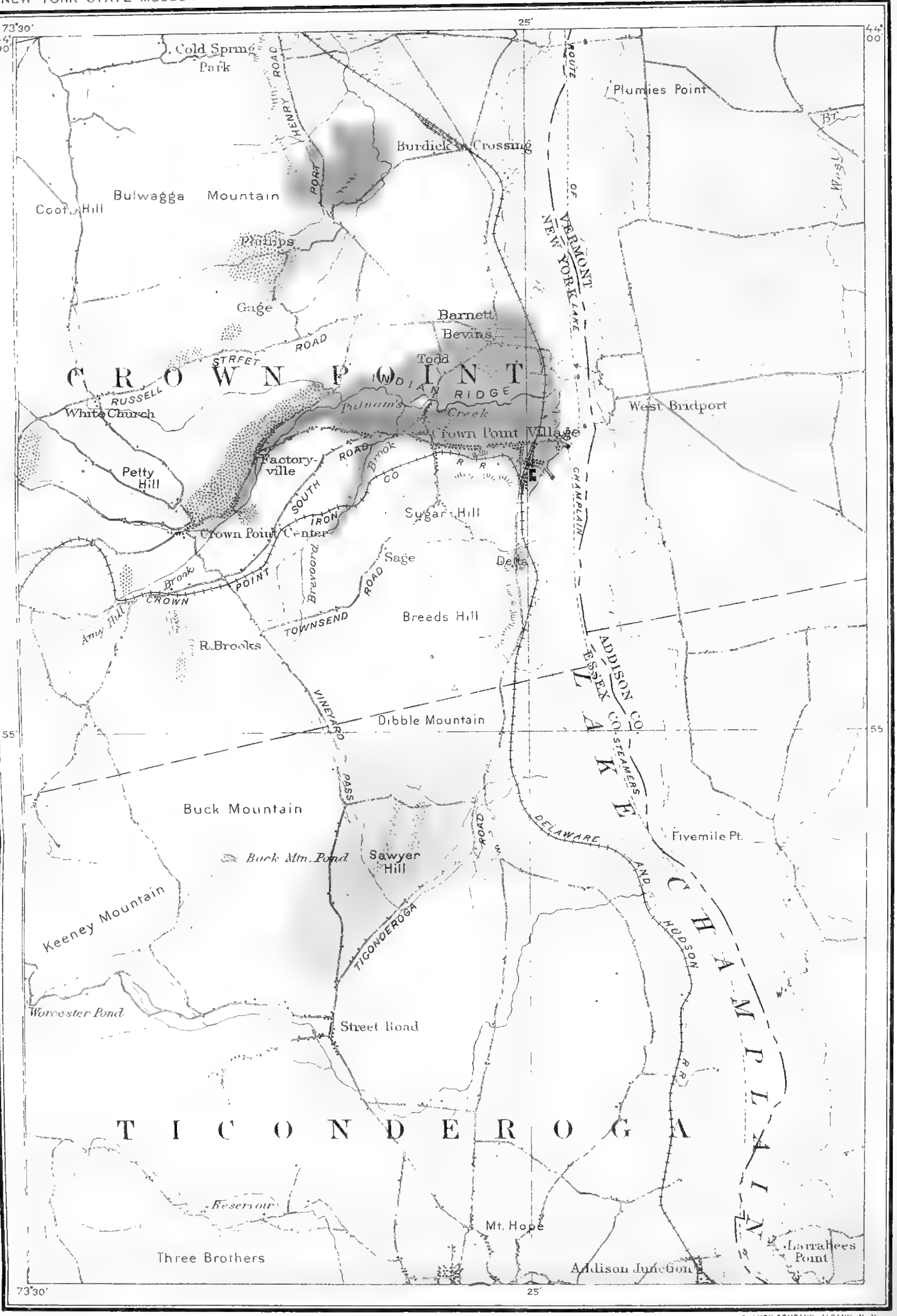
MAP 5. CROWN POINT EMBAYMENT



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MAP 5. CROWN POINT EMBAYMENT

Principal localities, roads, etc., mentioned in the text, also moraines, shore-lines, cliffs, beaches, etc., and distribution of soil types.

Scale $\frac{1}{62500}$

Miles

Kilometers

Contour interval 20 feet

Datum is mean sea level

LEGEND

Moraines | Cobble Beaches | Wave Cliffs | Sandy Beach Lines | Sandspit | Railroad Bed

Marginal or Delta Channels | Sandy-Loamy Marine Delta Deposits | Loamy Lake Bottom Deposits | Marine Clays | Modern Alluvium | Gravelly Morainic Deposits

Uncolored portions of the map indicate areas of unmodified till sheet or exposed bed rock.

having been formed in an open body of water. As proof of this, he states that they are found along definitely correlated lines extending the whole length of the valley on both the New York and Vermont sides. They are strongly developed at the extreme north end of the valley in the Dannemora quadrangle.

No evidence of a decisive nature has been observed about Crown Point by the writer relative to whether these shore lines were formed in a glacial lake or in a marine inlet. The shore lines here, however, lie at definite intervals apart; they are found at just the altitude expected at this latitude according to the tilted planes postulated by Woodworth. They are strongly developed, even the highest ones at over 500 feet located at the bases of Bulwagga and Buck mountains. They all appear to have been formed along the margins of large bodies of water where the waves had an uninterrupted sweep across long, open stretches.

Still earlier than open-water conditions, however, marginal lake conditions may well have prevailed in the western and southern parts of the embayment. There is good evidence for this. About the White Church and to the south occur sandy loam deposits up to 600 feet. At the base of Buck mountain occurs the marginal scourway at 560 to 580 feet (on United States Geological Survey map) that has been described above. This marginal drainage continued southward through the Vineyard pass and formed the Sawyer hill marginal moraine with a top at an altitude of 540 feet. The evidence shows that without doubt this moraine was formed against the side of the ice mass that elsewhere choked the valley. Large masses of ice buried in this moraine melted out and left kettle-holes of indisputable character. The fact that these kettle-holes have never been filled in by wash which wave action would have drifted into them is taken by Woodworth to mean that the postglacial waters never stood here above 540 feet, the altitude of their rims, since the retreat of the ice (Woodworth, 1905, p. 155). The highest stand of the open waters at this locality is probably marked by the faint shore line (at 487.5 feet A. T.) just below where the road passes over the edge of the flat terrace.

The Gillette morainic knoll on the South road was evidently a part originally of the line of low morainic hills behind Crown Point Center. Had it been formed separately at an earlier time we should find the 450 foot shore line that skirts its southern base continued around the northern side. Such is not the case. It was continuous with the rest of the moraine to the north and stood in an open body of water at that time. Subsequently, it has been cut off and isolated by Putnam's creek.

Whatever the nature of these inland waters, marine or glacial, it is certain that they remained at a definite level for a long period of time, then dropped quickly to a lower level, at which they remained for another long period, and that this was repeated several times. Had the region been occupied continuously by an inlet from the sea, as postulated by Fairchild, and had the surface of this inlet stood always at sea level, the present altitude of the ancient shore lines could be accounted for only by subsequent elevation of the land. This elevation must have occurred, then, at irregular intervals instead of steadily. The land must have remained stationary at each period when a well-marked shore line was formed, and must have risen rapidly during the intervening intervals that are not marked by well-defined shore line phenomena. Elevation at the north must have tilted the waters gradually from the north end of the valley southward. The land must have risen as far south as New York harbor in order to convert the bottom of the inlet into dry land. All evidence, however, shows that the reverse of these conditions prevailed here; and that the lower Hudson has sunken since glacial times and is still sinking.

Woodworth has adduced good evidence for the continued stand of a glacial lake at each of these levels. He has shown that the wearing down of outlets to the south has several times resulted in lowering the level of the glacial lake; that a final retreat of the ice from the northern end of the valley allowed marine waters to enter from the north. This stage, and this stage only, is recorded by fossil remains. They are all of marine nature.

EROSION

Since the marine waters left the embayment, or rather, since the land has risen in its relation to the sea, Putnam's creek has done a large amount of valley cutting. It has not only continued with its tributaries to dissect the uplands that form the old lake beds, and which it had begun to cut through during the marine occupation, but it has divided the marine delta into two parts and has removed fully one-third of it from the central portion. It has excavated here from the 180 foot delta surface down to a base level that was once, probably, below the present level of Lake Champlain, as will be explained presently. During this process of degradation the creek meandered from side to side widening and cutting down its valley bottom. Especially on the south side it has left terraces beautifully illustrating this process. They may be seen to good advantage in a series of four as one ascends from Bly's mill on the creek to Crown Point village. Other stream terraces may be seen along the road between Crown Point and Factoryville.

After the marine waters left the embayment by reason of the land rising at the north and shutting off their ingress via the St Lawrence valley, the present Lake Champlain came into existence. It is only a puny remnant of that splendid body of water that filled the basin between the Green mountains and the Adirondacks as the glacier retreated. It occupies now only a long narrow trough at the west side of the valley where in early times the Silurian limestones were broken away from the base of the Adirondacks against which they abutted.

The early settlers regarded Bulwagga bay (Port Henry quadrangle) as the head of Lake Champlain. The true basin of the lake runs off steeply near the end of Crown Point peninsula. On early maps that portion of the lake between Crown Point peninsula and Whitehall is designated as "Wood creek" or "River Flowing into Lake Champlain." Peet (1904, p. 468) regards this portion as a river valley drowned by setting back of the lake waters due to the uplift at the north. He locates the delta of this stream by soundings on the lake charts about 5 miles northeast of Port Henry. This delta is now submerged 50 to 75 feet beneath the surface of the lake.

Putnam's creek, a tributary to this drowned river, is likewise flooded in its lower reaches. Its recent valley floor — for it had formerly reached base level — is now being silted up and aggraded. Degradation has ceased.

8 RESUMÉ AND CONCLUSIONS

1 At the retreat of the Hudson-Champlain valley-glacier, the area uncovered by the ice was occupied by open waters of wide extent.

2 These open waters extended as far north as the ice mass that blocked the northern portal of the Champlain valley.

3 They registered their existence at different stages by well-defined shore line phenomena. These phenomena are all well developed in the region about Crown Point, and indicate long-continued stand of waters at each of these stages, with brief or transitory stands between them.

4 The lowest stage was marked at Crown Point by the formation of a large delta plain by Putnam's creek in the lowest part of

the embayment. The middle third of this has since been removed by stream erosion.

5 Prior to open-water conditions, a marginal lake may have been impounded in the western end of the embayment. This lake was drained by the marginal stream that flowed southward between Breed mountain and Buck mountain. It formed the Sawyer hill marginal moraine where it issued from the Vineyard pass.

6 The evidence afforded in this locality supports the hypothesis that all the shore lines were formed in an open body of water at a time when the ice had retreated to the far north end of the valley.

7 The shore lines about Crown Point correlate with the several stands postulated by Woodworth. They tend to support his hypothesis that these stands were conditioned by the wearing down of certain outlets to the south.

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New York State Museum

JOHN M. CLARKE, Director

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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:

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Bulletins are also found with the annual reports of the museum as follows:

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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.

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—— 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.
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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.*

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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.*
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77 Cushing, H. P. Geology of the Vicinity of Little Falls, Herkimer Co. 98p. il. 15pl. 2 maps. Jan. 1905. 30c.
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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.

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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.*
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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.
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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.
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2 Hall, James & Clarke, J. M. Paleozoic Reticulate Sponges. 350p. il. 70pl. 1898. $2, *cloth.*
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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. Free.

Outlines history and work of the museum with list of staff 1902.

Paleontology. 12p. 1899. *Out of print.*

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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.
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