Feb 15

New York State Education Department

NEW YORK STATE MUSEUM

61st ANNUAL REPORT

1907

In 3 volumes

VOLUME 1

REPORT OF THE DIRECTOR 1907

AND

APPENDIX 1

TRANSMITTED TO THE LEGISLATURE JANUARY 30, 1908

ALBANY
UNIVERSITY OF THE STATE OF NEW YORK
1908

STATE OF NEW YORK

EDUCATION DEPARTMENT

Regents of the University

With years when terms expire

State of New York

No. 31

IN ASSEMBLY

January 30, 1908

61st ANNUAL REPORT

OF THE

NEW YORK STATE MUSEUM

VOLUME 1

To the Legislature of the State of New York

We have the honor to submit herewith, pursuant to law, as the 61st Annual Report of the New York State Museum, the report of the Director, including the reports of the State Geologist and State Paleontologist, and the reports of the State Entomologist and the State Botanist, with appendixes.

St Clair McKelway
Vice Chancellor of the University

Andrew S. Draper
Commissioner of Education

CONTENTS

VOLUME 1

Report of the Director 1907

Education Department Bulletin

Published fortnightly by the University of the State of New York

Entered as second-class matter March 3, 1908, at the Post Office at Albany, N. Y., under the act of Congress of July 16, 1894

NO. 428 ALBANY, N. Y. AUGUST 1, 1908

New York State Museum

JOHN M. CLARKE, Director

Museum bulletin 121

FOURTH REPORT OF THE DIRECTOR OF THE SCIENCE DIVISION

INCLUDING THE

61ST REPORT OF THE STATE MUSEUM, THE 27TH REPORT OF THE STATE GEOLOGIST, AND THE REPORT OF THE STATE PALEONTOLOGIST FOR 1907

New York State Education Department
Science Division, January 22, 1908

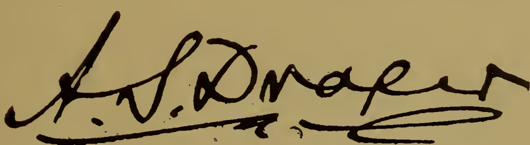
Hon. Andrew S. Draper LL.D.
Commissioner of Education

SIR: I have the honor to submit herewith my Fourth Annual Report as Director of the Science Division, for publication as the introductory portion of the 61st Annual Report of the State Museum.

Very respectfully
JOHN M. CLARKE
Director

State of New York
Education Department
COMMISSIONER'S ROOM

Approved for publication this 22d day of January 1908



Commissioner of Education

Education Department Bulletin

Published fortnightly by the University of the State of New York

Entered as second-class matter at the Post Office at Albany, N. Y., March 3, 1908, under the act of Congress of July 16, 1894

NO. 428 ALBANY, N. Y. AUGUST 1, 1908

New York State Museum

JOHN M. CLARKE, Director

Museum bulletin 121

FOURTH REPORT OF THE DIRECTOR OF THE SCIENCE DIVISION

INCLUDING THE

61st REPORT OF THE STATE MUSEUM, THE 27th REPORT OF THE STATE GEOLOGIST, AND THE REPORT OF THE STATE PALEONTOLOGIST FOR 1907

REPORT OF THE DIRECTOR 1907

INTRODUCTION

This report covers all departments of scientific work under the charge of the Education Department and the Regents of the University and concerns the progress made therein during the fiscal year 1906–7. It constitutes the 61st annual report on the State Museum and is introductory to all the scientific memoirs, bulletins and other publications issued from this office during the year mentioned.

Under the action of the Regents of the University (April 26, 1904) the work of the Science Division is "under the immediate supervision of the Commissioner of Education," and the advisory committee of the Board of Regents of the University having the affairs of this division in charge are the Honorables: T. Guilford Smith LL.D., Buffalo; Daniel Beach LL.D., Watkins; Lucian L. Shedden LL.B., Plattsburg.

The subjects to be presented in this report are considered under the following chapters:

I Condition of the scientific collections

II Report on the Geological Survey, including the work of the State Geologist and Paleontologist, of the Mineralogist and that in Industrial Geology.

III Report of the State Botanist

IV Report of the State Entomologist

V Report on the Zoology section

VI Report on the Archeology section

VII A State Historical Museum

VIII Publications of the year

IX Staff of the Science Division and State Museum

X Accessions to the collections

XI Appendix: New entries on the general locality record of the paleontological collections

XII Appendixes (to be continued in subsequent volumes). All the scientific publications of the year.

I

CONDITION OF THE SCIENTIFIC COLLECTIONS CONSTITUTING THE STATE MUSEUM

The collections of the State Museum, both those exposed for exhibition and the much larger quantity, under stress of circumstances now in storage, remain in essentially the same condition as reported last year. With the present straightened quarters additional display of material, however interesting and instructive, is effectively debarred and as a consequence none of the recent acquisitions in which the past year has been fruitful have been made accessible to the public. The members of the scientific staff are industrious in the acquirement of materials. These materials are in very large degree the basis of investigations and must be temporarily accessible for study. Eventually, however, (and that is, generally, as soon as possible) these scientific specimens, irrespective of the interest attaching to them, or of their excellence, must be packed away in storage to await their resurrection in more adequate quarters.

The distribution of the various collections was stated specifically in the report of last year. It remains unchanged. The materials of the museum now occupy parts of

A Geological Hall
B State Hall
C Capitol
D Storage house, Orange street
E Flint Granite Co., Cemetery Station
F Property of Joseph L. Verstrepen, Delaware street

The offices of the members of the staff are also divided, part in the State Hall, another part in the Geological Hall.

The State Museum is a divided house, but not a house divided against itself. It stands, and there is every reason to believe that its work fortifies it by an uninterrupted progress along lines that are not alone of immediate practical import to the commercial interests of the State, but, of far greater ultimate moment to the community, also to a more adequate conception of the works and processes of nature. In the world's history never has the fact been made clearer than now that the State which most encourages scientific investigations for the purpose alone of determining the relation of its citizenship to the active natural forces on which that citizenship depends is performing its highest duty to the community and insuring its own stability. Though every channel of scientific knowledge seems gorged with details of information which few can digest, yet out of this choked and tangled mass, gradually unravel the guiding lines of knowledge which must give direction to the future progress of the race.

The new museum. In view of the dismembered condition of the State collections and the widely separated divisions of the working force, the advent of new and adequate quarters is hailed as the opening of an era which can not fail to infuse a wholesome spirit and a more definite objective in the labors of this organization.

In the 70 years of its history the scientific departments have had no direct appeal to the people save through the avenue of publication. It has been at no time possible to adequately display the tangible evidence of the State's natural resources. The real educational value of the collections is still untried though not unproven.

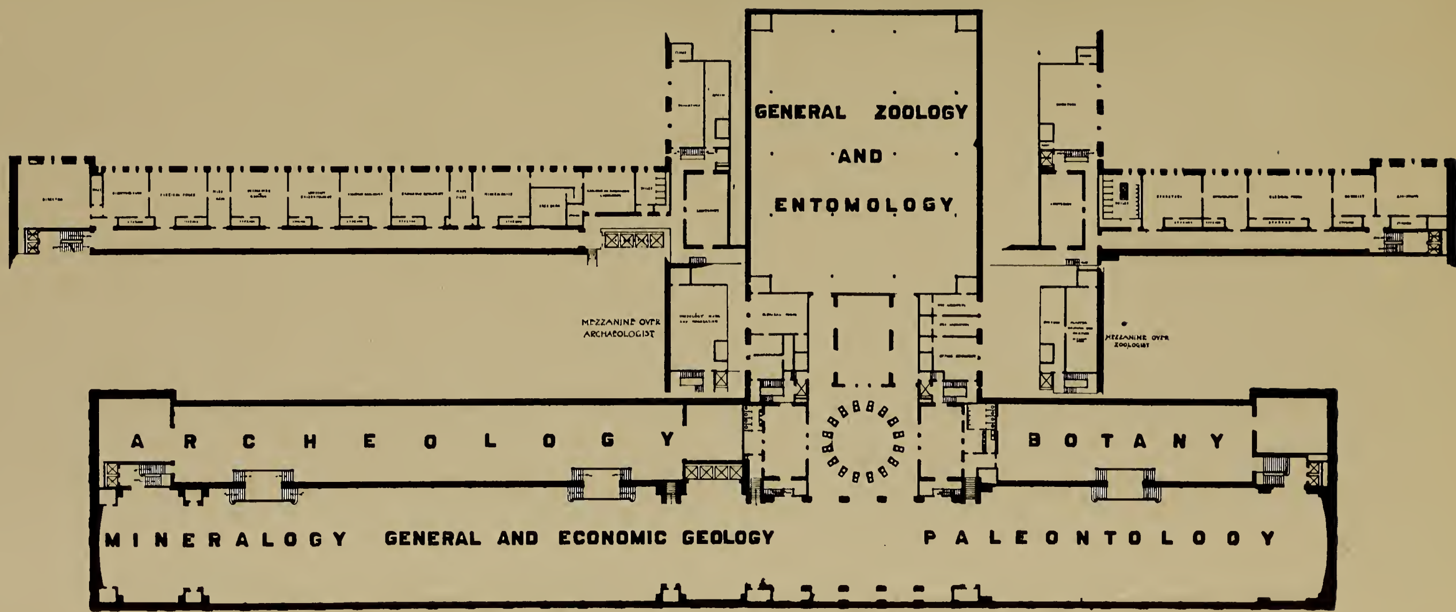
The provision made for museum quarters in the new Education Building on the basis of plans which have now been approved by the commission in charge thereof, will be not only adequate for present needs; it is hoped that provision has been made therein for the progress of another generation. Care has been taken to provide for such emergencies as time may bring and, while it is quite possible that the natural growth of the institution will uncover demands which have not yet presented themselves, experience has taught such vivid lessons in the economy of space that it is altogether likely we shall be equipped for such conditions.

The accompanying plan indicates the general arrangement of space alloted to the Science Division, exhibition rooms and offices. The most notable feature in this arrangement is the great hall extending the full length of the front, 580 feet, with a width of 54 feet. This noteworthy room covering fully 30,000 square feet of floor space is broken only by architectural features extending at intervals partly outward from the walls, sufficient to divide the magnitude of the space into sections adequately adapted to the diversity of the proposed collections without interrupting the vista through the entire space. It is proposed to assign this space to the collections in structural and industrial geology, mineralogy, stratigraphy and paleontology, thus bringing together collections which in this museum have been treated as homogeneous. This fine chamber presents a problem in the treatment for the purposes for which it is designed, as its great length and hight will tend to dwarf its contents unless these are displayed with studied care and with all possible assistance from approved and adequate appliances. From the central architectural feature of the chamber, the inclosed dome, corridors leading on either side into the north wing, open into a large room 131 x 106 feet affording a floor space of 13,886 square feet. This room is not divided except so far as the series of columns affords a basis for partition into communicating sections, should the materials to be installed require such treatment.

It is the present plan to reserve this large apartment to the collections in zoology, both vertebrate and invertebrate, inclusive of the extensive collections in economic and faunal entomology. To the right and left of the corridors leading to the wing are the offices of the Zoologist, equipped with room for necessary clerical force with dry and wet laboratories adjoining, and of the Archeologist. All the rooms thus described and apportioned are on the same level but over the last two chambers mentioned are mezzanines which afford space for storage of zoological material, maceration and plaster casting.

The architectural necessity of introducing trusses on the third floor of the building, crossing the inner subdivision of the main

Plate I


GENERAL ZOOLOGY
AND
ENTOMOLOGY
MEZZANINE OVER ARCHAEOLOGIST
MEZZANINE OVER ZOOLOGIST
ARCHEOLOGY
BOTANY
MINERALOGY
GENERAL AND ECONOMIC GEOLOGY
PALEONTOLOGY

or Washington avenue structure has resulted in an apparently very advantageous division of the museum floor into two levels. Thus from the main level described one rises by short flights of steps 5 feet to a higher platform running the entire length of the building on the inner side save where the space is divided by the dome and the corridors into the northern wing. This subdivision affords two long and somewhat narrow but not constrained chambers, one covering about 11,000 square feet, the other 5760 square feet. These rooms have excellent possibilities for the display of the extensive collections of the relics of Iroquois and other Indian cultures on one side, and for the botanical collections on the other.

The space thus available for exhibition purposes is

Hall of Geology	30 000	square feet
Hall of Zoology	13 886	"
Hall of Archeology	11 000	"
Hall of Botany	5 760	"
Total	60 646	"

All this exhibition space is lighted entirely from above; side light is wholly excluded. It is recognized that this mode of illumination will present its own problems in the effective disposition of the exhibits and may call for special construction or adaptations in the form of the cases in order to avoid puzzling or troublesome reflections, but it may prove to have especial advantages in flooding the whole chambers with light from one direction without the interruption or isolation that comes from light entering separate apertures, like a series of windows.

The construction which necessitates the elevation of the inner portion of the main floor also makes provision for a lower level on this inner side of the museum apartments. By a descent of 7 feet the lower level is reached and here, on either side of the main corridor to the wing, are rooms for the offices of the scientific and clerical staff adequately equipped with files, storage and laboratories. This lower floor turns the corner at each angle with the wing and runs beneath the offices of the Archeologist and Zoologist on the level above, providing room for an Insectory on one side and Artists rooms with north light on the other. This entire series of offices is supplied with lateral light and the suites have their own private corridors. The surface area of these offices is about 19,000 square feet. The total available space for all museum purposes is practically 80,000 square feet.

II

REPORT ON THE GEOLOGICAL SURVEY INCLUDING THE WORK OF THE STATE GEOLOGIST AND PALEONTOLOGIST, OF THE MINERALOGIST AND THAT IN INDUSTRIAL GEOLOGY

GEOLOGICAL SURVEY

Areal rock geology

In continuation of operations directed toward the execution of a geological map on the topographic base of 1 mile to the inch progress has been made along lines which have been pursued for several years.

Central and western New York. Since my last report the double map including the Rochester and Ontario Beach quadrangles, embracing the city of Rochester and its environs, has been issued. This report was prepared by Mr Hartnagel. The Geneva-Ovid double north and south sheet and the Portage-Nunda double east and west sheet are printing. The latter contains special maps of Letchworth park at the Portage falls of the Genesee river and a chapter on the postglacial history of the river.

The Auburn-Genoa and the Honeoye-Wayland quadrangles have been completed as separate double maps, while the map of Phelps remains as a single quadrangle. Work has also begun on the Caledonia quadrangle and some preliminary observations made on the Belfast sheet. All this work has been executed by D. D. Luther. Of other quadrangles awaiting publication are the Syracuse sheet by Prof. T. C. Hopkins and the Morrisville sheet by H. O. Whitnall. The field work for the Cazenovia sheet has also been completed and that on the Chittenango sheet begun by Mr Whitnall.

All the quadrangles above referred to cover areas of sedimentary rocks only and the problems arising thereupon are almost exclusively those of refinement of stratigraphy and correlation.

Field work on the Remsen quadrangle has been completed by Prof. W. J. Miller. The northern half of this quadrangle is occupied by crystalline rocks and the rest by the Paleozoic sedimentaries. The crystallines include (*a*) highly altered Grenville sediments, (*b*) syenite gneiss, (*c*) a complex made up chiefly of intermingled Grenville rocks and syenite. The Paleozoic rocks comprise the Trenton series of limestones and the Utica shale.

Northern New York. Since my last report the Long Lake map and accompanying report by Prof. H. P. Cushing have been issued.

Professor Cushing's work in the past season has continued upon the Theresa and Alexandria quadrangles which also involve problems pertaining to both the crystalline and the sedimentary rocks. The mapping of the former was completed last season. In the work on the Paleozoic sediments which required the aid of a paleontologist, Dr Ruedemann assisted with the cooperation by invitation of Mr E. O. Ulrich of the United States Geological Survey. Mr Ulrich's intimate acquaintance with rocks of similar age in other parts of the country rendered his collaboration of much value.

During the previous season the Potsdam sandstone had been studied and was found everywhere to grade upward into a dolomite formation quite like the rocks which elsewhere immediately overlie the Potsdam around the Adirondacks and which have been regarded and mapped as passage beds into the Beekmantown formation above. It was naturally expected that the Beekmantown formation would be present here, to be followed in proper succession by the Lowville, Black River and Trenton limestones. In working downward from the Trenton as the summit rock of the quadrangle, the Black River limestone appeared with a thickness of some 20 feet and with a sharp lithologic boundary separating it from the Lowville beneath.

The upper part of the Lowville proves to be abundantly fossiliferous, but when followed downward these fossiliferous limestones are succeeded by others which carry an abundant ostracode fauna but with little else. These two limestones have a combined thickness of some 75 feet. Just beneath them follows a considerable thickness of whitish, very impure limestones, sometimes shaly, alternating with occasional beds of pure limestone and of dolomitic limestone with again an ostracode fauna. This mass has a thickness of about 80 feet and beneath it lies a 10 foot mass of pure blackish limestone with many fossils, mainly gastropods but with some cephalopods and trilobites. There is some mixture of Lowville forms in this fauna but in the main it consists of forms which do not pass up into that formation. The fauna appears to be one not before noted in New York, and according to Mr Ulrich seems comparable with the fauna of the upper Stones River formation of other regions. Its close association with the Lowville, both stratigraphically and paleontologically, seems to preclude its reference to the Beekmantown formation and its fauna is wholly different. The name *Pamelia formation* is suggested by Professor Cushing for this series. The invasion of the sea during this stage was from the west, and this district marks the easternmost edge of its extent. Here alone in the State is the formation well exposed. A name for the New York expression of the series seems therefore called for. It overlapped an old land surface, thins rapidly eastward and thickens to the west, and its presence furnishes for the first time an adequate explanation of the great thickness of limestone reported by the drill in the deep wells of northwestern New York.

On reaching the base of the Pamelia formation it was found to rest everywhere on the beds which had been referred to as passage beds during the work of the previous season, and to rest on them with the most prominent unconformity noted among the sedimentaries in northern New York. The basal beds of the Pamelia formation are weak and therefore seldom exposed but when seen show everywhere a thin basal conglomerate and sandstone. The underlying formation had suffered considerable erosion as evinced by its varying thickness and the varying thickness of the beds of the Pamelia formation beneath the heavy fossiliferous limestone bed, as shown in numerous sections in small areas. The time interval in this unconformity seems to represent the whole, or the major part of Beekmantown and Chazy time. Nothing that can be correlated with the Beekmantown formation is represented in the section.

For the so called passage beds beneath, the name *Theresa formation* is proposed, their entire thickness being well exposed in the township of that name. This formation seems also to hold a fauna not before noted in the State.

The absence of the Beekmantown limestone, the great unconformity between the Theresa and Pamelia formations, and the close connection of the former with the Potsdam into which it grades, and of the latter with the Lowville, seems to add weight to the view previously urged, that the Potsdam-Beekmantown passage beds of northern New York, with possibly a portion of the Beekmantown, are so closely connected with the Potsdam that they must of necessity be classed with them, and that, since the normal fauna of the middle and upper Beekmantown is plainly a Lower Siluric fauna, the line of division between the two great rock groups is to be found somewhere within the limits of what has heretofore been considered as Beekmantown. In this connection the discovery of an unconformity between Brainerd and Seely's group A and group B of the Beekmantown, made by Messrs Ruedemann and Ulrich in the Ticonderoga region the past summer, comes to have large significance.

Both the Potsdam and the Theresa formations have large representation on the Alexandria quadrangle, but the chief interest attaches to the Precambric rocks. The main rock of the Thousand Island region is a granite gneiss, a bathylith of probable Laurentian age. Near its edges it holds abundant inclusions of schists, and passes by increase of these into a belt of schists cut by granite, these dikes diminishing as one recedes from the main granite mass. There is much in these schists to suggest that they are impure limestones transformed by the contact action of the granite gneiss. This Alexandria bathylith seems to have been much richer in mineralizing agents than was the similar Antwerp bathylith of the Theresa quadrangle. A coarse granite is also present which seems of later date.

Eastern Adirondacks. For a number of years, Prof. James F. Kemp, who has excellently served the State work in geology, has continued his investigations in the eastern Adirondacks. Under the auspices of the United States Geological Survey Professor Kemp has long devoted close attention to the intricate problems presented by the crystalline rock region of the Elizabethtown, Ausable, Mt Marcy and Lake Placid quadrangles. By an arrangement entered into with Professor Kemp, the Director of the United States Geological Survey and the Director of the New York State Survey, this work is now transferred to the supervision of this office with full assent to the eventual publication here of all the results acquired whenever the work shall have been completed. Under this understanding, Professor Kemp has reviewed and continued his work on these quadrangles. Some problems which seemed determined in the past have been of necessity reopened, for it was inevitable that there should be some gaps in the record and some former determinations requiring corroboration. During the past season Professor Kemp's work has been concentrated upon the Elizabethtown quadrangle, which is not only the most thickly settled of the four mentioned but economically the most important. Since the earlier fieldwork in this area was done, in 1896–97, we have come to recognize the great syenitic series of eruptive rocks which was imperfectly noted under other terms in earlier reports and thus made to accord with a scheme of classification at that time apparently satisfactory. This area, moreover, is on the border between the central anorthosite mass and the outer Grenville sedimentary and other gneisses. There are puzzling intermediate types and on the whole a complicated assemblage of rocks whose relations await determination. In the 10 years past there has also been extensive development of mining and diamond drilling in the great iron ore bodies at Mineville and it has been desirable to bring the records up to date. There lies between the boundary of the Elizabethtown quadrangle and Lake Champlain a comparatively narrow belt of country in the Port Henry quadrangle which it has seemed desirable to treat together with the former, and as the latter includes areas of Paleozoic sedimentaries the assistance of Dr Ruedemann was enlisted in the solution of problems involved in the mapping of these. The season's work, thus, has been largely devoted to (1) reviewing and plotting new data in regard to the Mineville ores, (2) verifying and amplifying observations on the Elizabethtown quadrangle, (3) traversing the Precambric formations of the Port Henry sheet. In general beneath the undoubted sediments of the Grenville and intimately involved with them along the borders there is a great series of rocks usually gneissoid but often massive, of a mineralogy ranging from the granites through the syenites to and into acidic diorites which are probably of intrusive origin and which represent one or more great bathyliths. Though at times decidedly variable in composition this may well be due to the fusing into their substance of the Grenville sediments, which range from quartzites to limestones. The whole aggregate has been extensively faulted. Distinct from this complex are the anorthosites and some related gabbros, but between the anorthosites and the syenites there are intermediate transitions which add to the difficulty of sharply defined mapping.

Valcour island, Lake Champlain. Prof. George H. Hudson is finishing the survey of the eastern shore of Valcour island on the scale of 1:1000 and proposes to reduce the remainder of the island to one of 1:3000.

The chief reason for continuing the survey on this large scale is the fact that the region is one of curiously changing dip and strike. It has been influenced not only by east and west faults together with some compression, but the influence of a great and somewhat distributed north and south fault close to the east edge of the island is very apparent. The southwesterly section has been remeasured and some important corrections made, and the east section of the island worked out with good exactitude. This is the most important section of the island, because its beds present a hundred times the area of the south section.

An interesting result of this investigation is the recognition of the repetition of the coral and stromatoporoid reefs in the Chazy

Plate 2

Cliff on Valcour island, Lake Champlain, showing the undercutting by frozen spray on a weak stratum of thinly laminated limestones overlain by more compact beds

Plate 3

Reef dolomite (base of upper Chazy) Smugglers Harbor, Valcour island, Lake Champlain.

Plate 4

Cystid point, Valcour island, Lake Champlain. The dipping upper Chazy beds at the left and the horizontal beds at the right indicate a syncline between

Plate 5

Paradise bay, northern arm, Valcour island, Lake Champlain Showing undercutting by freezing in joint planes and not by direct wave action

Plate 6

Another view at Paradise bay indicating the agency of frozen spray in undercutting the rock face

Plate 7

Glacial pebble from left bank of Saranac river about 1 mile above Plattsburg. Taken from the till close upon the glaciated bed rock. It shows a series of fine parallel striae made by sand grains lying between it and the bed rock and the usual irregular scratches and incisions caused by rubbing against other blocks in the till.

beds. Only one of these has commonly been recognized by other investigators. At Cystid point a reef is shown and its extinction and the deposit of sediment over it is clearly to be seen. Five meters down from this horizon and 300 meters to the north is another. Twenty-three meters down and 1000 meters to the north comes the more massive one which forms the "dove color" of Tiger point. Reef material is found again from 400 to 500 meters north of this and at a horizon 70 meters below the surface at Cystid point. This reef is as large as the Tiger point reef and in many respects resembles it. The shore is of a deeper blue dove color on the whole, yet this darker dove color may also be found in the Tiger point reef. The rock abounds in cephalopods and the trilobite Glaphurus pustulosus. The rocks of Sloop island (which show a pure dove colored rock as light as that of Tiger point) seem by their position to belong to this reef. One of the reefs noted belongs to the upper Chazy, the other 47 meters below it, is in the middle Chazy.

The fault system of the region is of interest and corrections have been made of the location of the faults mapped by others and also data on new faults acquired. A preliminary map of the intricate fault system of the Plattsburg region has been made and the fact brought forward that the form of Lake Champlain is the outward expression of some of the more extended of these faults. Enough evidence has been acquired to show the presence of two widely different systems and that correlation of the scattered observations is at least in part, possible. The north and south system appears to be the younger, or at least has suffered the most recent additions to its displacements.

A number of interesting observations have been made on the island, bearing on the glacial history of the region and on the striae of the glacial boulders. An enormous amount of the energy of a moving glacial sheet is spent in reducing its ground moraine to powder. The sheet of till in actual contact with the bed rock does not move so rapidly as the sheets lying over this. As a consequence comparatively few stones of the till are found with surfaces ground by contact with bed rock, for such a grinding produces a flat face with hundreds of parallel lines as may be seen in the adjoining photograph; on the contrary curved outlines predominate caused by contact with each other.

Highlands of the Hudson. Geological fieldwork in the Highlands was continued by Dr Charles P. Berkey during a part of the season along the lines developed last year. Although less time than usual was available for this work, considerable additional area was mapped in both the West Point and Carmel quadrangles, some portions of which have been studied in detail.

In the discussion of *Structural and Stratigraphic Features of the Basal Gneisses of the Highlands* published last year in Museum Bulletin 107, the major structural types of the Highlands formations were outlined. As a related problem the chief reasons for doubting the exact equivalence of the Inwood limestone and Manhattan schist to the Wappinger limestone and Hudson River shales were given. A special effort has been made the past season to follow out all of the more promising lines of field evidence bearing upon this question of stratigraphic succession and correlation. This has led to the tracing of the contact lines of the tongues of crystalline limestones and schists that project into the Highlands from the south side. If these formations could be followed entirely through the Highlands to the north side, as the earlier maps indicate, it was believed that some direct relationship between these crystallines of the south side and the better known Cambric strata of the northern border could be determined.

After studying for this special purpose all of the valleys that give such opportunities from the south, it seems necessary to conclude that there is no place in New York where the crystalline schists and limestones characteristic of the southerly areas can be traced through to the northern border. There is always a belt of several miles in width occupied only by the typical gneisses of the Highlands. This line of attack therefore furnishes no conclusive proof.

Observations made on numerous areas of the Cambric strata of the northern border indicate a much more profound metamorphic change in them in passing eastward from the Hudson river to the Connecticut line. Limestones and schists, that seem to be beyond question equivalents of the Wappinger and Hudson River formations, have in that district all the characteristics of the Inwood limestone and Manhattan schist of the vicinity of New York city.

With such results in two of the lines of attack, it seems necessary to make a more minute study of the Stony Point-Peekskill region, the one district where apparently almost typical Cambric formations occur on the southern border of the Highlands.

As the mapping of the ancient gneisses progresses it is evident that traces of interbedded limestones belonging to the oldest series of the region are comparatively common. Several occurrences in addition to those previously enumerated have been mapped. Associated with two of these small limestone belts are graphitic schists of considerable prominence. These types are believed to lend further support to the sedimentary character of certain portions of the series. One of the graphitic outcrops has attracted some local attention looking toward development.

It is clear, however, that the proportion of the igneous members to the sediments in the basal gneiss series varies greatly in different areas. In the eastern part of the Carmel quadrangle those interpreted as igneous types greatly predominate. The prevalence of schists, limestones and quartzose rocks considered sedimentary, is much more marked in the West Point quadrangle and especially in the vicinity of the Hudson river.

Surficial geology

The problems relating to the impounding and drainage of surface waters upon the retreat of the glacial ice, the making and breaking of glacial and postglacial lakes, the molding of the present topography of the country to the change in the level of the marine waters and their former incursion into what are now fresh-water passages, have involved investigation along lines and in areas indicated in my report of last year, by Prof. J. B. Woodworth in the northeastern region, Prof. H. L. Fairchild in the central and western region and Prof. A. P. Brigham in the Mohawk valley.

For the northeastern region Professor Woodworth has practically completed the detailed mapping and report for the Schuylerville quadrangle. The report will give an account of the extensive sand deposits between Saratoga and Fort Edward which are not without economic interest because of the occurrence of molding sands in that district. The remarkable rock basins of Round lake and Saratoga lake are dealt with, but a final report on these features must await the detailed mapping of the topographic sheets in which their southern and western portions lie. These lake depressions notwithstanding their small size are of singular interest. The report will contain a diagnosis of late glacial lake and river changes, adding much in details to the preliminary sketch made in the report on *Ancient Water Levels of the Champlain and Hudson Valleys.* Similar work on the Rouse Point sheet lying directly east of the Mooers sheet already published has progressed and the completion of this map will carry the line of marine deposits from the base of the Adirondacks along the International boundary to Lake Champlain. The customary classification of glacial deposits for the purpose of geologic mapping breaks down in this area by reason of the modification of the deposits through action of sea waves and currents. The problem of how best to map these modified glacial deposits has perhaps not yet been satisfactorily solved. The problem is a particularly difficult one by reason of the varying degree of alteration and rearrangement of the original accumulations. Some parts of the area display a typical glacial topography and underlying structure of the materials; yet other districts show the glacial deposits entirely recomposed in beaches, bars, and offshore sediments. These features are not always clear; there are large tracts in which no distinctive surface characters exist and in which the deposits can only be discriminated on such broad groupings as stratified, gravelly, sandy or clayey. This results in the necessity of coloring large areas as undifferentiated glacial and marine or glacio-marine gravels and sands.

On the Rouse Point quadrangle there is a marked belt of sandy beach deposits about the hills at levels between 180 and 220 feet above sea level. Along the northern border of the area in the vicinity of Champlain village, pocket beaches occur at lower levels. Marine shells have been found in sufficient abundance to give some idea of the fauna. There is a noticeable abundance of Mya arenaria at these lower levels, but it is absent at the higher stands of the sea. Either this mollusk reached the area relatively late or lived only in the deeper offshore stations. Owing to its abundance in shallow surface deposits I am inclined to the view that it migrated into the Champlain area much later than Saxicava rugosa and Macoma greenlandica. If this be true it may be possible to differentiate locally these life zones. Mytilus edulis also appears in abundance and in an excellent state of preservation at these lower levels, as on the Isle la Motte.

The field work indicates pretty clearly that a morainal belt extends southeastward across the Mooers area towards Chazy, indicating a protrusion of the ice front into the Champlain embayment at a late stage, possibly as an ice advance after the sea once got into the area. Unless the unfossiliferous clays about East Beekmantown and near the lake shores in that vicinity and around Alburg can be referred to the lacustrine stage, no deposits are recognized which can be definitely referred to the glacial lake waters which preceded the marine invasion in this field, nor have any Prewisconsin drift deposits been found.

The shores of Lake Champlain about its northern end seem in places to be higher than when the cliffs were cut. The evidence from many parts of the shore is not conclusive for or against changes of level, either a rising or a sinking. Such channels as that from Champlain village suggest a rising of the water level. It is probable that the highly tilted Siluric slates in Vermont are being crowded up and that downward movements have been taking place among the faulted rocks of the New York shore along the International border.

Western, central and northwestern New York. As a result of Professor Fairchild's investigations the story of the succession of glacial waters in western, central and northern New York is approaching completion. Following several introductory and preliminary papers, the glacial waters held in the Lake Erie basin in this State have been described in State Museum bulletin 106. The later waters in central New York down to the Iroquois stage are described in the paper awaiting publication. Lake Iroquois is well known in its general character and history, but there yet remains for description: (1) the local glacial lakes held in the valleys of the western and northern Adirondacks during the Iroquois stage; (2) the extinction of Lake Iroquois; (3) the sea level waters which occupied the Ontario basin subsequent to Lake Iroquois and preceding the present Lake Ontario. The past summer's work has been on these three elements of the history, and is briefly summarized in the following description.

(1) *Local glacial lakes.* All the well defined valleys sloping westward or northward from the Adirondack mass must have held glacial waters while the ice acted as a barrier. The largest and most interesting of these local lakes was the one in the Black river valley, which in all the elements concerned in the functions and relationship of such waters is the most excellent known in the State. The larger part of the summer was used in the study of this lake, and its description will form the subject of a future paper.

(2) *Iroquois extinction.* A broad ridge of Potsdam sandstone extending north from the Adirondacks into Canada forms the divide between the Champlain and Ontario basins and is the critical area in this study. A rapid examination of the divide shows that the Iroquois waters were held up to the Rome outlet until the south edge of the ice body had receded as far north as the International boundary, but that here the waters found lower escape across Covey hill, the north end of the ridge. The outflow here cut the great

ravine locally known as the " Gulf " in the resistant Potsdam sandstone, and the seaward escape of the Ontario basin waters was shifted from the Mohawk-Hudson to the Champlain-St Lawrence. These waters, with level inferior to the Iroquois and with different outlet, require a distinctive name and it is proposed to call them Hypo-Iroquois.

With only a little further recession of the front of the ice sheet on the end or nose of Covey hill the Hypo-Iroquois waters found yet lower escape between the ice and the north-facing land slope, and the outflow carved the slope into a series of irregular benches or terraces. When the waters were lowered between three and four hundred feet below the intake of the Covey gulf the level of the ocean was reached and the waters in the Ontario basin blended with the sea.

The gravel bars of the Iroquois shore have been traced to a point midway between Watertown and Carthage, but eastward and northeastward from here the shoreline is weak and very irregular, passing far up the valleys of the present north-flowing streams. The deltas built at the mouths of these rivers in the Iroquois waters are proofs of the relation of streams to the high-level lake, and they have interesting characters. Excepting the Potsdam quadrangle the long stretch of the Iroquois shore from Carthage to Covey hill is unmapped by the topographic survey and its close study is not at present advisable.

(3) *Gilbert gulf.* The marine beaches on the north slope of Covey hill are remarkable for their strength, number and composition. The upper ones are strong, close set ridges of sandstone boulders. Aneroid measure makes the highest continuous bar about 460 feet A. T. This is 10 feet higher than the figures previously given for the upper reach of the marine waters by Gilbert and Woodworth. It is particularly desirable to determine the precise altitudes for the several Covey hill features and the State should place benches along the International boundary.

Passing down the hill slope from the marine summit bar it is found that 20 distinct bars occur in a descent of only 140 feet, the greatest interval (aneroid measure) being 12 feet. This multiplication of the wave-built ridges agrees with the theoretical expectation, since the vertical spacing was produced by the very slow, and probably uniform, uplifting of the land out of the sea, giving opportunity and time for bar construction at all interior levels.

Professor Woodworth has traced the marine shore westward some distance and Professor Fairchild has located the upper limit at points north of Burke and Malone. Topographic sheets of the region are necessary for the mapping.

The sea level waters in the Ontario basin, called Gilbert gulf have left definite shore features which had been mapped previous to this season as far north as the mouth of Stony creek, 3 miles southwest of Henderson. During the summer the mapping has been carried northeastward to Stone Mills, on the Theresa quadrangle.

The highest Gilbert gulf bars lie at about 262 feet altitude near Texas, northeast of Oswego, where the water plane passes beneath the level of Ontario. The plane rises to the north so that the highest bar is 325 feet at Henderson Harbor; 375 feet at Dexter; 380 to 390 feet at Stone Mills and Depauville; and about 400 feet at Clayton. Along the nearly north and south line of 46 miles between Texas and the Hogback hill, 4 miles southwest of Clayton the average rise is about 3 feet per mile. With the assistance of Mr F. A. Hinds of Watertown the altitude of the highest of the strong Iroquois bars on the Farr place, 3 miles east of Watertown, was determined by precise leveling as 733 feet, a reduction of 7 feet from the previous aneroid figures. Using this corrected altitude we find that the deformation of the Iroquois shore in the stretch between Richland and Farr's is $733-566 \div 30$ miles $= 5.6$ feet per mile. It appears therefore, that the average uplift on the Iroquois shore in this region is nearly twice that of the marine beaches, which fact has an important bearing on the time relations of the two water bodies.

Before the details of the closing stages of the Preontarian waters can be advantageously studied and the dramatic history fully written, the topographic sheets of the areas northwest and north of the Adirondacks must be published. The sheets more specially needed for this study are the four along the State boundary lying between the published Mooers and Massena sheets; also the sheet east of the Carthage sheet.

Aside from these items of Pleistocene history in the regions referred to, a review has been made of contemporary features of the Upper Genesee valley with special reference to the relations of the preglacial drainage and glacial lakes of the river to the production of the gorge and cataracts at Portage.

The region under study by Professor Brigham includes the Broadalbin, Gloversville, Amsterdam and Fonda quadrangles, an area of about 900 square miles, reaching from the southern Adirondack region into the edge of the Appalachian plateau south of the Mohawk river. It does not, however, include any uplands belonging to the Helderberg or Catskill regions, although these are near at hand and conspicuously viewed from the southern boundary of the area. The principal drainage of the area is through the Mohawk river, with several of its affluents, principally the Schoharie, while the Sacandaga controls the drainage of a part of the northern border. The northern limit is nearly marked by the village of Northville, while Duanesburg and Esperance villages are close to the southern border. On the west the area extends just beyond the Big Nose or west of Yosts Station.

Glacial lobes. Perhaps the most salient features brought out by the investigation of the territory are two glacial lobes, one a part of the great Mohawk glacier, which is now demonstrated to have moved westwardly for a short distance up the Mohawk valley and what may be called a *Sacandaga glacier,* moving southerly about the region of Northville, swinging toward the southwest in the neighborhood of Mayfield, filling into affluent westward flow with the Mohawk glacier about Gloversville. The existence of such a westward Mohawk flow was postulated by Chamberlin on the evidence which was at hand many years ago. Further advent of this westward movement has been given by Professor Brigham.

Conspicuous evidence of this movement is found in the glacial striae which are well distributed throughout nearly the entire area. About 60 localities of such striae have been found and recorded. The direction is not on the average greatly variant from westward, but north and south of the Mohawk river in the neighborhood of the Big Nose there are interesting divergences. On the north of the river to the west-northwest and on the south of the river toward the west-southwest, illustrating the axiradiant flow of Chamberlin, a still more interesting and somewhat puzzling divergence is found in the neighborhood of Galway village west and northward where some of the striae point distinctly toward the northwest and even branch toward the north-northwest. As the glacier apparently came around into the Mohawk valley from the Hudson-Champlain depression, this seems a curious condition. What possible effects, if any, of local glaciation in the Berkshires and Catskills may have produced results here, remain to be determined. It may be asked whether this postulated western flow might not have been a flow to the eastward as the striae themselves do not ordinarily give special evidence as to whether the flow was in one direction or the other, but the carriage of erratic material and the relative distribution of the drift in certain localities, leave the westward flow beyond question. A still more striking confirmation is found in connection with the Schoharie valley. On the east side of the lower Schoharie within this district, the drift is a very massive till and outcrops of the bed rock are almost absent. In fact that section of the Schoharie valley from Esperance to Fort Hunter was filled with till to a remarkable extent and the postglacial excavations by the stream have produced a singularly interesting series of topographic forms normal to river action. On the west of the Schoharie on the contrary, outcrops of the bed rock are everywhere present, the drift is very thin, ledges and glaciated benches are frequent and the region gives every evidence of having been powerfully scoured. These conditions as between east and west are exactly what would be expected from a westward moving glacier, passing over the hills in the neighborhood of Minaville, dumping and filling in the valley transverse to its course, and drifting powerfully against the edges of the exposed striae west of the stream, cleaning away the drift and giving to the whole topography a characteristic glacial expression. It should be remembered, however, that these striae and other evidences of a westward flow only determine the last glacial conditions of the area. What earlier flows there may have been and what their directions were, must for the present, and perhaps always, be left to conjecture.

As above indicated, the valleys drained by the Sacandaga distributaries permitted a considerable glacier to flow southward out of the mountain region and the striae, while not so numerous as in the Mohawk region, are sufficient in number and distributed in such a manner as to leave no doubt of the directions already described. Two localities of striae about 4 miles southeast of Batchellerville show gradings of a south-southwest direction, belonging evidently to this Sacandaga or southern Adirondack movement, which was quite at right angles to the northwestward movement already noted in the neighborhood of Galway.

Interlobate moraine. One of the most interesting glacial developments in the entire district is a belt of sand hills extending across the Gloversville and Broadalbin quadrangles from Gloversville westward over Cliff hill and eastward toward Broadalbin, Hagadorn's Mills and Barkersville. This grade moraine is in many parts massive, from 1 to 2 miles wide, hills sometimes low and spreading and other times lofty and massive, more often with constructional moraine forms, sometimes toward the southern edge tending toward the drumlin form, as if that edge of the moraine had been overridden. No doubt some of the smaller present hills are of the nature of dunes as there are localities where the sand is still exposed to the free action of the winds. A considerable part of the city of Gloversville is situated on this moraine, and the more direct road from Gloversville to Broadalbin is about in the center of the moraine and traverses a region which has many of the characteristics of a desert. This grade moraine apparently was accumulated between the two lobes already described where the edges touched or approximated each other. As far as can be judged from limited observations and from the appearance of topographic maps, the moraine belt extends from Barkersville northeastward along the base of the mountains to Corinth. Its western extension if any, has not yet been traced.

Recessional moraines. South of the moraine already described, in the field of the Mohawk glacier, special moraine accumulations are almost absent excepting heavy deposits of till in the Mohawk valley which have been so reshaped as largely to lose their character as moraines. In any case they represent dumping and filling in the immediate Mohawk valley and the work of localized tongues. The region south of the river to the limit of the district is distinctly free of anything which could be called morainic. On the eastern edge of the district from the interlobate moraine southward to the Mohawk river a number of small morainic areas were found, generally of till. It is evident that these extend over in some measure into the Saratoga quadrangles eastward, and further study may develop a distinct belt of such moraine. In that case it would appear to mark the recession of the glacier out of the Mohawk valley to limit the western edge of the Hudson valley glacier at that stage of recession. This would be in harmony with Professor Woodworth's efforts at the determination of the existence of a Hudson valley glacier extending down toward Schenectady and thus preventing the accumulation of the sands of Lake Albany over the region northward from Schenectady. Various accumulations that may be called recessional are found in the Sacandaga region, especially in the neighborhood of Osborne's bridge and northward but more especially in the Sacandaga valley northward from Northville and northward from Edinburg. Here are two great accumulations of constructional hills of sand and gravel which may be regarded as the terminal of the Sacandaga glacier at that stage of its recession.

Distribution of the drift. Some facts have already been given in the description of the glacial lobes. No general estimates of the thickness of the drifts are offered. These it is believed are sure to be delusive. It may be said in a general way that in the Adirondack portion of the area the drift is apt to be thick in the valleys and it is generally thin on the slopes and summits as would be expected. In the Sacandaga basin south of Northville and over the region of the Great Vly the drift is of unknown thickness and outcrops are rare. Naturally the drift is very massive along the belt of the interlobate moraine, and south of this moraine extending from about West Perth eastward for 7 or 8 miles there is a broad flat topped plateaulike mass of till sometimes showing sandy phases. The north edge of this region is near Broadalbin and the south near Perth, the ridge averaging perhaps 3 to 4 miles in width. It is on the high ground between the Mohawk and Sacandaga basins and it is seen as a conspicuous profile from all high points south of the Mohawk river. It is historic in the sense of having carried the ancient highway of Johnstown to Saratoga. It is conjectured that it has been a great overridden moraine of an earlier age but this suggestion is offered doubtfully and with hesitation. South of this region toward the Mohawk river, especially in the region between Galway and Amsterdam the drift is thin. Around Johnstown eastward and westward it is comparatively massive. So is it also at many points in the Mohawk valley. South of the Mohawk it inclines to be thick near the river but averages thin wherever the glacier overrode the higher sandstones which lie south of the black shales. An exception, however, appears several miles about Charleston Fourcorners where the geological map shows almost no outcrops and where the drift must be comparatively massive. An interesting belt of drumlins exists in the vicinity of Gloversville and Johnstown. At Johnstown these drumlins make up a large part of the territory, show altitudes of from 50 to 150 feet and are the most conspicuous elements in the topography. The same is true northward and northwestward of Gloversville to the base of the Adirondacks. A few of these drumlins are peculiarly massive and noble in proportion, making an aggregate of great ellipsoid swells which command the attention of the observer. The same forms are found eastward of Gloversville and along the road from Gloversville to Mayfield and curiously these forms in some cases emerge among the sands of the interlobate moraine. Some of these are seen between Gloversville and Broadalbin, the sands sweeping around the base of the drumlins and in some cases partly up on one side or one end. Many of the drumlins are conspicuous for groups of large boulders turned on their eastern slopes. The axis of the drumlins is in a way east-west but within the field of the Sacandaga glacier some of them tend towards the northeast-southwest direction as do the drumlinoid forms about Mayfield. Thus the drumlins and drumlinoids fall into perfect harmony in direction of trend with the glacial striae. The till of many of these drumlins is comparatively light and sandy but this may be said also of the ground moraine in general in the vicinity of the crystalline rocks. Indeed the ground moraine everywhere in the region follows the usual law of glacial deposits in showing the close kinship to the bed rocks from which it has been so largely derived. This has a conspicuous bearing on the agriculture of the region and it will be found, for example, that the drift around Johnstown partakes especially of the character of the underlying black shales and the soils are consequently rich and the region agriculturally prosperous. A similar belt, productive for the same reason, is found south of the Mohawk river for a width of 4 or 5 miles in the vicinity of Scotch Church, Minaville and Glenville. On the higher sandstone hills the drift, as already indicated, is not only thin but partakes of the poverty of the sandstones so far as its productive capacity is concerned.

Lake deposits. Some of the most interesting accumulations of the district were made in standing water. These include small areas of high level sands, evidently in pools or lakelets sustained by retaining walls of ice. An example of this is found west of Hagadorn's Mills, a tablelike deposit which has been cut in two by the waters of the Kenneatta. Another of these level sand deposits likewise dissected by a stream, is found southwestward from Benedict and another conspicuous example lies just westward from Edinburg. In the eastern part of Gloversville is an area of flat or gentle sloping sands or clays which are doubtfully interpreted as deposits of a lake surrounded by a glacial moraine and waning glacial ice.

Deposits of Lake Sacandaga. This name is given to a body of water which evidently occupied the depression now known as the Great Vly. Its water was apparently held in place by the massive drift in the region of the interlobate moraine and by the receding ice of the Sacandaga in the direction of Batchellerville and Conklinville. The basal deposits of the Vly are undoubtedly sediments of this lake overlain by large accumulations of swamp and vegetable material. The most interesting and distinctly formed delta of the district was built by the issuing waters of the Sacandaga glacier at and south of Northville. Most of Northville village lies upon a flat table which is a remnant of this delta. The delta can be traced for about a mile north of Northville heading against the great recessional moraine to which reference has already been made. South of Northville it has been largely dissected and much of it swept away by the Sacandaga river. Slight remnants are seen on the east of the river but the major parts of it are on the west. Beginning with the flat sandy area on which the resort known as Sacandaga Park is situated and extending southward to a point eastward from Cranberry creek and past Ogden's creek toward Northampton some small areas of till emerge from the silts of the delta near its edge and from Sacandaga Park to Osborne's bridge much of the old delta area is occupied by terraces and flat plains and old channels of the Sacandaga river.

Lake deposits of the Mohawk valley. These include conspicuous deposits of sand, silts, clay and gravel at altitudes varying from 440 to 460 feet, in some cases a little higher. These are found about the Lower Cayadutta and west of Fonda. They extend from Fultonville to the Schoharie creek south of the river. They are found conspicuously along the north side of the river and east and west of Tribes Hill. They also appear at the golf grounds of the Antlers Club and along the river on the north side of Amsterdam, and east and west around Port Jackson. These deposits are conspicuous and they are to be seen at Hoffmans Ferry. In the great delta on the north side there are minor exhibitions of them southeastward to Rotterdam or a little beyond. These silts and sands evidently represent waters at an altitude of from 440 to 460 feet and the determination of a barrier by which such waters should be maintained has been one of the most puzzling questions of the investigation. No entirely satisfactory answer is at hand, but it is the best belief of the writer that the barrier was ice in the vicinity of Schenectady. It is not necessary to believe that the entire strip of the valley from Schenectady westward was in the earlier stage occupied by these waters continuously, for at some points in the vicinity of Amsterdam, for example, there are the accustomed clays containing scratched stones and there are sands and gravels of such irregular character as to lead to the conviction that the waters in which they were deposited were in the immediate presence of ice, which could have been no other than a local remnant ice tongue extending up the valley from the main glacier which still lingered in the region of the middle Hudson. These deposits at similar levels are found to the westward of the area now under consideration, nearly or quite up to Little Falls. It seems very probable that the capacity of stagnant ice to maintain a barrier has been greatly underrated. Such ice is often covered with debris. The streams which would flow over it, proceeding from a recent glaciated region would naturally be so overloaded that they would tend to aggregate rather than to erode. No spillways or water-swept areas at the proper altitude have been found on the hill flats westward from Schenectady although some search has been made for them. The problem demands further study but the evidence is conclusive that lake waters in front of a waning ice tongue occupied a long section of the Mohawk valley at about the altitudes indicated.

There is some evidence that such conspicuous accumulations for example, as the great sand flat "west of Fonda" is not altogether and perhaps is not largely a delta of the Cayadutta creek, for on the very borders of the Mohawk river on the south edge of the lacustrine accumulation is found at least one locality cross-graveled, dipping to the northward, whereas, as further north and toward the head of the supposed delta, the deposits are silts and fine sands. This points to the suggestion that the deposited part at least was made while the immediate valley of the Mohawk was occupied by a remnant glacier from which these gravels were derived.

Deposits of Lake Albany age. The waters of Lake Albany extended up the Mohawk valley. The writer is not aware that this fact has been sufficiently recognized, but by consulting the contour maps of the valley it will be seen that the waters of Lake Albany at an altitude of 340 or more feet would extend far up the present course of the river. This also carries with it the interesting conclusion that the Iroquois drainage which swept down the Mohawk valley and is believed to have deposited as a delta the Schenectady and Albany sands, must have been a drainage following the belt of still water through a long stretch of the Mohawk valley. A number of deposits of coarse gravels have been identified in the area as probably belonging to the Lake Albany stage. It could not have any reference to the present or recent work of the river and they do not seem to belong to the earlier 440 to 460 foot stage already described. Such deposits of coarse gravels occur down at Yosts where they have been largely excavated by the New York Central Railroad. They form a stone ridge east of Randall, south of which ridge is an interesting old channel of the river waters. They occur again in the hill about 40 feet in hight which extends northeastward from Fort Hunter and they are found conspicuously developed as appears by the map, from Hoffmans Ferry toward Schenectady. Doubtless these deposits were much more extensive than they are at present, having been largely swept away by the waters of the river after Lake Albany subsided. Reference has been made to the heavy tills of the Mohawk valley. These are basal and massive on both sides of the river. At certain points as already described, they are capped by the lacustrine silts and sands of the higher level, but in many cases these sands, which must have sloped down to the flood plain level originally, and amassed tills, have been swept away along the lower slopes so that in cross-section we should have massive tills sloping from the upland down to the river. At certain points, as east of Fultonville and along all the lower parts of the city of Amsterdam, are belts of water-swept till. Along these lower grounds of the city of Amsterdam till is very thin, bed rock near at hand, and east of the city are fields of boulders which apparently are remnants of tills of which great Iroquois currents have removed finer materials. For many miles along the Mohawk river the deposits of the drift are exceedingly steep. They are almost cliffs and there is an entire absence of morainic contours. These forms could not have been constructional in the glacial sense. When these tills were dumped into the Mohawk valley they must have been purely morainic forms resulting from a melting down of the ice tongues which occupied the valley. It would seem that these slopes of till with their occasional covers of the customary silts have been powerfully undercut by Iroquois waters, giving the steep slopes of the present, but it must also be recognized that that undercutting could not effectively take place until there was some subsidence of Lake Albany waters allowing effective current action by the grade stream carrying the drainage of the glacial Great Lakes. These facts and suppositions involve a problem concerning the Iroquois drainage and the waters of Lake Albany which deserves further and more final investigation. An interesting remnant of the Lake Albany silts is found near South Schenectady along the waters of the Normans kill. Here, near the region of the Amsterdam quadrangle is a small embayment of Lake Albany waters and therefore a reentrant area of sands which joined with the greater area that appears in the Schenectady quadrangle.

Schoharie lake. An interesting development of lacustrine sands and clays is found along the Schoharie river from Esperance up stream for some miles. In looking for a cause of these lacustrine accumulations it was discovered that by the dumping and filling process already described a great till barrier had been formed across the Schoharie valley just south of the small village of Burtonsville. That till barrier raised the waters of the Schoharie above that point to a hight of about 100 feet greater than at present. The till has been cut away down leaving cliffs largely of till but also in part, on the concave side of the bend, cliffs of bed rock. It would appear that this raising of the waters must have extended about 20 miles up the Schoharie from Esperance and that the lake was maintained there in the immediate postglacial times until the barrier could be cut away. There is apparently a well marked delta belonging to this lake above Central Bridge and along the valley towards Cobleskill. The conditions of this lake above Schoharie village need further study for their full elucidation.

Areas of marsh and obstructed drainage. It was not practicable to distinguish in the mapping between areas of existing marsh and areas of soft meadow which represent recent or comparatively recent lake filling. These areas, however, serve in an interesting way to show the obstruction of drainage caused by glacial deposits and a moment's inspection of the map would show that where the deposits are conspicuously massive, as along the belt of interlobate moraine, the areas of marsh and lake fillings are conspicuous. It is quite possible that many small areas apparently due to recent lake filling, may have been areas also occupied by small lakes of glacial age. This, however, can not be determined unless there are chances for suitable excavation or exposure of the materials. Thus along Auries creek about 2 miles southwest of Glen is a flat ground about a mile in length which would naturally be taken as a combination of lake filling and flood plain but a chance section made by the stream shows massive lacustrine clays containing glaciated stones and therefore demonstrably representing a lake of glacial age.

Summary. The field investigations for these four quadrangles, Broadalbin, Gloversville, Amsterdam and Fonda, are practically completed and seem to show conclusively the presence of the two great glacial lobes already described with a massive interlobate moraine with scant evidences of any recessional moraine in the case of the Mohawk glacier, but at least one conspicuous belt of recessional moraine in the case of the Sacandaga glacier. The retreat of the ice is marked by the presence of glacial waters, notably small high level sand plains of the Sacandaga delta, the high level lacustrine silts and sands of the Mohawk valley, the gravels and sands of the Lake Albany and Iroquois stage, and the lacustrine clays of Lake Schenectady. Postglacial modifications of the glacial deposits are conspicuous along the valleys of the Mohawk and the Schoharie. Curiously along the Mohawk there is nothing that can be called ordinarily alluvial terrace. Meanders are practically absent while along the Schoharie terraces meanders and abundant oxbow channels are typical and conspicuous. These differences point to radical differences in the history of the major valley as compared with that of its tributary, and these differences have to do, it would seem, with the marked lacustrine conditions and great lake outflow that belonged to the Mohawk valley. As already intimated the conclusions here announced by Professor Brigham and the hypothesis suggested need explanation and confirmation by close study of surrounding areas. It is desirable to know the westward and southern limits of the Mohawk lobe. From the general appearance of the topography it would seem that the powerful glaciation of the Mohawk region must have ceased not far south of the boundary of the present area. The map of the Berne quadrangle south of the Amsterdam quadrangle seems to show interesting conditions which it has not been possible to study in the field. Near the middle of the quadrangle there is a conspicuous bifurcation in the trends of the drumlinoid or linear forms of topography, indicating apparently a push to the west as a part of the flow of the Mohawk glacier already described, and a push to the south along the lines of the Hudson valley. It is conjectured that a study of this area in the field will show corresponding directions of the glacial striae and that here may perhaps be found a point of conspicuous divergence between the Mohawk and Hudson river lobes of the glacier at a certain stage of their activity.

Industrial geology

Mines and quarries. The third of the series of annual bulletins reviewing the progress of the mineral industries in the State was published in July of the current year. There is a steady demand for information relating to the mineral resources, such as is given in these publications, and the continuance of their issue seems advisable.

The statistics collected for publication in the report indicate a material growth in the importance of the mining and quarry industries during recent years. The total output of all materials reported by the individual producers was valued in 1906 at $37,118,430, the valuation being based on the crude or first marketable form of the products. The corresponding total for 1905 was $35,470,987 and for 1904 it was $28,812,595. The varied character of the industries is shown by the fact that there are some 35 different materials produced in commercial quantities. Among the more notable developments recorded in the last report are those relating to the iron ore, gypsum and salt industries, all of which have possibilities for expansion greatly beyond present proportions.

These mineral statistics are gathered and tabulated with ultimate care. It is believed that they present the most accurate analysis given to the public of the condition of mineral production in this State. They are published with promptitude and as early as possible after the close of the calendar year.

Iron ores. The description of the iron ore resources of the State has been an urgent need for some time. The previous reports of Emmons, Putnam and Smock are out of print and besides are wanting in many particulars to make them representative of present conditions in the technical and scientific branches of the subject. Field work preliminary to a new investigation was started in 1905 by the Assistant State Geologist and has been continued as opportunity offered during subsequent seasons. Owing to the size of the territory that has to be covered by field work it has been deemed advisable to issue a separate report on each of the larger districts, whereby an earlier publication of the results will be assured. The Adirondack magnetites will be described in the first report, the preparation of which is now practically completed. In this part of the work the cooperation of Prof. J. F. Kemp has been secured. He has kindly undertaken to prepare a description of the Mineville district which he has recently mapped in connection with the survey of the Adirondacks now being carried out under the direction of the State Geologist.

The investigation of the Adirondack magnetites has brought out much that is new concerning their geology. The important problems bearing upon the character of the rock associates and origin of the so called nontitaniferous magnetites have been studied with care, and while they are extremely puzzling, it is believed that progress has been made in their elucidation. The walls inclosing this class of ores belong to the feldspathic gneiss series which it has been found includes both igneous and sedimentary derivatives. There may be distinguished, thus, two main varieties under which all of the occurrences probably are included, though in a few cases the evidence is insufficient at present to place the magnetites definitely with either. The igneous rocks which carry the ore belong to several types, ranging from acid granites on the one hand to granites poor in quartz, syenites and even more basic phases that approach the gabbro-anorthosite group which contains the titaniferous ores. It appears very probable that there is a close relation in the geological occurrence of both classes of ores found in the igneous rocks, since the latter show the most intimate connection in their fundamental characters. Like the titaniferous class, the low-titanium ores (they are not strictly nontitaniferous) are native to the wall rocks and have formed in their present place by some process incident to the cooling and consolidation of the latter. Magmatic segregation has perhaps been influential in some instances, as has already been pointed out by Cushing, but the mineral associations of most of the magnetites point to gaseous or gas-aqueous agencies as the more important factor in the process of formation. The ore bodies originated previous to the dynamic stresses which have affected the whole region and thus have been drawn out and alined parallel to the general foliation. The magnetites found in the sedimentary gneisses differ from the others in several respects. They are always pyritic and have, as associated minerals, garnet, scapolite, sillimanite and usually much hornblende. Their origin is doubtful as the evidence bearing upon it is subject to different interpretations. They may be ancient beds interstratified with the wall rocks or later introductions due to ground waters or insulations set up by the igneous invasions. They are frequently cut by granitic masses and they are possibly an older series than the other magnetites.

The mining industry of the Adirondacks has grown considerably in the last two or three years. The outlook for its future seems quite promising. Not only are the low-titanium ores being developed on a larger scale than previously, but there is a good prospect that the titaniferous deposits will soon be worked on a commercial scale. The new enterprise at Lake Sanford, mentioned in the issue of this report for 1906, has been active during the current year in carrying on investigations; productive operations only await the construction of a railroad to the locality which is in a now inaccessible part of the Adirondacks.

In accordance with the recommendation made in my report of last year the Legislature granted a specific appropriation for the exploitation of the Clinton hematite ores of central New York. It was therein pointed out that a large body of these ores lies almost wholly undeveloped along a belt of country more than 100 miles in length, east and west between Clinton and Wolcott, that it was of first importance to the iron industry in this State to determine probabilities of variation in the volume of this ore body in its dip and local variations in the quality of the ore.

To ascertain these facts borings are necessary at various points south of the observed or buried line of outcrop. The more numerous such borings are the more accurate the deductions will be. It would be well if series of such holes could be put down at points from half a mile to 2 miles back of the outcrop at alternating intervals of about 5 miles, but the present provision will not cover the cost of so much drilling. We are therefore now engaged in putting in with diamond core drill a single series of holes which will have an approximate average depth of 175 to 200 feet and which have thus far been located about 2 miles south of known surface outcrops. The outcome of this undertaking will have to be deferred to the next report.

Oil shales. An undeveloped source of eventual wealth to the State lies in its vast deposits of densely black, bituminous shales which reek with the components of natural gas and petroleum. These beds of black shale lie in the Devonic system of western and southwestern New York, particularly in the Genesee and Portage divisions of the Upper Devonic and are to be found in outcrop quite freely from Canandaigua lake westward to Lake Erie. Preliminary efforts have been made this year to ascertain the available hydrocarbon content of these shales for the purpose of instituting comparisons between them and similar shales like those of Scotland which are today distilled for the commercial production of petroleum, paraffin and ammonia sulfate. The method of treatment of the Scotch shales and the products resulting may be thus briefly stated. The oil is distilled at a temperature of about 900° F. The spent shale is then heated to about 1300° F. to increase the yield of ammonia and permanent gases from the shale. The Scotch shales yield on an average 25 gallons of *crude oil* and 45 pounds of *ammonia sulfate* per ton.

The first distillation of the crude oil yields:

1 *Green naphtha.* This is treated with sulfuric acid and caustic soda yielding " shale spirit " or naphtha.

2 *Still coke;* a valuable smokeless fuel, the production of which has now become an extensively capitalized industry.

3 *Green oil;* the source of paraffin.

The oil is tested with sulfuric acid and caustic soda and is then ready for the second distillation, by which it is fractionated into *light* and *heavy* oils, the latter containing solid paraffin. The light oils are used in making four grades of burning oils. The *paraffin* is obtained from the heavy oil by cooling below 32° F. and straining out by means of filter presses. The paraffin is then subjected to further treatment producing paraffin wax.

The value of the products of the Scotch shale industry is upward of £2,000,000 annually, and is rapidly increasing. The results derived from the analyses made of the New York shales are too incomplete to afford adequate basis of comparison as the method of distillation employed seems not that best adapted to the problem. The indicated proportions of fixed carbon and volatile hydrocarbons are apparently less than in the Scotch shales, but it is not certain that a more exact treatment with care to prevent volatilization of the hydrocarbons would not give a different result. At all events the results obtained are sufficiently encouraging to justify further pursuit of the inquiry.

SEISMOLOGICAL STATION

The seismological station of the State Museum has rendered efficient service throughout the year. Except for occasional stoppages of short duration — usually less than an hour each — due to the necessity of making readjustments from time to time, it has been operative continuously since March 10, 1906, when the instruments were first installed.

One of the chief objects of the records is to secure information relative to the character and frequency of earth tremors in the vicinity of Albany, which are set up by distant shocks. This line of investigation has never before been carried on anywhere within a radius of several hundred miles from the station. The results thus far obtained have shown the locality to be well adapted for receiving records and have already thrown considerable light on the subject. With the present equipment the larger earthquakes throughout the world are registered within a few minutes of their occurrence. It is hoped also that the observations may afford information as to possible earth movements of local nature. These have not been detected as yet, though it is considered more than probable that there are slow oscillations going on within the neighboring region which in the course of time will manifest cumulative effects of sensible magnitude. The observations must be continued over a considerable period to form a basis for the study of these movements.

The importance of seismological investigations is rapidly gaining recognition in this country; stations are now planned or under installation at Cambridge, Mass., New Haven, Conn., and Ann Arbor, Mich., as part of the scientific equipment of the several universities at those places. In the near future there will thus be a series of stations covering the northeastern section of the country quite completely, as observations are now made also at Cheltenham and Baltimore, Md., and Washington, D. C. It may be suggested that the work might be materially advanced by coordination of the different observing points, and it is hoped that some arrangement of the kind will be effected. In this manner the detection of the small local movements which are apt to be confused with the feebler tremors of distant origin would be specially facilitated.

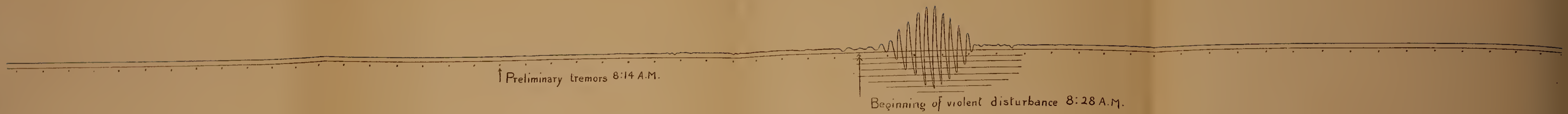
The Albany station has been called upon frequently to supply information regarding earthquake occurrences, both for the press and for scientific purposes. Records have been available some times long before the arrival of telegraphic dispatches from the centers of disturbance. It has also been possible to demonstrate the nonexistence of many reported shocks in the neighboring region. The observations relating to the San Francisco and Valparaiso earthquakes have been supplied to the California Earthquake Commission and the International Seismological Association for use in the preparation of their reports.

The year just ended was the first for which a complete series of records has been obtained. In all, 19 disturbances, large and small, were registered. A tabulation of the data is given herewith, accompanied by notes explanatory of the individual occurrences. Similar information covering the period March 10 to October 1, 1906, was included in the report for that year.

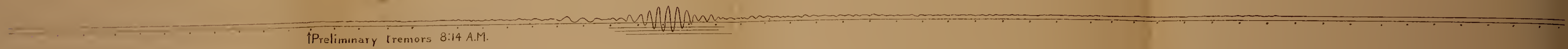
The character of the records traced by the instruments differs in each case, and it is not possible to give all the elements for every disturbance. Some of the more remote shocks which are apparently of relatively small proportion cause only feeble vibrations indicated by a slightly wavy line as traced on the recording cylinder. The record of larger earthquakes, on the other hand, is usually resolvable into several portions of distinctive character from which deductions may be made, according to well known principles, as to the distance traveled by the waves, and the direction and relative magnitude of the disturbance.

SEISMOGRAMS

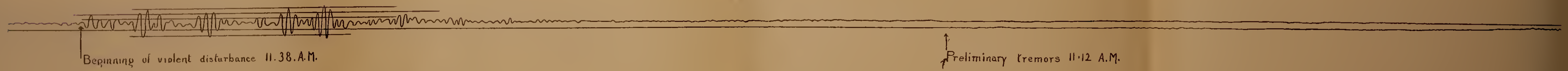
July 1, 1907
North-south vibrations



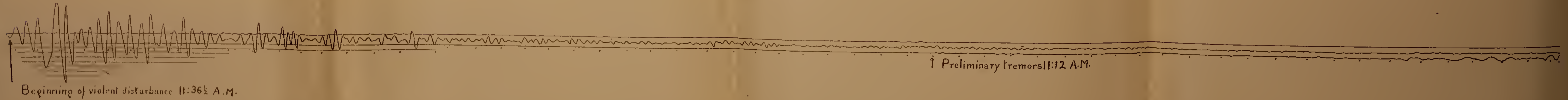
July 1, 1907
East-west vibrations



September 2, 1907
North-south vibrations



September 2, 1907
East-west vibrations



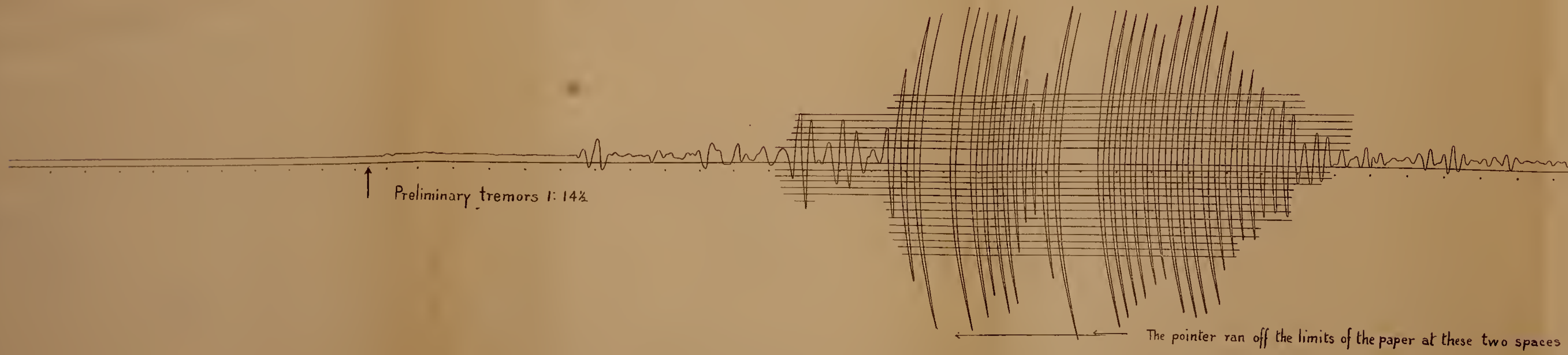
SESIMOGRAMS

Kingston earthquake

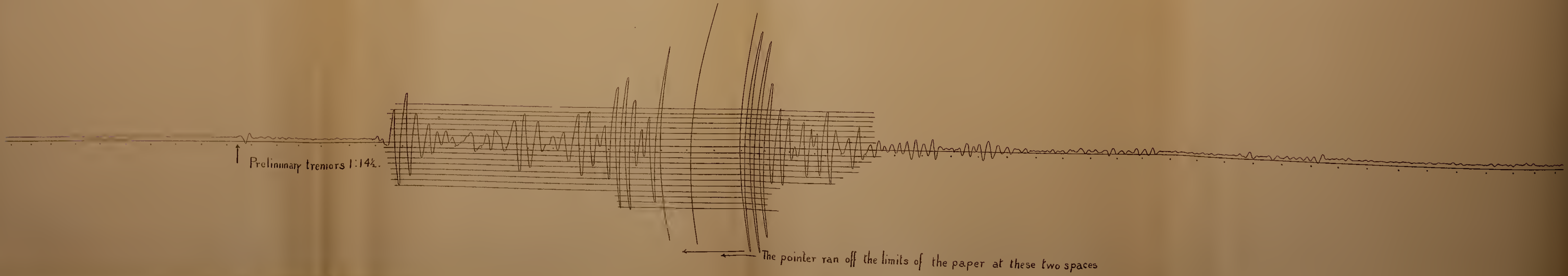
January 14, 1907
East-west vibrations

Mexican earthquake

April 15, 1907
North-south vibrations



April 15, 1907
East-west vibrations



A description of the instruments in use at the station has been given in a previous report. The important constants applicable to the interpretation of the records are as follows: Latitude, n. 42° 39′ 6″; longitude, w. 73° 45′ 18″. Weight of each pendulum, including arm, 11.283 kilograms. Distance of center of gravity from rotating axis 84.6 centimeters. The period of the pendulum (time required for a complete swing) averages 30 seconds, with variations of two or three seconds from the mean. The recording arm has a multiplying ratio of 10. The base of the instruments is approximately 85 feet above sea level.

RECORD OF EARTHQUAKES AT ALBANY STATION OCTOBER 1, 1906 TO OCTOBER 1, 1907

Standard Time

Date	Beginning preliminaries			Beginning principal part		Maximum		End		Max. amplitude
1906	h.	m.		h.	m.	h.	m.	h.	m.	mm
Oct. 1	9	28	p. m.	..	..	..	..	10	30	1
Nov. 14	1	34	p. m.	..	..	..	..	1	41	7
Dec. 3	5	03	p. m.	..	..	..	..	5	30	....
Dec. 22	1	39	p. m.	2	03	2	15	3	0	10
Dec. 23	12	39	p. m.	12	52	12	52	1	34	5
1907										
Jan. 2	7	53	a. m.	7	55	7	56	8	24	8
Jan. 4	12	43	a. m.	1	25	1	26	2	17	6
Jan. 14	3	47	p. m.	..	..	..	..	4	12	1.5
Mar. 31	5	16	p. m.	..	..	..	..	5	47	....
Apr. 15	1	14½	a. m.	1	19½	1	33	3	0	*a*
May 28	10	00	a. m.	..	..	..	..	..	..	....
May 31	8	02	a. m.	..	..	8	12	9	00	....
June 1	3	55	a. m.	..	..	..	..	4	38	....
June 4	10	31	p. m.	..	..	..	..	11	53	2
June 28	1	25	p. m.	..	..	..	..	2	12	....
July 1	8	14	a. m.	8	23	8	28½	9	15	50
Aug. 17	11	40	a. m.	..	..	..	..	12	15 p. m.	....
Sept. 2	11	12	a. m.	11	36½	11	38	3	00 p. m.	50
Sept. 23	4	46	p. m.	..	..	..	..	5	37	....

a Amplitude over 150mm maximum exceeding the limit of registry.

October 1. A slight movement lasting a little over an hour and registered only on the north-south pendulum, showing the direction to be nearly at right angles. The same disturbance was noticed at the stations at Washington, Isle of Wight and Perth, Australia. Its origin was not definitely fixed, so far as has been learned, but it was probably in the southern Pacific or Indian ocean.

November 14. A small disturbance, probably centered within 2000 miles of Albany. Slight shocks were reported in New Mexico and Kingston, Jamaica.

December 3. A series of minute vibrations producing a wavy line. Disturbance was of West Indian origin.

December 22. A very characteristic record of a macroseism. The east-west component was the larger with a maximum amplitude of 10 millimeters as compared with 6 millimeters for the north-south component. The duration of the preliminary tremors indicated a source from 6000 to 10,000 miles distant. A heavy earthquake was reported in Russian Turkestan in the vicinity of Lake Balkash at 11.20 p. m., and when due allowance is made for time difference and transmission of the waves, the relation between the record and this disturbance becomes apparent.

December 23. Registered mainly on the east-west machine, with an indicated distance of 4500 miles from Albany. A distinct occurrence from the preceding, perhaps originating in the Cordilleran region of Mexico or South America.

January 2. The same disturbance was recorded at Laibach, Austria, a little later than at Albany. Its center was somewhere in the Pacific.

January 4. A distant shock of unknown source.

January 14. The earthquake which destroyed Kingston and had its focus in the vicinity of that city. The record of the waves was scarcely proportional to the reported intensity of the shock, showing only vibrations of small compass without any distinct division into preliminary and main portions. The first waves to arrive were apparently the main ones, as the destructive shock occurred at 3.35 p. m., according to press dispatches, or 12 minutes before the beginning of the record. This would indicate a velocity of about 3 kilometers per second which is the average rate of travel of the larger waves.

March 31. Faint vibrations of undoubted seismic character. An earthquake was reported in Turkish Armenia on this date, but the accounts are so vague that no connection can be established certainly with the Albany tracing.

April 15. Remarkable for the magnitude and duration of the main tremors. The indicated intensity of the shock exceeds that of any recorded before or since by the seismograph. The two components have nearly the same amplitude in their principal parts, though the east-west machine shows a longer absolute period of disturbance, the north-south pendulum ceasing to vibrate at 2.20 a. m. The pointers of both pendulums swung completely off the cylinder. The earthquake seems to have been centered south of Mexico City in a sparsely inhabited region, which accounts for the small damage and loss of life that ensued.

May 28. Slight trembling indicated on the north-south pendulum, continuing at intervals until 5 p. m.

May 31. Faint tremors of seismic nature.

June 1. Small disturbance, coincident with a slight shock in Ecuador.

June 4. A distant earthquake traced for over an hour on the north-south pendulum.

June 28. Small tremors.

July 1. This disturbance would seem to have been a severe one, and perhaps 5000 miles distant in a southerly direction. The Havana station reported its passage at 7.43 a. m. It was probably submarine.

August 17. A thickening of the line traced by the north-south instrument, breaking into minute waves 20 minutes after the beginning

September 2. A very distant shock, as shown by the long duration of the preliminary tremors and by the continuance of the record for an interval of nearly four hours. Vibrations much more pronounced on the north-south machine. The Isle of Wright station reported its passage later than American stations so that it undoubtedly came from the Pacific.

September 23. Vibrations of small amplitude throughout.

September 24. North-south pendulum showed a condition of slight instability, due to a small earthquake. Disturbance recorded at Washington.

MINERALOGY

In the section of mineralogy, the research work has included an investigation of the crystal forms of the calcite from Rossie, St Lawrence co., a study of the crystal forms and twinning habit of the new occurrence of calcite from Sterlingbush, Lewis co., and a study of the minerals from Newcomb, Essex co. The work on the Rossie calcite which yielded two forms new to the species and 12 which are new to the occurrence, has amply demonstrated the value of detailed crystallographic study on a large number of specimens from localities even as well known as this one. The work on the Newcomb minerals, which is still in progress, has already yielded a new form for arsenopyrite and three new forms for wernerite as well as a ratio for the axial elements of the latter mineral very close to that determined by vom Rath.[1] The tourmalin crystals

[1] Pogg. Ann. 1863. p. 119–254, 262.

from Newcomb have also proved of interest as showing several rare crystal forms.

A case containing a few examples of the large and unique calcite crystals from Sterlingbush has been installed in the corridor of the fourth floor of the Capitol where the fine pink and purple colors of these specimens show to excellent effect.

The packing for storage of the large collection of New York minerals was completed and a system of labeling for the boxes has been devised by which newly collected material can be readily sorted into its place when the entire collection is reassembled.

A collection illustrating the recent work of the museum in mineralogy was exhibited at the last annual reception of the New York Academy of Science at the American Museum of Natural History in December.

The mineral collections have been enriched through the gift of Mrs J. V. L. Pruyn of a collection illustrating the minerals from the vicinity of Mount Vesuvius, and by the gift of Mr H. H. Hindshaw of a large collection of minerals from Lyon Mountain, Clinton co., N. Y., which latter amply supplements the material previously acquired by the museum from this interesting locality. A beautiful series of minerals from foreign localities was obtained from Dr F. Krantz of Bonn.

The field work of this section has resulted in the collection of a number of handsome specimens from the graphite mines in the vicinity of Crown Point and Ticonderoga, Essex co., of a series of over 50 specimens of tremolite from a new locality near Gouverneur, St Lawrence co., and of a large number of specimens of calcite for exhibition and study from the limestone quarries at Smith's Basin, Alsen and West Camp.

An important addition to the series of gem minerals from New York, comprises 26 crystals of diopside from the well known locality at DeKalb, St Lawrence co. These average 15 millimeters in diameter, the largest measuring 35 millimeters across the basal section. They are, for the most part, transparent and of a fine emerald green color. They were obtained by the Assistant State Geologist from Mr Calvin Mitchell of DeKalb Junction.

PALEONTOLOGY

Early Devonic faunas. In all of my recent reports reference has been made to the progress of investigations and correlation studies of the New York early Devonic faunas and those of the

ɪwly
liffi-
the
this
the
vait-
now
vork
ress.
elop-
the
past
State
stern
de-
ssils
been
State

the
ocks
berg
crops
y by
Hall
and
Vork
f the
mak-
e by
ed a
n re-
ilyses
l sec-
ts of
d the
iation
gions
ession
fforts
skany

The hexactinellid sponge Hydnoceras bathense Hall & Clarke. 1/6 natural size. This and the following plate show a series of slabs recently put on exhibition. About 250 sponges have been made visible by careful preparation and others lie buried in the rock. The blocks represent a small portion of a great sponge plantation, in the Chemung rocks at Bath, N. Y.

from Newcc
rare crystal :
A case coı
crystals fron
fourth floor
these specin
The packi
minerals was
been devisec
sorted into il
A collectic
alogy was e:
Academy of
in December
The mineı
Mrs J. V. L.
vicinity of I
shaw of a la
ton co., N.
ously acquir
beautiful se
from Dr F.
The field
number of
vicinity of (
of over 50 s
neur, St La
calcite for e
Smith's Basi
An import
York, compr
at DeKalb,
diameter, the
tion. They a
green color.
from Mr Ca

Early De
has been m:
studies of tl

ıwly
liffi-
the
this
the
vait-
now
vork
ress.
ꜰlop-
the
past
State
stern
: de-
ıssils
been
State

the
ocks
berg
rops
y by
Hall
l and
York
f the
mak-
e by
ed a
n re-
ılyses
l sec-
its of
d the
ıation
gions
ssion
fforts
skany

Plate 9

Fossil sponges
Hydnoceras bathense Hall & Clarke
1/6 natural size

from New
rare crysta

A case c
crystals fr
fourth floo
these spec

The pac
minerals w
been devis
sorted into

A collec
alogy was
Academy
in Decemt

The mi
Mrs J. V.
vicinity o
shaw of a
ton co., N
ously acq
beautiful
from Dr

The fiel
number o
vicinity o
of over 5
neur, St
calcite fo
Smith's B

An imp
York, con
at DeKal
diameter,
tion. The
green col
from Mr

Early
has been
studies o

St Lawrence gulf region. The work has progressed more slowly than could have been anticipated largely because of the great difficulties involved in executing the plates in accordance with the accepted standard of our lithography. The first volume of this memoir covering especially the geology and paleontology of the Gaspé region of Canada has stood complete in type for a year awaiting the production of these plates. The illustrative matter is now finished and it will be possible to distribute this part of the work within a short time. Meanwhile the second part has gone to press. This second volume is concerned with these faunas in their development in New Brunswick and Maine and particularly recounts the aspects and character of the faunas in New York. During the past year a very significant addition to the Oriskany faunas in this State has been made by the discovery in Orange county along the eastern limb of the Skunnemunk mountain syncline of a considerable development of this horizon in which the preservation of the fossils is instructive and the species full of interest, as many have been seen for the first time, others mark the first appearance in this State of forms recorded from more eastern localities.

When Professor Hall was elaborating the paleontology of the Helderberg and Oriskany formations the development of these rocks in the Appalachian region of New York south of the Helderberg mountains did not contribute materially to his stores. The outcrops in this region had been delineated with approximate accuracy by Mather but in all his paleontological work in New York, Hall seldom got far away from the undisturbed rocks of the central and western districts of the State to which he was early wedded. Work was later done in this Appalachian region by N. H. Darton of the United States Geological Survey (which can not be regarded as making any advance in accuracy upon that done 50 years before by Lieutenant Mather) and by Dr Heinrich Ries, who constucted a map and report of Orange county recording interesting data in regard to details of stratigraphy without attempting close analyses on the basis of paleontology. In the instructive but involved sections entangled in Appalachian folding the arenaceous deposits of the Lower Devonic have generally passed as "Oriskany" and the calcareous beds beneath as "Lower Helderberg," a discrimination which is no longer accurate or adequate. In late years the regions have been given careful study at certain points and the succession of the faunas closely analyzed. Perhaps the first of these efforts was that made by the writer to portray the character of the Oriskany fauna of Becraft mountain, the sole outlier of this stage on the east of the Hudson river. This was followed in the year 1903 by two important contributions, one by Stuart Weller on the Paleozoic rocks and faunas of New Jersey, in which he discussed the sections at the entrance of the western or Port Jervis-Otisville branch of the divided Paleozoics of eastern New York and those further south in his own state; another by Gilbert van Ingen and P. E. Clark on the "Disturbed Rocks in the Vicinity of Rondout, N. Y." [Mus. Bul. 69] in which all the precise determinations were made by Mr van Ingen.

In 1905 Prof. H. W. Shimer published the paleontology of the section at Port Jervis known as Trilobite mountain [Upper Siluric and Lower Devonic Faunas of Trilobite Mountain, Orange County, N. Y., Mus. Bul. 80].

Prof. George H. Chadwick has recently brought together some results of further examinations made for the State Museum, of the sections at Rondout and southward into Greene county, with the special aim of elucidating the composition of the Port Ewen fauna. Though these results have not been put in final form the author's determinations are of very considerable interest.

The Port Ewen beds, to rehearse briefly the history of this stratigraphic unit, are a series of thin limestones and gray lime shales, which, in the Appalachian region of New York and New Jersey lie immediately below the Oriskany silicious limestone and upon the Becraft limestone, bear the lithic character of the New Scotland lime shales and carry a large percentage of Helderberg fossils. It is a division not recognized by the early geologists in their partition of the "Lower Helderberg" and it is entirely absent from the succession west of Schoharie. Its earliest recognition as a definite unit was by Prof. W. M. Davis in 1882 who termed these rocks whose position he determined as above the Becraft limestone, the "Upper shaly beds" contrasting them in this designation with the "Catskill or Delthyris shaly limestone" below. Professor Davis did not attempt to delimit these beds and did actually, according to Professor Chadwick, include in his division some part of the "Upper Pentamerus limestone." The writer in a joint publication with Professor Schuchert [Science, Dec. 15, 1899], recognizing the distinct unit character of these strata termed them the "Kingston beds," later substituting for this term, which proved to have been employed by the Canadian geologists for a quite different formation, the name *Port Ewen beds* from their exposure near Port Ewen station on the West Shore Railroad. The character of the fauna of these Port Ewen beds has not been well understood and it was this problem that carried Professor Chadwick into the field. Through the efforts of Mr Chadwick and Mr Shimer we have now a fairly adequate idea of the composition of the fauna of these beds.

Though, as already stated, the preponderance in the census of the species so far as known, is Helderbergian there is a noteworthy percentage of species that may be regarded as normal or at least usual to the calcareous Oriskany above. Various others have been recognized as passing upward from the Helderbergian into this Oriskany and Mr Chadwick in his closest analyses of the assemblage has pointed out its generally decadent condition as a Helderberg fauna.

There are also other species of very first import which have and probably must continue to be regarded as index fossils of the Oriskany formation. Chadwick determines Megalanteris ovalis, Beachia suessana, Leptocoelia flabellites, Leptostrophia oriskania, Brachyprion majus and B. schuchertanum. He indicates also the possible occurrence of Spirifer arenosus. Professor Shimer determines Spirifer murchisoni and Meristella lata.

It becomes now a question for very careful consideration whether a fauna lying beneath the normal position of the Oriskany beds and carrying such fossils as these, can with propriety be regarded a Helderbergian fauna notwithstanding its preponderance of Helderberg species. Upon this line of inquiry the recently discovered Oriskany fauna already referred to will throw additional light but the evident earlier immigration into the eastern New York region of Oriskany species than had before been noted is not in anywise out of harmony with the evidence of their association in the Gaspé basin at the northeast.

Monograph of the Eurypterida. It has long been the writer's purpose to prepare a revision of these remarkable crustaceans which occur in a variety and abundance in the rocks of New York unequaled elsewhere in the world. The Bertie waterlime outcrops in Erie, Cayuga and Herkimer counties and the Salina (Pittsford) shales in Monroe and Orange counties have now afforded a really extraordinary manifestation of the profusion of these creatures. Fifty years ago James E. De Kay and Professor Hall had described the commoner forms of these crustaceans Eurypterus and Pterygotus from the Bertie waterlimes, and Messrs Grote and Pitt some years since published in the bulletins of the Buffalo Society of Natural Sciences accounts of supposed additional species occurring in these rocks at Buffalo. With the exception of the latter practically all accounts of these fossils in this State have been published in the reports of this institution; some notices in the *Palaeontology of New York*, volume 7; Mr Clifton J. Sarle described the remarkably interesting species from the Salina beds of Pittsford in Museum bulletin 69 and the writer the extraordinary fauna from the Otisville shales in bulletin 107. The collections of the museum representing these genera: Eurypterus, Pterygotus, Eusarcus, Hughmilleria, Stylonurus etc. are very extensive. All of the material described by Mr Sarle and the writer is here and recent additions to the specimens from these localities run up into hundreds of examples. Large collections have also been made by us in recent years from the localities in Herkimer county. The museum of the Buffalo Society of Natural Sciences is the possessor of most commanding collections of eurypteroids from the Bertie waterlimes in that city, which have been greatly enlarged of late by the enthusiastic interest of Mr Lewis J. Bennett, president of the Buffalo Cement Co. from whose quarries nearly all the specimens of these Bertie waterlime crustaceans scattered through the museums of the world, have come. In later years Mr Bennett has provided that all specimens taken from his quarries go into the museum of the Buffalo Society with the result that these collections have become fairly stupendous and vastly illuminating. The courtesy of a formal vote of the trustees of the Buffalo Society of Natural Sciences has enabled me to feel confident that this fine material will be subject to my use. It is my hope soon to reach a time when these investigations may be taken up for uninterrupted pursuit. Meanwhile progress is made as occasion affords.

Mastodons. In my report for 1903 I gave a summary of records of discoveries of mastodon remains in this State since the date of the first finding of the bones of the Mastodon americanus a short distance below Albany in 1705. The list there given afforded evidence of about 60 distinct occurrences of these skeletons. Last year I supplemented this record with four items. During the past season another discovery has been made. A brief notice of this follows and thereafter some notes of interest on other remains.

1907. *Perkinsville, Steuben co.* This skeleton was found in August last by John Morsch on his farm near the west end of

Perkinsville swamp and ¾ mile north of the railroad station of Portway. This swamp is a nearly equilateral triangle about 1½ miles on the side. It occupies a shallow depression in a mass of morainic drift of unknown depth at the head of the Cohocton valley and is adjacent to the west side of a low ridge that separates the drainage area of the Cohocton river from that of the Canaseraga creek. It has an altitude of 1360 A. T. The surface layer of the swamp is black muck to a depth of 6″ — 1′, beneath which is a bed of nearly white marl 6″ — 6′ in thickness. The bones were found about 26 rods from the highway and 4 or 5 rods from the north edge of the black soil or border of the swamp. In digging about a small boulder Mr Morsch came upon one of the larger leg bones and proceeded to take out the remains of the skeleton. These bones lay largely in their natural position and while perhaps the numerical two thirds of the skeleton were preserved, the more conspicuous bones were fragmentary or wanting. At the conclusion of the excavation it was found that all four legs and feet, a large number of ribs and vertebrae, parts of the shoulder girdle and one ramus of the lower jaw with teeth had been recovered. The skull with tusks, greater parts of pelvis and scapulae were gone. It would seem that the animal in sinking into the mire had been left with the more protuberant portions of the body, the head probably thrown up and back, exposed to the air and inviting the attack of rodents. The absence of these parts when all the other bones had so compactly kept together, left little likelihood of their being found in any other part of the swamp. The preservation of the bones recovered was excellent for mounting and it is to be regretted that the specimen just missed being a desirable acquisition to a scientific museum.

1876. *Pike, Wyoming co.* [See Report Paleontologist, 1907 p. 932]. I append here some additional data concerning the Pike skull taken from a recently published account [Guide to the Genesee Valley Museum, Letchworth Park, by Henry R. Howland, 1907, p. 5].

These remains of a mastodon were found in the summer of 1876 in cutting a farm land ditch on the farm of Charles Dennis, on the outskirts of the village of Pike, which is about 7 miles from Glen Iris, and through which flows the Wiscoy creek, one of the tributaries of the Genesee river. The tusks were fortunately quite perfect and with them were found a part of the skull, some vertebrae and some foot bones. In order that these remains should be properly preserved they were at once purchased by Mr Letchworth who caused them to be mounted at the natural history establishment of Prof. Henry A. Ward in Rochester, N. Y. The prompt action taken in the matter resulted in the preservation of this valuable relic which was returned to Pike and allowed to remain on exhibition at the Pike Seminary until the completion of the Genesee Valley Museum Building in 1898. In 1904 the seminary building was destroyed by fire. The measurements of the Pike mastodon are as follows:

Length of skull, measured in a straight line from back to front..	43½ inches
Length of tusks, measured along lower curve	96½ inches
Greatest circumference of the tusks........	23 inches

I append here some historically interesting observations on the occurrence of mastodon bones in America made by Dr Johann David Schoepf in his *Reise durch einige der mittlern und südlichen vereinigten nordamerikanischen Staaten, nach Ost-Florida und den Bahama-Inseln, unternommen in den Jahren 1783 und 1784*, volume 1, pages 408–15, 1788. This is a work of extraordinary interest which has been quite overlooked by students of American history. Its author was a surgeon in the Hessian forces sent over by George III and remained after the consummation of peace to travel through the country and collect scientific materials. The narrative gives a lively, anecdotal picture of the domestic and community life of the times interspersed with interesting reflections on the new government. Dr Schoepf was the author of other more technical works arising from his American experiences. He wrote a treatise on American Materia Medica, on the Reptiles of the country and was the first man of science to produce a special treatise on the geology of North America. His *Beyträge zur Mineralogischen Kenntnisse der Ostlichen Theils von Nordamerika und seiner Gebürge* published in 1787 is characterized by acute observation and keen interpretations of geological phenomena. It was 50 years in advance of the times and wholly ignored by the first American workers in the same field. Of these books only his Materia Medica was translated into English. German was unpopular, it was the language of the hated Hessians and of the Hanoverian house. So these very illuminating and interesting volumes have been buried as deep as Captain Kidd's treasure.

Among the natural rarities of the Kentucky regions, the many large teeth and bones belonging to an animal no longer existing in all America have long excited the wonder of all travelers. The place where they were first discovered in great heaps is a low hill, on the east side of the Ohio, 2–3 miles from its banks and about 584 miles below Fort Pitt, measured along the course of the river. At the sources of a little brook where there are extensive salt licks, the heavy tread of the buffalo herds which gather there, with help of wind and weather, have uncovered these bone heaps which are buried only a little way beneath the surface. The mass of bones is said to be very considerable; to judge only from what lies bare or projects from the surface, some estimate that there must be the ribs of at least 12–15 animals. How many more yet may not be buried under the earth? It was perhaps a numerous herd of beasts that here found their common grave. As to the former owners of these bones, the native Americans have just as little knowledge as the opinions of the most learned students of nature have imparted. On account of the immense size of the bones and of the elephantlike tusks found among them the natural inference has arisen that they are remains of elephants formerly native in this part of the world or by accident brought here and destroyed, and one is all the more justified in the opinion, which has in itself nothing contradictory, as in so many other regions similar elephant bones have been discovered where the race of elephants is as little native as in America.

By exact comparison between these bones from the Ohio and other bones and teeth from living elephants, certain variations have been marked which raise new doubts. Particularly it has been found that the thigh bones on the Ohio are thicker and stouter than those of the well known elephants; that the tusks are often somewhat twisted and especially that the crowns of the molar teeth are furnished with wedge-shaped elevations which the present elephant does not possess. For these, and especially the last reason, the learned Dr Hunter[1] believes himself justified in assuming that these American bones and teeth must have belonged to a flesh-eating animal larger than the known elephant. From their relations to the bones found in Siberia, Norway and other northern lands of the old world, Raspé seeks to make it appear probable that they are the remains of a great animal (elephant or not) which was of a special species and originally was adapted to colder regions, the whole race of which has from unknown causes now become extinct.[2]

With this view Daubenton and other savants agree and Mr Pennant believes that this still undetermined animal may yet be encountered alive somewhere in the interior unknown regions of America, and calls it therefore in his synopsis, the *American elephant.* If now, remains of the hippopotamus have not to some extent on the Ohio been mixed with those of the elephant and hence given rise to errors, this idea needs further elucidation.

In Pittsburg I saw in the possession of an artillery officer a thigh bone, a molar and a tusk which he had himself brought from that region. The thigh bone, though quite dry and here and there with

[1] Philos. Trans. 1768. v. LVIII.

[2] Philos. Trans. 1769. v. LIX. Dissertatio epistolaris de Ossibus & Dentibus Elephantum, aliarumque Belluarum, in America boreali etc. obviis, quae indigenarum belluarum esse ostenditur. *I. C. Raspé*

some of its substance lost, weighed not less than 81 pounds, was 3 feet, 9½ inches long; in the middle where it was comparatively flat its circumference was only 20 inches but on the lower joint 2 feet, 6½ inches. The tusk was 3 feet long, 4 inches in diameter at the end, but it was not entire. I could see no evidence of its being twisted. The molar tooth which I received as a gift, weighed easily 6 pounds and the crown was armed with three wedge-shaped elevated processes.[1]

The first two pieces were given to the library in Philadelphia where I afterward had the opportunity of seeing them. As an incident it may be observed that the officer referred to, in order to fetch these three pieces from their locality a few miles from the boat on the Ohio, paid one of the soldiers a slight pourboir of 1000 paper dollars equivalent in value to 2400 Rhenish florins. Besides the molar referred to I have seen in Philadelphia in the collection of Mr du Sumetière, several others, found in other parts of America. These were all quite similar and some had the elevated processes of the crown particularly sharp, while in others they were low. If this style of tooth only were always found among the elephantlike bones discovered at various separated places in America, then the assumption that they belonged to an ancient race of American elephants would be much strengthened. It has recently become known that the spot on the Ohio is not the only one in North America where similar remains of these animals are found. Teeth have been discovered on the Tar river in North Carolina, near Yorktown in Pennsylvania and in Ulster county in New York. Catesby mentions an elephant tusk dug up in South Carolina; Kalm an entire skeleton in the country of the Illinois and others have been found in South America. The largest collection of the Ohio fossil bones is in the possession of Dr Morgan of Philadelphia. On account of the trackless distance it was formerly very difficult to obtain these remains which had to be brought by a long circuit down to New Orleans and then up to Philadelphia by sea. Now the settlement of Kentucky affords better prospect of an early and more exact knowledge of the remarkable bone deposit. It would be superfluous to repeat the various theories which have been advanced to explain the occurrence of this accumulation of remains of so very strange an animal. Floods, marvelous changes of climate, of the earth's center of gravity and of its axis, have been invoked. The American hunters satisfy themselves with the explanation that these were real elephants killed off by a hard winter which they were not able to withstand and to support their opinions they point out that often an extraordinarily

[1] This molar is now in the very fine scientific collection of Privy Counselor Schmidel of Anspach and both in respect to weight as well as in entire structure entirely different from the elephant's tooth with which the Privy Counselor has compared it. The molar of an elephant which Mr Sparrmann has described, weighed only 4½ pounds.

severe winter kills off other species of animals specially acclimated to this part of the world.[1]

It is easy to see that such a restricted cause could have no effect in accumulating the deposits of these animals in the tropic South America. No one, however, has been happier in his theories upon this problem than the author of the *Essai sur l'origine de la population de l'Amerique,* volume II, page 298, who regards all these bones (whether in jest or earnest, no one knows) as nothing more than the remains of a troop of fallen angels (equipped with six-pound back teeth!) which, according to his notion, were the original inhabitants of the earth in its primitive and glorious state, until, because of their transgressions they were condemned to universal destruction near their own earthly habitation, whereupon the rest of the purified planet was cleaned up for the reception of the present improved race of mankind.

Devonic crinoids of New York. The work on the New York crinoids has shown a fauna of exceptional and unexpected interest. Thus far nearly 40 genera have been recognized, some for the first time in Devonic rocks and the number closely approaches the total genera hitherto known from the Devonic rocks of the world. The group of the Inadunata is well toward completion and many drawings of the species made. These investigations are being made by Mr Edwin Kirk.

Paleozoic corals. Excellent progress has been made by Dr T. Wayland Vaughan on the anaylsis of the genera of the Paleozoic corals. Dr Vaughan labors under the disadvantage of endeavoring to rescue the results of previous attempts made here to define and illustrate these fossils but his efforts give promise of an eventually satisfactory outcome.

Devonic fishes. A monograph of the Devonic Fishes of New York by Dr Charles R. Eastman was issued during the year as Memoir 10. This work affords a comprehensive survey of present knowledge of the fishes obtained from the rocks of this State and though these remains are in many instances in highly incomplete condition, it has laid the foundation of future study of these organisms. Moreover the author's wide acquaintance with his subject has given his general conclusions more than ordinary interest and force. Under the title "Zoological conclusions" problems of the evolution of the fishes are discussed, such as the origin of the eel-

[1] In the severe winter of 1779-80 a great number of roe deer were found dead here and there in the woods in the interior of America and its mountains; often many together near the frozen springs where they were accustomed to drink or to lick salt. A multitude of birds and other animals were also killed that winter.

shaped fishes among races which have not progressed, the origin of the paired fins and the development of the effective fins. The chapter entitled " Geological conclusions " is of special interest as indicating the distribution and migrations of the early fish fauna and may well be reproduced here.

GEOLOGICAL CONCLUSIONS

It will be convenient to include under this head certain topics whose practical bearing is of chief interest to the geologist, although the evidence involved is partly zoological, and in still larger part geographical, or paleogeographical. We refer to such matters as relate to the areal and vertical distribution of Devonic fish life, the dispersion of new types and varieties, migration, succession and occasional recurrence of faunas, and indications furnished by the fossils themselves in regard to climatal and physical conditions, either those of local nature, or others prevailing over wide areas. Thus, by way of illustration, we are able to affirm from the general complexion of ancient faunas, that the climate of arctic regions was notably warmer during the Devonic and late Paleozoic than at subsequent periods. We are in possession, also, of a large fund of evidence regarding migrational movements, and can delineate with great exactitude a number of physical barriers that were interposed to lines of migration. Means are at hand in very many cases for distinguishing between free swimming inhabitants of the open sea and other forms whose structural organization proves them to have been bottom feeders, mud grovelers, or frequenters of estuaries and fresh-water lagoons. Manifestly inferences of this nature are of far-reaching geological significance, besides having a direct practical application. Finally, a knowledge of the relations of successive vertebrate faunas is an important corollary to the information we have concerning fossil invertebrate faunas, the two categories being mutually complementary, and taken altogether are essential to a natural classification of geologic formations.

We may consider first some of the more general conclusions derived from a study of the distribution of Devonic fishes, having special reference to those of New York State. In the first place it is necessary to bear in mind that the Devonic faunas of the interior of North America announce themselves as belonging to two distinct types, one being more or less confined to the eastern, and the other to the west central United States and Canada. Or, to put it differently, it is possible to recognize within the interior of our continent two more or less distinct geological provinces of the Devonic, differing from each other and from the more remote areas lying to the westward (Cordilleran and continued border provinces) in their respective faunal characteristics. The eastern interior province, which has received the name of Appalachian, is typically represented in New York State, but extends westward into Ontario and Michigan, and southwestward into the Ohio valley region, forming circumscribed areas known as the Cumberland and Indiana basins. The western interior province is represented typically in Iowa, and was more or less effectively separated from the eastern during early and Middle Devonic time. Its limits are coextensive with the so called Dakota sea, which was open to the northwest during the mid-Devonic through Manitoba, the Mackenzie Basin, and across Behring straits into Siberia, but was probably closed to the northeast. The suggestion has been made, and indeed been received with some favor, that intercommunication existed during the mid-Devonic between the typical Iowan and Eurasian faunas by means of a northeasterly passageway through Manitoba, Hudson and James bays, Greenland, Spitzbergen and circumpolar regions. More recently, however, weighty objections have been opposed to this theory, and it has been asserted very emphatically by Professor Schuchert that there is not the slightest reason to connect the Hudson and James Bay Devonic with that of the Dakota sea (or western intercontinental province). It is further denied by the same author that this latter province was in connection with a southern ocean, extending into Brazil, until Hamilton time. On the other hand students are agreed that communication was maintained between the Appalachian province and that of the southern hemisphere during the mid-Devonic. Concerning the pathways that were open between the Appalachian and Eurasian provinces during the Middle and later Devonic there are still some differences of opinion.

It will be observed accordingly, that the Devonic in this country was preeminently an era of provincial development of marine faunas. Furthermore it appears that diversity in this respect is more strongly marked in the Appalachian region, where there were varying conditions of sedimentary deposition, than in the Cordilleran and continental border regions, where these conditions were more uniform. Thus, in the eastern province, as Professor Williams has pointed out, diversity and alternation of deposits are accompanied by numerous successive and distinct faunas; in the extreme western regions, uniformity of prevailing calcareous sedimentation for long periods is characterized by the abnormally long continuance of many Devonic species; and the central continental province, midway between the two, is marked by the unmistakable recurrence of Devonic species well along into the Carbonic. Another noteworthy feature of the Devonic which has been developed very fully and clearly by the painstaking investigation of Dr Clarke is that faunal changes within the ancient Appalachian sea are sometimes so precisely indicated that it is possible, as in the case of the Portage group, to trace the boundaries not only of local provinces, but of local subprovinces characterizing the stage in question. Thus, the Genesee province of the Portage is divided into Chautauquan and Naples subprovinces on the basis of differences in their faunal facies; and an interesting peculiarity of the Naples subprovince is that, as stated by Dr Clarke "with contemporaneous faunas of the Appalachian gulf" its fauna "has in its purity no organic relation, direct or sequential."

It is very necessary to understand this matter of the provincial character of Devonic faunas in North America. Also, in tabulating the facts of distribution, one must keep in mind the inferred lines of intercommunication between those provinces that were connected, as well as the position of barriers between others that are known to have been separated. The data upon which our information in regard to these matters reposes have been brought together chiefly by workers in invertebrate paleontology, and as the evidence at their disposal is enormous as compared with that obtained from a study of the vertebrates alone, no deductions drawn from the latter are likely to prejudice the results depending upon a different class of remains. In point of fact, no discoveries of fossil fishes have yet been made which tend to contradict or discredit conclusions already established on the basis of fossil invertebrate evidence. The known distribution of the former is in all respects consonant with, and one is tempted to add, confirmatory of the principles that have been formulated from a study of the latter. We find simply that the more mobile free-swimming contingent of Devonic faunas followed the same routes and penetrated, probably with greater facility, into the same areas as the slower moving invertebrate associates of the original fauna, wherever we are able to trace its migrations.

Nevertheless, some facts relating to the distribution of Devonic vertebrates stand out with such distinctness as to attract particular attention. The earlier Devonic horizons in New York State are singularly deficient in fish remains, and the faunas that appear successively in the Meso- and Neodevonic are introduced with little or no foreshadowing, save that the members of the Hamilton fish fauna are largely a residuum or evolution product of the preceding Onondaga congeries. Clearly, however, the Mesodevonic fish faunas are not indigenous in the Appalachian basin for we meet with practically the same assemblage in rocks of equivalent age elsewhere, as for instance, in the Eifel district (Calceola beds) and Bohemia (étages F^2 and G^1–G^3) ; and besides, the Oriskanian fauna contains no elements, so far as known, out of which the Onondaga might have developed. The vertebrate portion of the latter is, therefore, quite unmistakably an immigrant fauna. That it did not come in from the northeast may be asserted with equal confidence, for none of its members are represented in the maritime provinces of eastern North America, nor indeed, in the Lower Old Red sandstone of North Britain, Greenland or Spitzbergen. As in the case of the majority of invertebrates, the Onondaga fish fauna came in from the west, and in course of time very probably withdrew westward, many of its characteristics persisting into the Hamilton of the western interior province. The Hamilton piscine fauna is so obviously the descendant of the preceding Onondaga, and these two together have so much in common with the Eifelian, Bohemian and Russian Mesodevonic, as to confirm in the strongest possible manner the contention of Professors Clarke and Schuchert that the Ulsterian and Erian should be recognized as divisions of the Middle Devonic.

Attention has been called by Professor Schuchert to the similarity between the Middle Devonic fauna of the Hudson Bay region, and that of the Mississippian Onondaga. A number of considerations are proffered to show that while each of these faunas has its individual facies, yet both are of that type which characterizes the American, in contradistinction to the Eurasian province; and moreover, they differ both in horizon and facies from the Stringocephalus zone of western and northwestern Canada. It is inferred, accordingly, that the Hudson Bay Devonic area was entirely shut off from communication with the Dakota sea, but on the other hand it is thought probable that intermittent connection existed between the former basin and the Mississippian sea. An opening is also posited by the same writer, lasting throughout the Devonic, between the Appalachian and Eurasian provinces, the route leading through the so called Connecticut straits, thence along the Gulf of St Lawrence and across the Atlantic. Having established what seems to him a reasonable basis for the propositions just stated, Professor Schuchert sums up his conclusions in regard to Middle Devonic faunal distribution in the following paragraph:

" The Onondaga fauna is the outgrowth of the Oriskanian fauna of the North Atlantic type plus the migration during Onondaga time of other North Atlantic forms by way of the Connecticut trough and invasions from the far south through the Indiana basin. The Hamilton fauna is the descendant of that of the Onondaga plus North European migrants by way of the Connecticut trough, South American arrivals by way of the Indiana basin, and slight invasions from the Dakota sea by way of Traverse straits. These three openings then remained in existence during the greater part of Upper Devonic time."

This rather full statement in regard to conceptual waterways has been made not for the purpose of criticism, but in order to synthesize as far as possible certain elements of apparently conflicting nature. The test of a sound judgment is its ability to unify various and sometimes even dissonant concepts. In the present instance it becomes necessary to reconcile with the evidence furnished by Helderbergian and Oriskanian invertebrates in favor of an invasion from the northeast, certain other evidence that appears at first sight discordant, namely, the failure of any Lower Devonic vertebrates to take part in the migration. As will be seen from an inspection of the faunal lists, the abundant and rather diversified fish fauna occurring in the synclinal basin of the Restigouche near Campbellton, N. B., is without a single representative in rocks of Lower or Middle Devonic age in the Appalachian province. No traits are observed in the Onondaga or Hamilton fish faunas which can be ascribed to an immigration from eastern Canada by way of the putative water route called by Clarke the "Appalachian strait," and by Dana the " Connecticut trough," which is supposed to have been open during the late Siluric and greater part of the Devonic. None of the Appalachian Mesodevonic vertebrates can be regarded as the genetic descendant of forms that existed at an earlier period in the maritime provinces in eastern North America. The problem is to reconcile this diversity of evidence without contradiction, and it is believed that a solvent will be found in Dr Clarke's recent determination of the Gaspé sandstones as of later than Oriskanian age.

In his sketch of the geology of Percé, published in 1904, Dr Clarke declared that the fairly rich marine fauna of the lower beds about Gaspé Basin reveals evidence of both early and late Devonic age, and that the prevailing sedimentation is of the same aspect as characterizes both in New York and Europe the deposits of the Devonic or Old Red lakes and lagoons. This preliminary statement strikes at the root of the whole matter, and sounds the keynote of an interpretation which has since been more fully evaluated by the skilful New York State Geologist. The results of his extended investigation of the invertebrate paleontology of the Gaspé Devonic remain as yet unpublished, but an idea of their general import may be gathered from the following extract from a private communication, which we are enabled to present here through the courtesy of Dr Clarke:

" The profusion of evidence that has been obtained from a study of invertebrate paleontology seems indubitably to indicate that the Gaspé sandstones are not of the geological age assigned to them by Logan and the Canadian geologists generally. That is to say, they are not Oriskanian, for, though they contain certain Oriskany species, these are the survivors of the earlier limestone faunas of that region persisting during the incursion of a distinctively Hamilton Lamellibranch and Brachiopod fauna from the southwest.

Dawson subdivided the Gaspé sandstone into three parts: the lower division coordinated with the Oriskany and Onondaga; the middle, equivalent to the Hamilton group; and an upper conceived to be equivalent to the Chemung. This entirely arbitrary subdivision was based upon the distribution of the terrestrial flora, and is not, I think, in any way borne out by the present evidence. The weakness of the comparison lies in the attempt to correlate with true marine deposits the very heavy mantle of sands of telluric, delta or lagoon origin conformable in every way physiographically to the Old Red deposits elsewhere, the few marine fossils which it contains being the accumulation of overwash from outside during times of stress. Ells and Low have suggested the probability that the fish-bearing beds at Scaumenac and Campbellton were laid down in an area separated from the more northerly region by barriers of old land, and in my judgment this is an entirely probable condition, not eliminating the possibility of connection between the two basins at some point further westward."

Indeed, as early as 1883, it was noted by R. W. Ells that a number of invertebrate fossils from the northern limit of the Gaspé Devonic were " strongly typical of the Hamilton formation," thus leading to the inference that " the Gaspe sandstone series, of the coast, is probably of the same age, though the absence of typical shells in a large portion of it makes their separation more difficult." The same author had previously described the beds at Campbellton, N. B., before they were found to contain fish remains, and had pronounced upon their equivalence with the lower part of the Gaspé sandstones. This opinion was based upon evidence of paleobotany, and, having been confirmed a few years afterward by J. W. Dawson, is now generally accepted. Indeed, Logan seems to have entertained similar views as early as 1863 [Geol. Can. p. 450]. As for the plant and fish-bearing beds at Scaumenac bay, on the Quebec side of the Restigouche, these are asserted by Dawson to be "no doubt the equivalents and continuation of the upper part of the Gaspé sandstones." In the absence of a more precise indication of their age, these beds are commonly referred to as Upper Devonic, and their vertebrate content favors that conclusion.

In the light of Dr Clarke's coordination of the Gaspé sandstone series with rocks of Postoriskanian age, we are no longer required to look in that direction, nor to the probably contemporaneous Campbellton fauna for the origin of the Onondaga fish fauna found in New York State. On the other hand it may be conceded as rather more likely that there was some movement among vertebrate organisms in the reverse direction, for such an hypothesis would account for the presence of a typical Onondaga species, Machaeracanthus sulcatus, at different levels in the Gaspé series (Logan's Divisions 1 and 6). The genus Cephalaspis is common to both the Gaspé series and Campbellton beds, and together with the majority of forms from the latter horizon is indicative of Old Red sandstone conditions.

Reverting now to the Hudson Bay Middle Devonic fauna, we find that, as listed by Whiteaves, it is unmistakably of about the same age as the Onondaga. According to Schuchert, its faunal facies "is more that of the Mississippian type than any other known in America." This similarity is therefore held to indicate that there was at least intermittent connection between the two basins during Onondaga time, and persisting well into the Hamilton. It is admitted, however, that the question as to how the stream of migration entered the Hudson Bay area during the Middle Devonic is not so easy to answer. Precisely at this point some light is thrown on the problem by vertebrate paleontology. A number of specimens of Macropetalichthys sullivanti (=M. rapheidolabis) are recorded by Bell and Whiteaves from the country immediately west and south of Hudson and James bays. This exclusively Onondaga species (Mr Schuchert inadvertently calls it a Hamilton fossil) is most abundant in Ohio and Indiana, and decidedly less common in New York State. The same genus, represented by some two or three species, occurs also in the Eifelian Devonic, which is equivalent practically to the Onondaga, and in the slightly earlier horizon in Bohemia designated as étage G^1. No trace of it occurs, however, in the Mesodevonic of the maritime provinces of eastern North America. One may readily infer that this genus and its various associates are indigene in Bohemia, a part of the vertebrate fauna from étage G^1 being inceptive in étage F.

Thence it spread northeastward into Russia, westward into the Eifel District, and northwestward into the Hudson and James Bay region. From this latter region we may suppose it to have passed southward through Ontario by means of a passageway connecting with the Appalachian gulf over the area that is now occupied by Ohio and Indiana, where the fauna reached its climacteric. The most conspicuous elements of the fauna are Arthrodires and Ptyctodonts, groups which began immediately upon their introduction to attain a most remarkable development. Throughout the Hamilton and later Devonic, conditions must have been eminently favorable in the Appalachian sea for the further specialization of armor-clad Dipnoans of the type represented by Dinichthys and its congeners. Like their earliest predecessors, they became of greatest importance locally in Ohio.

The wide interest to all concerned with the philosophy of paleontology and the far-reaching significance of such detailed investigations as are brought together here, are very effectively set forth in the following paragraphs.

There are no other means for attaching significance to a truth except by perceiving its relations to other truths. Thus far we have been concerned principally in assembling, and to some slight extent in correlating recognizable truths; in a word, facts of observation have been brought into orderly array. The next step is to examine them in their bearing upon other known facts, to deduce their general significance, and to assign to the results a commensurate worth in surveying the whole field of paleontological inquiry. The ultimate yield of scientific study is the fruition of philosophical ideas.

To obtain a large perspective of the body of facts at our disposal, it is desirable to marshal them in different ways, and to examine them from different points of view. Their relevancy from a geological standpoint needs consideration, with the object of drawing from them conclusions of geological import. In still larger measure it behooves us to consider them as an increment to zoological science, compacting its substantial framework and vastly extending our knowledge of the evolutionary history of organisms. Are we proposing to ourselves an explanation of life, our vision must include not only living matter as we find it today, but also those manifestations of it that existed in the remote past. Side by side with the development of the individual we must examine the evolutionary history of the race. The more we learn of vital processes now operating, the better able are we to understand their operation in times anterior to our own. Comparisons that are enlightening when made between members of the modern fauna may often be profitably extended so as to include members of extinct faunas. Where the time element acts as an impediment to our studies it must be eliminated so far as possible. Zoology of the past does not differ in essence from zoology of the present, any more than ancient history differs fundamentally from modern.

Among other large problems that suggest themselves in reviewing our knowledge of Devonic fishes are those relating to the habits and mode of life of the creatures represented, their adaptation to physical environment, the effects of such adaptation as manifested in their structural modifications and subsequent racial history, and finally the important topics of migration and geographical distribution. All of these issues, though subsidiary to the main theme, offer nevertheless fruitful fields for exploration. It would take us too far astray from the immediate purpose of this paper to consider all of these matters seriatim, particularly as materials are already at hand for those who may wish to pursue them further. For instance, in regard to the habits and mode of existence of ancient forms of fish life, many suggestive hints are contained in the writings of Claypole, Dollo, Jaekel, Kemna and others.

A large and very important literature exists on the subject of faunal migrations in general, and geographical distribution, which will be referred to later. The question of adaptation to environment has been less fully treated than others in the above category, since, from the nature of the case, our information is more deficient in this respect. The viewpoint, however, is exceedingly instructive, and such light as is obtainable from it is most welcome. That we have not overstated the truth must be clear to all who have gained a right understanding of the working of this principle in analogous cases. As convenient an illustration as any is furnished by human history. One of the notable phenomena in the annals of mankind, and one of the most beneficent in its subtle and far-reaching consequences, is the marvelous civilization attained by the ancient Hellenes. Yet the unfolding and superb blossoming of the flower of Greek genius, together with its rare beauty while it lasted — this surprising spectacle utterly fails of comprehension except as we take account of influences of heredity and environment. To understand Athenian character and habits, or to attempt to account for that civilization which flourished, as Milton says,

> Where on the Aegean shore a city stands
> Built nobly, pure the air, and light the soil,

it is above all things imperative to understand the conditions of Attic soil and climate. For as soon as one inquires critically into the physical surroundings of the classical Athenian, one discovers that his culture is not primarily dependent upon his peculiar character, but is very largely the resultant of his outward circumstances, and influenced to a marked degree by his climate. One perceives, therefore, that ample justification exists for the following statement, taken from a very readable work on classical antiquity (Tucker's *Life in Ancient Athens*), with which we will conclude our remarks on this head:

" From the bare facts that the Athenian lived in a land which supplied a frugal and simple, but sufficient and wholesome diet, in a climate which makes for sociable outdoor life without producing languor, in an atmosphere which sets off whatsoever things are shapely and beautiful, on a soil furnished with a plentiful supply of excellent material for plastic art — from these simple facts should we start before we attempt to understand those ways which characterize what is loosely called his 'civilization.'"

There is yet another way in which we may view the sum total of facts resulting from paleontological inquiry, or even the small part of it which is here brought together. We may seek to interpret our collection of facts from the humanistic standpoint. Granted that this knowledge does not appreciably affect our vital interests, what is it worth to us in other respects? How far does knowledge of this sort tend to enlarge human consciousness? Does reflection upon it tend to vivify our perception of the workings of natural law? And if so, does there not arise from fulness of perception a keener sense of the nobility and dignity of the relation man bears to the wonderful planet he inhabits, and is there not a quicker response on his part to the suggestions which that clarified sense awakens? There can be but one answer to this last question. It is inevitable that there should be a prompt and vigorous response from within when once it is realized that "whatever else man may be, he is the sum of a series of actions linked with all that has gone on before upon this earth." The experience is no less common in paleontology than in other sciences that, after one has gained sufficient insight, ideas and impressions of a certain sort enter our minds, sharpen our vision, and enlarge our mental horizon by elevating us to a summit of observation unattainable before. Possibly there belongs to paleontology an even larger quota of these emancipating conceptions than is true of other sciences, in view of its predominant historical interest — being, as it were, a limitless extension of universal history.

To realize to some extent what the loss of these emancipating conceptions would mean to us, it is only necessary to contrast the olden-time idea of creation with modern evolutionary beliefs. Or, regarding the paleontological record as the continuous unfolding of consciousness, whose beginnings are coeval with the origin of protoplasm, and whose crowning resultant is man, we may picture to ourselves the contracted outlook, the void in our knowledge, and the impoverishment of ideas that would be our portion in case no documents had been preserved to instruct us of the far distant past. Imagine our loss were the records of early human history obliterated. What would be our poverty had the grandeur of Rome been dissolved into a mass of meaningless ruins, had the splendid story of Greece and Athens been blotted out, had we remained unconscious that Marathon was ever fought, or that such a one as Socrates had ever lived; had we no line from Homer, no thought from Plato, no inspired word from Palestine vibrating through the ages!

Again let it be said that conceptions of this nature are not foreign to the scope or peculiar province of paleontology. They are, in fact, inherent in all science; they are not mixed with it, but combined with it, and hence do not properly form either its distillate or residuum. If there be any who question how far these ideas are relevant to the study of fossil fishes, we may be allowed to recommend all such to read the lives of Louis Agassiz and Hugh Miller, especially the recent character study of the latter by Mr Mackenzie (1906). An answer is recorded there so plainly that he who runs may read. Wherever the work of Miller is remembered and appreciated, it is not for the value of his discoveries, nor for his contributions to science, but for the native shrewdness, clearness, intensity and discernment with which he drew philosophical conclusions from the study of nature. And his impulse in this direction was first quickened and set in motion by his discovery of fish-bearing nodules in the Old Red sandstone of the north of Scotland. We can not forbear in this connection to quote the following passage from an address delivered a few years ago by M. Albert Gaudry, president of one of the sections of the French Academy:

"Quand on passe à Cromarty, dans le Nord de l'Écosse, on aperçoit une colonne érigée en l'honneur de l'ouvrier carrier Hugh Miller; en cassant des pierres, l'ouvrier de Cromarty admirait qu'on y trouvât des créatures fossiles, et il en tirait des pensées si hautes qu' il est devenu un des paléontologistes célèbres de la Grande-Bretagne. Beaucoup de gens sont comme Miller: c'est chose étonnante que l'ardeur avec laquelle, dans tous les pays du monde, on brise les roches pour surprendre les secrets des temps passés: bâtis hier, les Musées de paléontologie sont aujourd' hui trop petits."

Graptolites of New York. At this writing the second volume (Memoir 11) of the monograph of the Graptolites, prepared by Dr Rudolf Ruedemann is leaving the press. Volume 1 (Memoir 7) on the species of the earlier rocks was issued in 1905. The present work embraces the later forms and completes the subject embracing most if not all species reported from the United States of this interesting and long extinct group of organisms. In this volume there are altogether 149 species and varieties of graptolites described. The greater part of these come from the upper part of the Lower Siluric (Champlainic), the great majority from the Trenton shales; a smaller part from the Siluric zones distinguished in the upper part of the Lower Siluric, which broadly correspond to the Black river — lower Trenton, middle — upper Trenton, Utica and Lorraine beds. All of these can be correlated with well known European zones.

In view of the fact that the slate belt of eastern New York has furnished a practically complete succession of graptolite beds, extending from the top of the Cambric to nearly the top of the Lower Siluric, the conditions of deposition of graptolite beds are fully investigated and the conclusion reached that graptolite shales are, as a rule, deposited in the same region for longer intervals than most other fossiliferous rocks. This leads to the inference of the origin of their beds in deeper parts of the sea than most of the fossiliferous rocks. This conception is found to be in full accord with the views held by Suess, Neumayr and Haug in regard to the deeper sea origin of the deposits in geosynclines and is also applicable to the Paleozoic Appalachian geosyncline, as far as the Lower Siluric era is concerned. The graptolite shales of the Appalachian geosyncline reappear in Arkansas and the Indian Territory and again in the Rocky mountains, but are absent in the vast intervening area. These facts suggest that the Appalachian and Rocky mountains geosynclines were connected in the south by a westerly bend of the Appalachian geosyncline now buried in the Gulf of Mexico or the Gulf States, a northern embayment of which is, however, still exposed in Arkansas and the Indian Territory.

A synoptic view of the genera of the graptolites of the United States is given. This brings out graphically the fact of three successive culminating periods of the graptolites, each marked by the appearance of a new group or order that has given to the class a new lease of life by advancing to a new structure. The first of these is the dichograptid culmination in the Beekmantown shale; the next the dicellograptid-diplograptid climax in the Trenton shale and the last the monograptid culmination in the Siluric. The structural and phylogenetic causes of these culminations will be made the subject of a separate study.

A separate chapter is devoted to the morphology of the spines of the graptolites since these represent one of the striking features of numerous forms. It is found that in the great majority of forms the spines are placed distinctly on the most exposed parts in response to stimuli from the environment. In many others (dwarfed phylogenetic forms) a general spinosity is clearly but an expression of waning vital power and in a third important group, the most typical representative of which is Glossograptus, a general spinosity is produced by a tendency to repetition of the lateral spines commonly found in any graptolite at the sicular extremity. In Lasiograptus and related forms finally the spines were found to result from the suppression of thecal structures caused by restraint of environment, or in an endeavor to lighten the periderm.

Another chapter was invited by the multitude of forms of the appendages of the sicular extremity of Climacograptus bicornis occurring in the Normanskill shales. It was found that the several varieties based on the forms of these appendages are all connected by transitions and represent one complex system marking the climacteric period of the species. In a further chapter the possible influence of the presence of spines on the development of a retioloid structure in the periderm is investigated and the inference attained that even the spinose forms of Diplograptus possess in their thick periderm a layer of retioloid meshes, and of stronger ledges, and that the development of this layer is roughly proportional to that of the spines. This cause has combined with the tendency of the rhabdosomes to become lighter after the floating and swimming habit had been adopted, and produced the order Retiolitidae with a reticulate periderm.

The dilatations, "disks," wings or vesicles of the nemacaulus of Diplograptus, Climacograptus and Cryptograptus are separately considered and evidence brought forward to show that they were inflations of the outer periderm of the nemacaulus through which the virgula or axis passes uninterrupted.

The verification by a recent investigation by Schepotieff, of a former observation by the writer, that the axis of the sicula (the virgula) passes through the nemacaulus and into the rhabdosome, is discussed in a further chapter. Other chapters on the morphology of the graptolites are devoted to the asymmetric section of the rhabdosome in some graptolites (as Climacograptus typicalis), to the axes of the Dicranograptidae, the morphology of the thecae of the Dichograptidae and Dicranograptidae.

In a part entitled "Notes on Phylogeny" the phylogenetic relations of the Leptograptidae and Dicranograptidae are first discussed and the derivation of Dicranograptus from Dicellograptus shown. It is argued that the branches of the Dicranograptidae formed together always a more or less slender double spiral whereby certain advantages of the arrangement of the thecae and a great elasticity of the suspended rhabdosome were attained, but at the same time the strain at the further (sicular) end where the two branches are connected, increased; hence the formation of the biserial portion in Dicranograptus to strengthen this end.

A synoptic and synonymic list of graptolites recorded from North America concludes the general part of the memoir.

A Devonic brittlestar

In a recent publication[1] I called incidental attention to the discovery by D. D. Luther of specimens of Helianthaster in the Portage (Cashaqua) shales at Interlaken, N. Y. a village lying on the divide

[1] Report State Paleontologist 1906, p. 36.

between Seneca and Cayuga lakes. The discovery was an interesting one as the genus had not before been known in the American Paleozoic rocks, but no attempt was then made to analyze the structure of the specimens. A halftone plate of the better of the two individuals found was given and the intimation made that the species was not identical with the German H. rhenanus F. Roemer, the only form hitherto referred to the genus. The publication of this figure induced Prof. H. P. Cushing of Adelbert College, to call my attention to a slab of similar fossils in his possession which had years ago been acquired by the late Samuel G. Williams while professor of geology at Cornell University. This specimen has been placed in my hands; it is from the Portage beds at Earl's quarry, Ithaca.

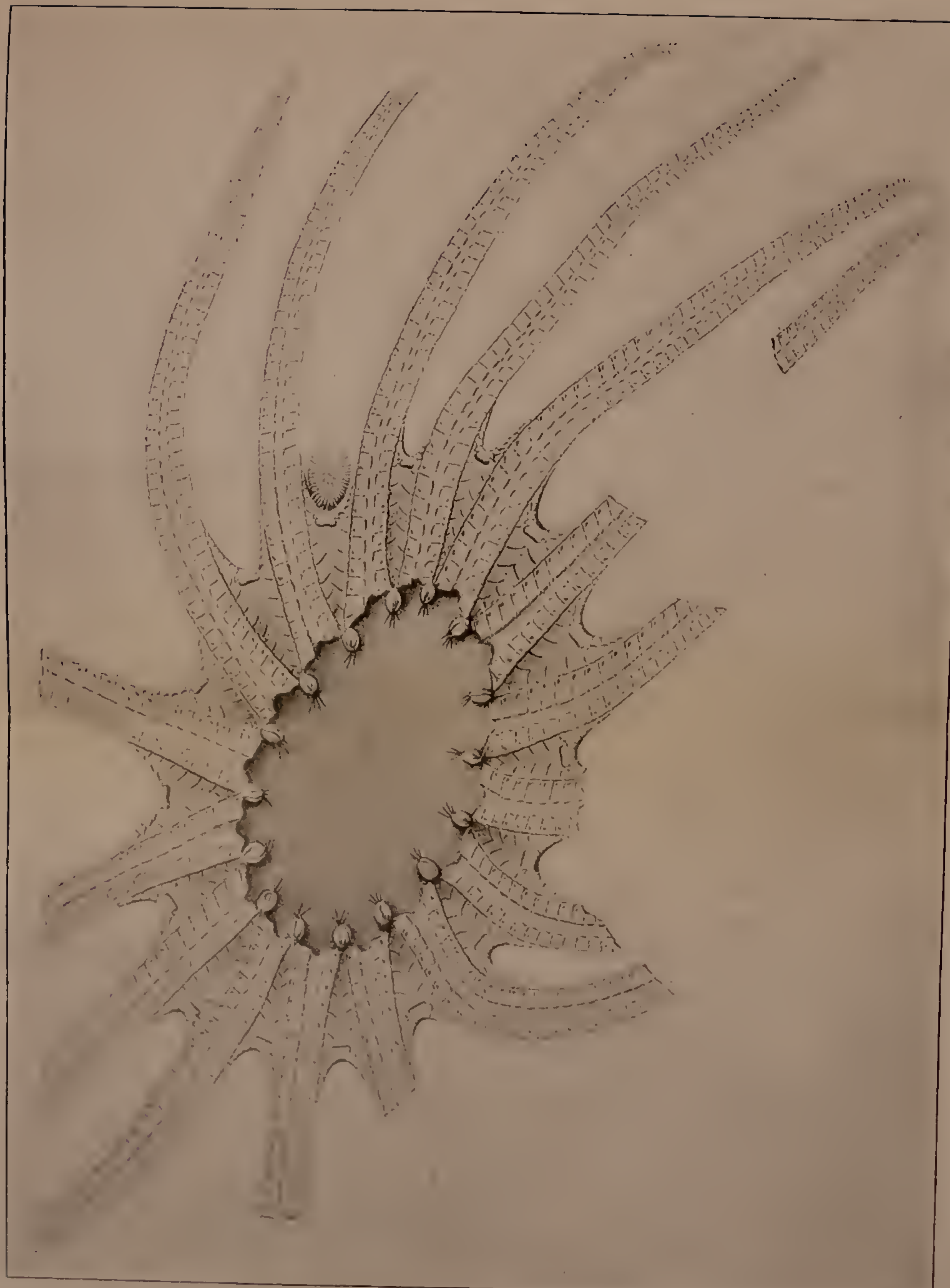
We have now five individuals of this species of Helianthaster, the two from Interlaken of which one displays the ventral aspect of the arms and the other appears to be an external cast of the same side of another individual; both of these are damaged about the oral region. The Earl's quarry slab carries three individuals all in ventral aspect, and all casts. Of one of these the mouth parts are missing but in the other two they are retained, in one particularly well. Not long ago I was successful in obtaining a magnificent specimen of Helianthaster from Bundenbach which has admirably lent itself to preparation and which elucidates some points of structure not recited by Stürtz in his admirable account of the structure of H. rhenanus and is indeed of much more commanding proportions than the material illustrated by that author.

As this genus is a novelty in New York paleontology it is of interest to call attention to these recent discoveries with such detail as the preservation of the specimens permits. Helianthaster, from its original description by F. Roemer[1] was a hardly recognizable genus. It was only after Stürtz rediscovered and analyzed the species from the Bundenbach shales that an approximate conception of this very commanding ophiuran was attained[2] and it is in the light of these determinations alone that the specimens here considered can be intelligently interpreted.

In regard to Helianthaster rhenanus the description given by Roemer in founding the genus [*op. cit.* p. 147] was based on specimens pyritized but involved in the shale in the usual mode of preservation of the Bundendach starfish and no attempt was

---

[1] Paleontographica. 1862. v. 9.
[2] Paleontographica. 1885. 32 81, pl. 8, fig. 3, 3a; 1889, 36.: 218, pl. 26, fig. 14, 15, 15a; pl. 27, fig. 14.



Helianthaster rhenanus F. Roemer
Stürtz's figure (Palaeontographica, v. 36, pl. 27) slightly reduced; showing the ventral aspect

:rix and
not the
assigned
.14–16).
ımerous
mostly
e of the
›st equal
.merican
ptical.
y a l u m
·e more
pare:l to
ɔmpared
on none
inct evi-
ɔ closely
.t of the
reserved
ıg inter-
stead of
u s ıt is
inct and

›nounced
ıich take
ɔjections
ırable to
.ke the
ength of
/ation as
is repre-
he latter
stinguish
ssigns to
row and
member
ting oral
ate these
of these
angle at
e base of each arm is narrow, long and acute, much more extreme

Helianthaster roemeri nov. Bundenbach. Natural size

made to solve the difficult problem of removal of the matrix and exposure of structural details. Roemer figured the best but not the largest of his specimens [pl. 28] and the number of arms assigned by him to this species is 16. Stürtz finds this number also (14–16). At all events the species is large and its arms relatively numerous in contrast with other Paleozoic ophiurans. The disk is mostly covered by the converging arms and the length of any one of the latter from the point where it becomes free to its tip is almost equal to the axis of the disk which in both the German and American specimens seems not to be normally circular but often elliptical.

The New York specimens, Helianthaster gyalum nov. are smaller than H. rhenanus. The *arms* are more numerous and appear to be quite uniformly 24–25. Compared to H. rhenanus they are relatively short, but very long compared with the size of the disk which is much suppressed, and on none of the specimens, all showing the oral surface, is any distinct evidence of it visible, so deeply do the arms cut into it and so closely do they lie together. Notwithstanding this apparent retreat of the disk the *madreporiform plate* is very large. This organ is preserved in but one example and but here it overlaps two adjoining interbrachial angles and the mouth parts pertaining thereto. Instead of being a flat or concave elongate plate as in H. rhenanus it is highly convex and circular; its surface markings less distinct and coarse than in that species.

The great *oral aperture* is margined by a series of pronounced "jaws" or sharp projecting elevated angles the sides of which take origin from the margins of adjoining arms. These oral projections are slightly expanded at their tips into blunt points comparable to but smaller than the "Höcker" of H. rhenanus but like them carry small spines projecting inward. The solidity and strength of these mouth parts is indicated by their prominence and elevation as shown in figure. It is probable that in this expression there is represented a combination of dorsal and ventral structure with the latter predominant by compression. Stürtz has been able to distinguish the dorsal and ventral details in H. rhenanus and assigns to the former a pair of divergent thickened crescentic narrow and vertical plates departing from the axis of each arm and each member joining one of the adjacent pair, thus producing the projecting oral processes. In our specimens it is not possible to discriminate these structures further than to recognize in them a combination of these oral plates with the spinous oral processes. The reentrant angle at the base of each arm is narrow, long and acute, much more extreme in these respects than in H. rhenanus and very much more elevated.

In the structure of the arms there is essential agreement with that described for H. rhenanus. On the ventral aspect there are two rows of plates "in corresponding condition to each other, which never touch along the arm axis." Apparently in H. gyalum there is a slight tendency to alternation of opposite ventral plates as shown on the mold of these structures in the Ithaca specimen. The separation of these series of ventral plates is exhibited on the mold as a solid uninterrupted ridge representing a longitudinal slit. The lateral plates are well defined and bear several spines each, in contradistinction to the German species which is described as having but a single spine on cach lateral.

A comparison of Stürtz's most complete individual of H. rhenanus and the specimen of Helianthaster from the Bundenbach slates obtained by me as that species, leads to the impression that they are not the same. The differences will be seen on examination of the figures here given of each. Stürtz's H. rhenanus has the free arms relatively very long, the disk correspondingly small, the reentrant angles of the disk heavily plated. The last named structures seem entirely absent on my specimen though the specimen presents a very clear oral surface; moreover the arms number 28 in contrast to the usual 14–16 of H. rhenanus, and both lateral and dorsal plates are enormously spinous. I think the differences are sufficiently distinctive to justify the designation of this species as H. roemeri.

FIELD MEETING OF AMERICAN GEOLOGISTS

The Geological section (E) of the American Association for the Advancement of Science held a summer field meeting at and near Plattsburg, N. Y., July 3–11, inclusive, to which all members of the Geological Society of America and the Association of American Geographers were invited. The itinerary for these meetings was planned and guided by members of the staff of this survey and as the excursions and addresses were most instructive and given under most favorable skies to a large company of geologists, an account of the proceedings, taken from the report of the secretary, Dr F. P. Gulliver [Science, Sept. 27, 1907] is inserted here.

The preliminary trip on July 3 was made to visit "The Gulf" at Covey hill. This drive of some 30 miles from Mooers, N. Y., across the Canadian boundary was exceedingly interesting to all students

Helianthaster gyalum. A mold of one of the specimens showing the elevated "jaws" and the madreporiform plate

Helianthaster gyalum. A slab bearing a number of specimens: from the Portage beds, Earl's quarry, Ithaca

of glacial geography. The marine and glacial shore lines were visited on the route westward from Mooers, and the party stopped for lunch in "The Gulf," near the two lakes which show the location of the gorge that represents the ancestor of Niagara. The noon talk, given by J. B. Woodworth, who has worked out the glacial history of this region, was on

Abandoned shore lines

At "The Gulf" Professor Woodworth spoke in substance as follows: "The Gulf" and Covey hill north of it constitute a locality of critical importance in the study of water levels in the Champlain and St Lawrence valleys. "The Gulf" pertains to the closing stages of the great ice-dammed lakes which formed in front of the ice in its retreat from the territory of the United States. When "The Gulf" was being excavated by a powerful torrent of water, the ice sheet still hugged the northern side of Covey hill, itself the northermost spur of the Adirondacks.

The waters which entered "The Gulf" came from the west, the region of Lake Iroquois, whose waters would have taken this path after the ice retreat offered a lower outlet than that at Rome. The waters passed from "The Gulf" into Lake Vermont, the preglacial lake occupying the valley of the present Lake Champlain. Lake Vermont could not at this stage of its existence have risen above the surface of the water in the waterfall pools of "The Gulf." The lower lake is now 645 feet above sea level. The sea could not at this latitude have stood higher than the bottom of "The Gulf."

With the further retreat of the ice from the northern slope of Covey hill the water, which had previously discharged through "The Gulf" on the south side of the hill, flowed around the northern slope of the hill and emptied into the sea. The salt water came in, and the history of the great glacial lake was completed.

Signs of wave action occur on the Champlain side of the Adirondacks as high as 720 feet, but these higher water levels do not continue about the northern side of Covey hill north of "The Gulf." A good beach is continuous from the Champlain valley about Covey hill into the upper St Lawrence valley with an altitude of 450 feet at Covey hill. Higher signs of probable wave action occur up to 570 feet, merging into beaches evidently made by torrential waters confined between the hillside and the retreating ice front.

"The Gulf" was properly understood by Ebenezer Emmons to have been made by a powerful torrent flowing where now no stream can flow. Gilbert, with the knowledge of the glacial theory, sought for a torrent spillway along the retreating ice sheet, and considered "The Gulf" the outlet for the glacial waters. "The Gulf" therefore is an integral part of the wonderful story of the great glacial lakes, and the political chance which has drawn the boundary line between Canada and the United States across "The Gulf" serves doubly to remind us of its living type, the gorge of Niagara.

On Thursday, July 4, those who had taken the preliminary trip to Covey hill drove from Mooers southward to West Chazy along many abandoned shore lines, at elevations varying from 300 to 600 feet above the present sea level. At West Chazy others joined the party from Plattsburg, and all met on Cobblestone hill, where a halt was made for an hour to study the remarkable beaches of cobbles showing pronounced bars, spits and hooks, at levels of 600 feet and over above sea level.

These beaches of heavy glacial detritus were laid down in a freshwater glacial lake, when the ice stood a short distance north of this point, by the waters discharging from the northwest over Flat Rock from the Altona spillway.

Thence the party drove across the bare Potsdam sandstone over the Altona spillway, where striking evidences were seen of the scouring action of torrential glacial waters. After lunch at a spring of water running from the Potsdam sandstone in the spillway the party listened to a talk by Prof. H. L. Fairchild on

Lake Iroquois extinction

Lake Iroquois was the great glacial water held in the Ontario basin while the Laurentian ice mass occupied the St Lawrence valley and forced the overflow by the Rome outlet to the Mohawk and Hudson valleys. This original Iroquois outlet was effective for several thousand years, and determined the water level for nearly the whole existence of the glacial waters.

When the ice body weakened, and the front receded on the salient which projects northeastward from the Adirondacks into Canada, a lower escape for the ice-dammed waters was opened across the Covey hill ridge, precisely at the International boundary.

"The Gulf," as it is locally known, is a great cut in Potsdam sandstone, long since noted by Emmons and Gilbert, and recently described by Woodworth. The present altitude of the head of the Covey outlet is over 900 feet, but at the time it was opened the locality was about 460 feet lower than today, and the initiation of

Plate 14

Beach, north slope of Covey Hill, Canada

Beach, north slope of Covey Hill, Canada

Plate 16

Covey Hill, Canada

Curved end of bar, Cobblestone hill, Altona, N. Y.

Plate 18

Cobblestone hill Altona, N. Y., Professor C. H. Hitchcock in picture

the river flow must have been inferior to the Rome level, which is now 440 feet.

After at least many centuries of flow this predecessor of the St Lawrence river, carrying the overflow of the second stage of Iroquois waters (or Hypo-Iroquois), was extinguished by the ice recession opening a yet lower pass, on the north slope of Covey hill. This third phase of the Iroquois waters was short-lived and of rapidly falling levels, the river flow past the ice front only terracing the sandstone slope.

When the waters were lowered about 450 feet below the Gulf channel, they became confluent with the oceanic waters, and the Ontario basin was occupied by the Gilbert gulf, a branch of the Champlain or Hochelagan sea.

On Friday the parties from Mooers and Plattsburg met at Chazy where Professor Cushing and Dr Ruedemann showed the visiting geologists many interesting features of the Chazy limestone, the local succession of beds, the characteristic fossils, the faults, and the dissection which have produced the present topography. After supper, while waiting for the train to Plattsburg, the party sat on the hotel porch and listened to a talk by Dr R. Ruedemann on

The Lower Siluric paleogeography of the Champlain basin

The relations of the faunas of the Beekmantown, Fort Cassin, Chazy, Black River, Trenton, and Utica beds to those of the Atlantic and Pacific basins and the Mississippian sea were discussed, and by means of these relations the probable marine connections of the Chazy basin and the Levis channel with the oceanic basins traced. It was suggested that the Beekmantown sea, while extending as far as the Newfoundland embayment, held an American epicontinental fauna; that the Fort Cassin fauna did not reach Canada, but flourished in the Appalachian trough to the south of the Chazy basin, and also spread westward into the epicontinental sea. The typical Chazy fauna is thus far recorded only for the Chazy basin and the southern Appalachian trough. It extended as far as the Mingan islands, and came probably from the Atlantic basin. There is also evidence that it had some connection with the American epicontinental sea.

The Black River and Trenton faunas, while largely American in their aspects, contain European species as the first of the Lower Siluric; and the connection of the Trenton sea with the Atlantic ocean can not be doubted. In Utica time the channel became so wide that an oceanic current could enter the epicontinental sea from the northwest, bringing with it new faunal elements, and spreading mud shales over a large area of eastern North America.

The evidence of a deeper sea in the Levis channel, furnished by the series of Lower Siluric graptolite shales, was also presented, and the relations of the graptolite shales to the mobile parts of the earth crust, the geosynclines, briefly mentioned.

Friday evening the party went to Cliff Haven, 3 miles south of Plattsburg, where the authorities of the Champlain Assembly had placed at the disposal of Section E the New York cottage, in which the party were delightfully housed for five days. Excursions were made each day to various points, and in the evening all returned to the broad piazzas of the cottage, where they sat and discussed the various trips, within a few feet of one of the striking fault-line scarps of the region, looking out over the waters of Lake Champlain.

On Saturday morning, July 6, the party gathered on the steam launch kindly furnished by the State of New York, and under the guidance of Professor Cushing, Dr Ruedemann and Professor Hudson, took a charming sail on Lake Champlain. The party visited Crab and Valcour islands and studied the Palezoic sediments which are there so beautifully exposed with their many interesting structural features.

At noon the party enjoyed the delightful hospitality of Prof. and Mrs George H. Hudson of Plattsburg at their charming camp on Valcour island. After lunch a talk was given by John M. Clarke on

Lake Champlain

Dr Clarke spoke of the origin of the Lake Champlain valley as the result of a series of downthrown fault blocks having the evident aspect of a *graben*. He referred to the later evidence as confirmatory of Logan's conception of the Lake Champlain fault and indicated that this origin was borne out by the present attitude of the downthrown Paleozoics against the abrupt eastern scarps of the Adirondack crystalline shield.

Reference was also made by the speaker to the possibility that the geographical name Trembleau, which designates the prominent headland and mountain ridge just south of Port Kent, embodies the record of an ancient seismic disturbance, and with this as a text fuller reference was made to the Canadian earthquake of 1663

Cuspate foreland, Valcour, N. Y.

Plate 20

Maclurea magna, Chazy, N. Y.

which appears from the records preserved in contemporary documents to be the severest disturbance this continent has ever suffered from terrestrial dislocations. This earthquake was evidently a movement of the Paleozoics against the crystalline shield along the course of the St Lawrence river or the St Lawrence fault, and its destructive effects from Montreal down to Tadousac were tremendous. It seemed to the speaker quite reasonable to infer that this displacement must have been continued along the contact line of the Paleozoics and the crystallines in the direction of the Champlain fault, although the historic records for this region are very meager.

After lunch the party divided, one portion spending the afternoon on the shores of Valcour island studying stratigraphy and paleontology. The others sailed southward to the delta of Ausable river, where a landing was made and photographs taken showing some of the recent shore-line changes. Thence this party sailed across the lake between Stave and Providence islands, and then northward along the Vermont shore, returning to Cliff Haven.

In the evening in the auditorium of the Catholic Summer School the one formal gathering of the Plattsburg meeting took place. The Rev. John Talbot Smith LL.D., president of the summer school, welcomed the geologists in the name of the authorities of Champlain Assembly and introduced the vice president of Section E, Dr Alfred C. Lane, who gave his vice presidential address on the " Early Surroundings of Life."

Prof. B. K. Emerson thanked the authorities of the Champlain Assembly for their hospitable reception of Section E.

On Sunday various features of the local geology were visited by members of the section. Others attended services at the chapel on the grounds.

At noon the party were entertained most delightfully by the Hon. Smith M. Weed and his family at his summer home on the shores of Lake Champlain. In the afternoon another sail was taken in a steam launch on Lake Champlain.

In the evening Prof. George H. Hudson, of the Plattsburg Normal School, showed the laboratories and some of the work of his students. The members then met in the science classroom, and listened to an informal talk by Professor Hudson on " Blastoidocrinus and its Type," illustrated by 50 lantern slides. The slides of Billings's type were from negatives possessing an amplification of 10 diameters, and showed in a remarkable manner many points of structure not before noted in the specimen. The outer folds of the hydrospires were seen to extend under the interbrachials to the edges of the bibrachials. The position of the stem was shown to be not normal, as Billings supposed, but thrust up into the coelomic cavity and separating the basals from the radials. There were no features to show a specific difference between the Canadian type and the more perfect Valcour island specimen, but the type served to corroborate in a clear manner much of the detail worked out from the latter and published in Bulletin 107 of the New York State Museum.

On Monday, July 8, the party went by train from Plattsburg to Lyon Mountain, and spent the day studying the magnetite mines under the guidance of Mr Newland. After lunch the section listened to a paper by D. H. Newland on

The iron ores of the Adirondack region

Four varieties of iron ores are found within the limits of the Adirondack region, each constituting a more or less independent class of deposits as regards geological associations and mode of origin. The varieties are as follows: (1) nontitaniferous magnetites, (2) titaniferous magnetities, (3) hematites, (4) limonites. In respect to the relative age or period of formation, it is probable that the magnetites of class 1 are the oldest, since they antedate the metamorphism and structural disturbances that affected the region during Precambric times. The titaniferous ores were formed before the oldest of the fossiliferous rocks of the region (the Potsdam sandstone) was deposited, and are generally regarded to be contemporaneous with the igneous inclusions in which they occur. The hematite ores are probably later than the Potsdam; while the limonites have the character of bog ores and are relatively recent surface concentrations.

The nontitaniferous magnetites are the most widespread of all the ores in their geographical distribution, and have been in the past and still are the main source of supply for the region. In a strict sense they are hardly deserving of the name that has been applied to them by geologists, since they nearly always carry titanium, though the amount is small, usually but a fraction of one per cent. These ores are found in all parts of the Adirondacks, except the central which is occupied by the great gabbro-anorthosite mass. They are associated with different members of the Precambric crystalline series including gneisses of igneous derivation with the mineralogy of granites and syenites, with gneisses of doubtful relationships, and with the schists and limestones of the sedimentary (Grenville) type. Their origin is obscure, a problem that has been fruitful in discussion and theorizing among geologists. It is doubtful if any one of the explanations that have been advanced is satisfactory as a general basis for the whole group; rather it would seem that the varying conditions surrounding the character and associations of the deposits indicate that they have been formed by a complexity of processes which may have differed materially in individual cases.

The titaniferous magnetites are distinguished from those of the preceding group by their higher percentage of titanium, which ranges from about 3 or 4 per cent, as a minimum up to a maximum of 10 or 15 per cent, and by the fact that they are always inclosed by basic igneous rocks of the gabbro family. They have been described by Prof. J. F. Kemp as basic segregations formed during the cooling and consolidation of the wall rocks, an explanation that is generally regarded as correct. Some of the largest deposits of iron ores in the region belong to this class, those of Lake Sanford being specially extensive. After a long period of inactivity, due to the difficulties encountered in smelting the ores in the blast furnaces, attention is now being directed to the deposits with a view to their utilization. It has been found that the ores in some cases at least are not simply magnetite carrying titanium uniformly through its mass, but that they consist of a mixture of magnetite and ilmenite, the former having almost no titanium, a condition that is favorable to their commercial treatment.

The hematite ores are practically limited to the western Adirondack region of St Lawrence and Jefferson counties. In this area the Grenville schists and limestones attain wide development, forming an interbedded series which has been upturned and sharply folded. Granite intrusions are numerous, but there is a noticeable lack of the basic igneous rocks that occur abundantly in the central and eastern Adirondacks. The ore bodies consist of lenticular, tabular, or irregular masses inclosed within belts of the schist and limestone, or lying along the contact of these rocks as at the Caledonia mine. Stringers and larger bands of ore often extend out from the main bodies for considerable distances into the foot and hanging walls. The deposits have originated, without much doubt, by a process of replacement. They grade at the borders into the wall rock and frequently inclusions may be found that show complete transition from the rock to the ore. Where the walls are schist, the ore often preserves the appearance of banding and cleavage, and not uncommonly carries a small percentage of graphite, the only mineral that seems to have successfully resisted the solvent action of the iron-bearing solutions.

As to the source from which the iron has come, the explanation advanced by C. H. Smyth jr, merits full acceptance since it meets the conditions surrounding the geology of the deposits. His theory is that the iron has been derived from pyrite and magnetite, which occur abundantly in the schist in the immediate vicinity of the ore bodies. By oxidation the pyrite would yield ferrous and ferric sulfates, which would be readily taken up by the underground circulations. Free sulfuric acid would also result and react upon the veins and disseminations of megnetite. By reaction with the limestone and the minerals of the schist, the solutions would decompose and the iron precipitate as carbonate and limonite. By subsequent alteration these minerals have been changed to hematite. Residual masses of carbonate are occasionally found in the deposits. Whenever the Potsdam sandstone is found in contact with the ore, the lower layers show a deep iron stain, evidently the effect of impregnation by the iron-bearing solutions.

The fourth class of iron ores, the limonites, are not of much importance in the Adirondack region. The deposits are, as already stated, superficial accumulations due to the washing and leaching of the neighboring rocks and soils. They seldom, if ever, exist of sufficient size and richness to repay working, at least under present conditions.

On Tuesday an excursion to Keeseville and the Ausable chasm was made by train and tallyho. Professors Woodworth and Cushing showed the party the marine delta of the Ausable river, the former lake shore lines, the post-Hochelagan gorge of the Ausable river cut in Potsdam sandstone, the Potsdam conglomerate, the northern slope of Trembleau mountain, and the anorthosite.

In the evening at the Champlain Club Prof. H. P. Cushing discussed the

Evidences of physical oscillations during the Cambro-Silurian in northeastern New York

as brought out by a general study of the stratigraphy of the region. There was a great Potsdam subsidence on the northeast, diminishing to zero westward. The succeeding Beekmantown depression encroached further on the land than did the Potsdam on the southern margin of the region, but like that was greatest on the northeast. During the Beekmantown occurred an uplift which caused cessation of deposition in all the region except the eastern border, confining the later Beekmantown and the Chazy deposits to that district. Oscillation then occurred between the Beekmantown and the Chazy, pinching out the Chazy to the south. Depression then ensued on the south and west, and the Lowville beds were deposited. The Black River limestone followed, this being the first formation found on all three sides of the region, which indicates connecting waters and similar conditions on these sides.

In the following Trenton time it seems likely that the waters nearly overspread the entire present Adirondack region, though shore-line conditions and small subsidence are characteristic of the Mohawk valley region.

Utica shale conditions came in from the east, and gradually encroached westward on the Trenton, so that the one thickens as the other thins, the Trenton thickest on the west, the Utica on the east. Following the Utica came the uplift which brought most of the region above sea level.

On Wednesday, July 10, the party regretfully bade goodbye to the hospitable authorities of the Catholic Summer School, and took the delightful sail down Lake Champlain.

At Baldwins, the steamboat terminal at the northern end of Lake George, the party were met by Prof. J. F. Kemp, by whom they were guided in the Lake George valley. The first stop was Hague, where the graphite bed at the Lakeside mine was studied. The bed is 10 feet thick, and consists of a graphite schist in which graphite supplies the micaceous mineral. Feldspar, quartz and a little pyrite constitute the associated minerals. In physical aspect the beds appear but slightly changed from a shaly sandstone. The floor and roof rocks are a garnet-feldspar gneiss with much sillimanite. The pegmatitic phases are frequent. The several methods of origin, organic; hydrocarbons akin to petroleum; the influence of eruptive rocks, etc., were passed in review. The forms of occurrence of graphite in the Adirondacks, in crystalline limestones, pegmatite veins, and schists or quartzites were set forth. The invariable association even of the graphite-bearing pegmatites with Grenville sediments was emphasized, and the schists seemed most probably a metamorphosed carbonaceous sediment, or one which had been impregnated with a heavy oil.

The party next visited the potholes on Indian Kettles point, 2 miles north of Hague. These interesting relics of the glacial epoch are on a rocky point, and 15 feet or more above the present lake.

In the evening a brief exposition of the local geology and physiography was given by J. F. Kemp, and illustrated by manuscript maps. The sediments of the Grenville series are the oldest rocks, now greatly metamorphosed. A syenitic series of eruptives, the most extensive of the local formations, succeeded the Grenville, and these are also greatly metamorphosed. There are also rocks intermediate between syenite and gabbro; true gabbros and granites. Lastly came a few basaltic dikes. There are no late Paleozoics in the region, but the Potsdam and Beekmantown are near or in the Lake George basin. The physiography was believed by the speaker to be chiefly due to block faulting, which was freshened up by the ice-sculpturing of the glacial epoch.

The next morning the party proceeded to Huletts, and visited an igneous contact on Tafts point. At Huletts dock interesting pegmatites and the effects of shearing and faulting were seen. Three sets of displacement could be detected. The party were kindly taken about the lake by Dr Smith Ely Jeliffe in his launch, adding greatly to their pleasure and profit. After lunch in the charming summer home of Professor and Mrs Kemp the members continued south through the lake and dispersed.

III

REPORT OF THE STATE BOTANIST

The State Botanist reports that the interval between the collecting seasons of 1906 and 1907 was devoted to office work which consists of the examination and identification as far as possible of unidentified collected material and the accumulated contributed material, the preparation of the annual report and the incorporation of the new material in the herbarium. The field work has been principally a continuation of the investigation and collection of specimens of the Crataegus flora and mycological flora. Of the former, considerable collections have been made in two specially prolific localities, one near Corning, Steuben co., the other near Clayton, Jefferson co. Collections here were made both in the flowering and in the fruiting period of these plants. The identification of much of this material has not yet been made.

The season of 1907 has been singularly like that of 1906 in its unfavorable influence on the mushroom crop. Frequent rains with prevailing low temperature occurred early in the season. These were followed by a long period of dry weather which was exceedingly unfavorable to mushroom growth. Notwithstanding these adverse conditions about 25 species of fungi have been added to the list of already known New York species. Of these, seven appear to be new or undescribed. In addition to these, eight species of flowering plants have been added to the State flora, but four of these are introduced plants. One alga, one hepatic moss and 10 lichens are among the additions to the flora. Most of these additions are due to the interest and activity of correspondents. Specimens of plants of various kinds, representing 125 species not new to the herbarium, have been collected. These serve to illustrate better and more completely the range and variation of their respective species. A list of the names of these and of those new to the herbarium accompanies this report.

Tests have been made of the edibility of several species of mushrooms. Eight of these have been approved and added to the list of edible fungi of New York, bringing the whole number up to 191. Descriptions and colored figures of these will be given in accordance with the plan recently followed.

In answer to requests for information concerning plants either personally or by letter, 891 identifications of species have been made for 86 applicants.

Stewart H. Burnham, assistant, has disinfected the collections of 1906 which needed such treatment, labeled and arranged them in their proper places, assisted in conducting the correspondence of the office, in the identification of specimens and in giving to inquirers the desired information concerning them. He has continued the work on a card catalogue of the fungi described by the State Botanist and prepared a list of these for publication.

Species added to the herbarium

New to the herbarium

Ajuga reptans *L.*
Biatora prasina *Fr.*
Biatorella simplex (*Dav.*) *B. & R.*
Boletus niveus *Fr.*
Centaurea solstitialis *L.*
Cetraria glauca (*L.*) *Ach.*
Chaetomium sphaerospermum *C. & E.*
Cladonia bacillaris (*Del.*) *Nyl.*
Clitocybe subcyathiformis *Pk.*
Clitopilus subplanus *Pk.*
Crataegus anomala *Sarg.*
C. plana *Sarg.*
C. suborbiculata *Sarg.*
Cronartium ribicola *Dietr.*
Diaporthe parasitica *Murr.*
Flammula pulchrifolia *Pk.*
Galium erectum *Huds.*
Hygrophorus coloratus *Pk.*

H. lacmus *Fr.*
Hypocrea polyporoidea *B. & C.*
Lactarius minusculus *Burl.*
Leaia piperata *Banker*
Lecidea platycarpa *Ach.*
Lophiotrema semiliberum (*Desm.*)
Lotus corniculatus *L.*
Metzgeria conjugata *Lindb.*
Monilia crataegi *Diedicke*
Myxosporium necans *Pk.*
Nolanea suaveolens *Pk.*
Parmelia cetrata *Ach.*
P. perforata (*Jacq.*) *Ach.*
Pholiota duroides *Pk.*
Physcia hypoleuca (*Muhl.*) *Tuck.*
Polyporus spraguei *B. & C.*
Polystictus montagnei *Fr.*
Rinodina oreina (*Ach.*) *Mass.*
Russula aeruginea *Fr.*
Sphaeropsis lyndonvillae *Sacc.*
S. persicae *E. & B.*
Stereocaulon coralloides *Fr.*
Stropharia bilamellata *Pk.*
Trentepohlia umbrina (*Kutz.*) *Born.*
Tubercularia davisiana *Sacc.*
Viola vagula *Greene*

Not new to the herbarium

Aecidium clematidis *DC.*
Ae. grossulariae (*Gmel.*) *Schum.*
Agaricus arvensis *Schaeff.*
Alsine longifolia (*Muhl.*) *Britton*
Amanita caesarea *Scop.*
A. formosa *G. & R.*
A. phalloides *Fr.*
A. rubescens *Fr.*
Amanitopsis farinosa *Schw.*
A. vaginata (*Bull.*) *Roze*
Aronia nigra (*Willd.*) *Britton*
Aster divaricatus *L.*
A. panic. bellidiflorus (*Willd.*)
Blitum capitatum *L.*
Boletus albocarneus *Pk.*
B. castaneus *Bull.*
B. chromapes *Frost*
B. clintonianus *Pk.*
B. elbensis *Pk.*
B. nebulosus *Pk.*
B. ravenelii *B. & C.*
B. subaureus *Pk.*
B. subtomentosus *L.*
Calvatia elata (*Mass.*) *Morg.*
Cantharellus cibarius *Fr.*
C. cinnabarinus *Schw.*
C. floccosus *Schw.*
C. minor *Pk.*
Carya amara Nutt.
C. glabra odorata (*Sarg.*)
Castanea dentata *Borkh.*
Chrysanthemum leucanthemum *L.*
Clitocybe amethystina (*Bolt.*)
C. candicans *Fr.*
C. laccata (*Scop.*) *Fr.*
Clitopilus caespitosus *Pk.*
Collybia acervata *Fr.*
C. dryophila (*Bull.*) *Fr.*
C. lacunosa *Pk.*
C. platyphylla *Fr.*
Conringia orientalis (*L.*) *Dum.*
Cortinarius torvus *Fr.*
Crataegus bissellii *Sarg.*
C. uniflora *Moench.*
Cypripedium arietinum *R. Br.*
Cystopus amaranthi *Berk.*
Dasystoma virginica (*L.*) *Britton*
Deconica bullacea *Bull.*
Dryopteris goldieana (*Hook.*) *Gray*
Eleocharis ovata (*Roth*) *R. & S.*
Erysimum cheiranthoides *L.*
Erysiphe polygoni *DC.*
Euphorbia polygonifolia *L.*
Flammula lubrica *Fr.*
Fraxinus lanceolata *Borck.*
F. pennsylvanica *Marsh.*
Fuligo ovata (*Schaeff.*) *Macb.*
Fusisporium destruens *Pk.*
Galium mollugo *L.*
Habenaria blephariglottis (*Willd.*)
H. ciliaris (*L.*) *R. Br.*
Helotium citrinum (*Hedw.*) *Fr.*
Helvella infula *Schaeff.*
Hydnum fennicum *Karst.*
H. septentrionale *Fr.*
Hygrophorus borealis *Pk.*
H. ceraceus *Fr.*
H. coccineus (*Schaeff.*)
H. marginatus *Pk.*
H. pratensis (*Pers.*) *Fr.*
Hypholoma candolleanum *Fr.*
H. capnoides *Fr.*
H. incertum *Pk.*
H. subaquilum *Banning*
H. sublateritium (*Schaeff.*)
Lactarius camphoratus *Fr.*
L. insulsus *Fr.*
L. oculatus (*Pk.*) *Burl.*
L. subdulcis *Fr.*
L. varius *Pk.*
Lentinus spretus *Pk.*
Lenzites separia *Fr.*
Lepiota acerina *Pk.*
Lycoperdon gemmatum *Batsch*
L. glabellum *Pk.*
L. subincarnatum *Pk.*
Marasmius glabellus *Pk.*
M. minutus *Pk.*
M. subnudus (*Ellis*) *Pk.*
Mycena rosella *Fr.*
Panus torulosus *Fr.*
Paxillus involutus *Batsch*

Phlebia radiata *Fr.*
Pholiota aggericola *Pk.*
P. caperata *Fr.*
P. discolor *Pk.*
P. praecox *Pers.*
Polyporus adustus *Willd.*
P. betulinus *Fr.*
P. caesius *Fr.*
P. cuticularis (*Bull.*) *Fr.*
Polystictus biformis *Klotz*
P. pergamenus *Fr.*
Psilocybe conissans *Pk.*
Puccinia andropogonis *Schw.*
P. coronata *Cd.*
Russula crustosa *Pk.*
R. decolorans *Fr.*
R. emetica *Fr.*
R. fallax *Fr.*
R. obscura *Rom.*
R. ochrophylla *Pk.*
R. pectinatoides *Pk.*
R. squalida *Pk.*
R. uncialis *Pk.*
R. variata *Banning*
R. virescens *Schaeff.*
Salix serissima (*Bail.*) *Fern.*
Thelephora palmata (*Scop.*) *Fr.*
Tricholoma personatum *Fr.*
T. vaccinum *Pers.*

Trees represented by trunk sections in the State Museum collection

Abies balsamea (*L.*) *Mill.*
Acer pennsylvanicum *L.*
A. rubrum *L.*
A. saccharum *Marsh.*
A. saccharinum *L.*
A. rubrum *L.* (*curly grain*)
Aesculus hippocastanum *L.*
Ailanthus glandulosus *Desf.*
Alnus incana (*L.*) *Willd.*
Amelanchier canadensis *T. & G.*
Aralia spinosa *L.*
Betula lenta *L.*
B. lutea *Michx.*
B. nigra *L.*
B. papyrifera *Marsh.*
B. populifolia *Marsh.*
B. papyrifera *Marsh.* (unblackened bark)
Carpinus caroliniana *Walt.*
Carya alba *Nutt.*
C. amara *Nutt.*
C. microcarpa *Nutt.*
C. porcina *Nutt.*
C. sulcata *Nutt.*
Castanea dentata (*Marsh.*) *Borkh.*
Celtis occidentalis *L.*
Cornus florida *L.*
Chamaecyparis thyoides (*L.*) *B.S.P.*
Crataegus punctata *Jacq.*
C. crus-galli *L.*
Diospyros virginiana *L.*
Fagus americana *Sweet*
Fraxinus americana *L.*
F. nigra *Marsh.*
F. pennsylvanica *Marsh.*
Gymnoclados dioicus *Koch*
Juglans cinerea *L.*
J. nigra *L.*
Juniperinus virginiana *L.*
Larix americana *Michx.*
Liquidamber styraciflua *L.*
Liriodendron tulipifera *L.*
Magnolia acuminata *L.*
Morus rubra *L.*
Nyssa sylvatica *Marsh.*
Ostrya virginiana (*Mill.*) *Koch*
Picea rubens *Sarg.*
Pinus echinata *Mill.*
P. resinosa *Ait.*
P. rigida *Mill.*
P. strobus *L.*
Platanus occidentalis *L.*
Populus candicans *Ait.*
P. deltoides *Marsh.*
P. dilatata *Ait.*
P. grandidentata *Michx.*
P. heterophylla *L.*
P. tremuloides *Michx.*
Prunus avium *L.*
P. pennsylvanica *L.f.*
P. serotina *Ehrh.*
Quercus acuminata (*Michx.*) *Houda*
Q. alba *L.*
Q. coccinea *Muench.*
Q. marilandica *Muench.*
Q. minor (*Marsh.*) *Sarg.*
Q. palustris *Muench.*
Q. platanoides (*Lam.*) *Sudw.*
Q. prinus *L.*
Q. rubra *L.*
Q. velutina *Lam.*
Rhus typhina *L.*
Robinia pseudacacia *L.*
Salix amygdaloides *Anders.*
S. nigra *Marsh.*
Sassafras officinale *N. & E.*
Thuja occidentalis *L.*
Tilia americana *L.*
Tsuga canadensis (*L.*) *Carr.*
Ulmus americana *L.*
U. fulva *Michx.*
U. racemosa *Thomas*
Viburnum lentago *L.*

Species still unrepresented

Acer negundo *L.*
A. nigrum *Michx.*
Carya tomentosa *Nutt.*
Fraxinus lanceolata *Borck.*
Gleditsia triacanthos *L.*
Picea canadensis (*Mill.*) *B. S. P.*
P. mariana (*Mill.*) *B. S. P.*
Pinus divaricata (*Ait.*) *Sudw.*
P. virginiana *Mill.*
Populus balsamifera *L.*
Quercus macrocarpa *Michx.*
Tilia heterophylla *Vent.*
T. michauxii *Nutt.*

IV

REPORT OF THE STATE ENTOMOLOGIST

The State Entomologist reports that the climatic conditions of 1907 have departed widely from those of normal years and, as a result the development of animal and plant life was exceptionally late. Warm weather finally came on very rapidly and all vegetation grew at such a rate that insects appeared unable to inflict material damage in many cases, consequently there has been an unusual dearth of injurious outbreaks, particularly in the early part of the year, and presumably due largely to this cause. An exceptional event was the capture by Dr Theodore P. Bailey of this city, of two specimens of the exceedingly rare Leucobrephos brephoides Walk; the specimens were taken the last of April in St Lawrence county and deposited in the State Museum.

Fruit tree insects. The *San José scale* is one of the most serious insect enemies of the horticulturist. The spread of earlier years has continued, and in places where very little effort has been made to check its ravages, the scale has become extremely abundant and in some instances at least, has practically ruined the crop. Our experiments of earlier years show very clearly that a lime-sulfur wash is thoroughly effective in destroying the scale as well as beneficial in checking certain other insect pests and fungous diseases. We have steadfastly insisted that it was wiser to use some such material than to employ the more easily applied mineral oils or preparations of the same, known as "soluble oils," because the latter under certain conditions may seriously injure the trees. This has been done in the face of a determined effort by interested parties to introduce oils and oil preparations as the most available remedies for San José scale. Despite the fact that these last named materials are valuable under some conditions, it remains true that we must still rely in large measure upon the lime-sulfur wash for the control of this pest. Our conservative recommendations, we believe, have deterred many from seriously injuring valuable orchards by making injudicious use of the more dangerous oil preparations.

The operations of the *grape root worm* in the Chautauqua region have been observed during the season and, in our judgment, there is a marked improvement over the conditions of earlier years. This change is partly due to the higher price of grapes and the consequent better care and fertilization given the vineyards, though it is probable that natural conditions have been of material service in reducing the numbers of this pest. It is still true that this enemy is abundant in limited areas, and danger of serious injury to vineyards here and there is by no means past.

Shade tree protection. Continued devastations by several shade tree pests have necessitated the giving of considerable attention to this phase of economic entomology. A bulletin on the *white marked tussock moth* and the *elm leaf beetle,* our two most injurious species, was issued in May and a number of warning articles sent to the press throughout the State. The general result has been highly beneficial and much interest has been aroused. The agitation of earlier years secured the appointment of a forester by the city of Albany. This official was placed in charge of the trees, and the spraying with poison resulted in marked benefit, despite the hindrances incident to work of that character. The city of Troy, through municipal agencies, accomplished considerable along this line. Before very long a number of other cities will be compelled, by the severity of insect depredations, to adopt some protective measures or lose many valuable trees. The experience of the last decade has demonstrated beyond all question the possibility of protecting our trees from injuries by such leaf feeders as the elm leaf beetle and the white marked tussock moth. It is practical to spray the trees so thoroughly that even in localities where the elm leaf beetle and the tussock moth caterpillars are rather abundant, there will be no serious injury to the foliage, and those interested in this work should insist upon the maintenance of such a standard.

Gipsy and brown tail moths. The work of last year in watching for the appearance of these insects within the borders of New York State, has been continued. Many caterpillars of various species, all native, however, have been sent in by different correspondents, some fearing that they had found one or the other of these pests. These fears, we are pleased to state, were groundless and, so far as known to us at the present time, neither of these species has obtained a foothold within our boundaries.

Several days in June were spent in the New England territory infested by these species, investigating in particular the recently undertaken work of destruction by means of parasites. Thousands of these beneficial parasites have been brought into this country, taken to the laboratory at Saugus, reared to maturity, the dangerous hyperparasites destroyed and the beneficial forms liberated under conditions favorable to their multiplication. Our investigations showed that certain of these European enemies had survived the winter and that there is at least a fair prospect of considerable benefit resulting from this systematic importation of natural enemies. The general situation is distinctly more encouraging than was the case last year. A general campaign of repression has been conducted most vigorously and the beneficial result therefrom is easily seen in Boston and vicinity. Furthermore, the Federal Department of Agriculture is cooperating with the Massachusetts authorities in an effort to prevent the further spread of the gipsy moth in particular. This latter phase of the work consists largely in keeping all highways free from caterpillars, so as to make it impossible for automobiles to carry these leaf feeders into uninfested regions. The gipsy moth is being combated strenuously in Rhode Island and Connecticut and there is a very strong probability that the few insects in the last named state will be speedily exterminated.

Forest insects. There were two outbreaks the past season of exceptional interest. The striped maple worm, Anisota rubicunda Fabr. was very abundant on sugar maples in Berlin and Stephentown, Rensselaer co., stripping the leaves from large blocks of forest and proving injurious over hundreds of acres. The snow-white linden moth, Ennomos subsignarius Hübn. was extraordinarily abundant on beech trees in the Catskills, defoliating large areas in and about the township of Hardenburgh. Both of these outbreaks are unusual, as neither of these species has been injurious in New York State for some years. Detailed accounts of these insects have been prepared and will be published in the Entomologist's report.

Aquatic insects. The studies of our fresh-water insects have been continued. Dr James G. Needham has completed his report on the work done at Old Forge, N. Y. in 1905, and it will be published as an appendix to the Entomologist's report. The monograph on the Stone flies (Plecoptera) begun by Dr Needham several years ago, is nearly completed and will prove an addition to our knowledge of this group. Dr Cornelius Betten, who has been studying the Caddis flies (Trichoptera) for the past six years, has nearly completed his report upon these forms. The investigations of these two gentlemen relate to a group which is of great economic importance owing to its value as fish food.

Gall midges. This group comprises among its members, several insects of prime economic importance, such as the Hessian fly, the wheat midge, pear midge and some other destructive forms. Furthermore, there is every probability that some other of our native species may become destructive in the near future. Our investigations have already disclosed hitherto unsuspected injuries by members of this group. We have succeeded in identifying several European forms not previously known to occur in this country. During the season we succeeded in rearing over 100 species, a considerable number of them proving to have been undescribed. The State collections in this group represent probably over 600 species. We have already described over 250 new forms, and it would not be surprising if, after working over the material, there were nearly as many more to characterize in addition to those previously described by other workers. The classification of the American species has been in a chaotic state, making it practically impossible to identify many of our forms. Our work, now well in hand, will revise the classification of this group.

The rearing of these insects requires much time and attention, and the success achieved last season was due very largely to the work of Assistant Entomologist D. B. Young. The collecting of the insects and the galls in the field also requires considerable time, and much of this work has been attended to by assistant I. L. Nixon. Mr J. R. Gillett was engaged throughout the summer in making microscopic mounts of these insects, some 2000 slides being prepared.

Publications. Numerous economic articles have been contributed by the Entomologist to the agricultural and local press. The large number of new species of Cecidomyiidae taken in 1907 made it advisable to issue preliminary descriptions of some, and a paper issued in advance of the report, entitled "New Species of Cecidomyiidae," published January 30, characterizes 179 new species. The second volume of Insects Affecting Park and Woodland Trees, New York State Museum memoir 8, appeared February 25 and has repeatedly proved its usefulness during the past season. The demand for information respecting shade tree pests led to the issuing of a special bulletin on the white marked tussock moth and elm leaf beetle, Museum bulletin 109, which appeared May 10, while the report of the Entomologist, owing to delays, was not issued till July 16.

Collections. The special collecting and rearing of Cecidomyiidae by members of the office staff, has resulted in very large additions to this group, which are particularly valuable because many of the forms are represented by both sexes, and in not a few instances by the larvae and the gall from which the insects were reared. Other additions to the State collections have been large, there being a total of over 10,000 pinned specimens. A number of very desirable species have been obtained through exchange.

The additions to the State collection during the past three or four years have ranged from 10,000 to 15,000 pinned specimens, all of which have to be properly labeled, assigned to their various groups and eventually determined. There has been, since the present entomologist took charge of this office, an approximately sixfold increase in the size of the State collection. A large proportion of the curatorial work in connection with arranging the collections devolves upon the assistants, and it is a pleasure to state that material progress has been made along this line. Assistant Entomologist D. B. Young has, during the past year, given considerable time to classifying the parasitic wasps, Ichneumonidae, and a portion of the Braconidae and also Hymenoptera belonging to the following groups: Pompilidae, Larridae, Bembecidae, Nyssonidae, Philanthidae, Pemphredonidae and Crabronidae. He has also done more or less incidental work with the Diptera. Assistant I. L. Nixon determined and arranged a number of the solitary bees, Andrenidae, assisted in arranging the Ichneumonidae and determined and arranged many of the Curculionidae. In addition he went over the Hill collection, noticed below, repairing and arranging many of the specimens and is responsible for a portion of the catalogue of this collection.

The Hill collection, an exceptionally valuable addition to the State collections, was received through the generosity of Erastus D. Hill, Carrie J. Hill Van Vleck and William W. Hill, heirs of the late William W. Hill, who desired that their father's work should be maintained as a permanent memorial of his labors in entomology. This collection consists of some 19,000 specimens, representing approximately 3500 species and is in excellent condition. It contains a large number of native species as well as representatives from Europe, Asia and Africa. The catalogue of the species is included as an appendix to the Entomologist's report.

V

REPORT ON THE ZOOLOGY SECTION

Research and field work have claimed the major attention of the Zoologist and the Taxidermist during this year. It has not been deemed worth while to consume much time upon the exhibition collections, in view of the complete rearrangement which will be necessary with the occupation of the new building. As usual the birds have received the chief attention. The New York series has been restored to order and many new mounts replace old ones. A portion of the older material replaced is available for loan to schools. The avifauna of the State is now represented by all but 17 of the species recognized as occurring within our borders, an increase of 17 since the last report. Among the species thus added are some specially noteworthy, such as the record specimens of European linnet and yellow-billed tropic-bird for which we are indebted to the generosity of their owners, and New York specimens of Gyrfalcon and passenger pigeon. A specimen of scaled petrel is also among the accessions. Several of the forms still missing are not rare, but no specimens of satisfactory quality have been proffered. In order that the friends of the museum may be aware of its needs, the list of these lacking species is subjoined:

Skua, Megalestris skua (Brunn.)
Trudeau's tern, Sterna trudeaui Aud.
Black-capped petrel, Aestrelata hasitata (Kuhl)
Booby, Sula sula (Linn.)
Black brant, Branta nigricans (Lawr.)
Barnacle goose, Branta leucopsis (Bechst.)
Eskimo curlew, Numenius borealis (Forst.)
Burrowing owl, Speotyto cunicularia hypogaea (Bonap.)
Skylark, Alauda arvensis Linn.
Holboell's redpoll, Acanthis linaria holboelli (Brehm)
Baird's sparrow, Ammodramus bairdii (Aud.)
Lark sparrow, Chondestes grammacus (Say)
Lawrence's warbler, Helminthophila lawrenci (Herrick)
Brewster's warbler, Helminthophila leucobronchialis (Brewst.)
Palm warbler, Dendroica palmarum (Gmel.)
Townsend's solitaire, Myadestes townsendi (Aud.)
Bicknell's thrush, Turdus aliciae bicknelli (Ridgw.)

From the hypothetic list the following six species, three less than last year:

Lesser fulmar, Fulmarus glacialis minor (Kjar.)
European teal, Nettion crecca (Linn.)
Masked duck, Nomonyx dominicus (Linn.)
Cory's least bittern, Ardetta neoxena Cory
Cooper's sandpiper, Tringa cooperi Baird
European green-finch

A group of Sora rail has been completed and awaits casing.

A family of black bears, consisting of a female with two cubs, and a male, is being mounted by the Ward Natural Science Establishment, after sketches submitted by Mr Charles Livingston Bull. The female is shown in an attitude of protection for the young against the possibly unfriendly intentions of the male. Mr Bull entitles his drawing " The Intruder."

The Taxidermist is engaged upon a mount of the muskrat and its haycock nest, showing the construction of the interior.

The Zoologist has continued his studies of the Arachnida, and has completed a synoptic check list and key to all the known acarians, phalangids, pseudoscorpions, pycnogonids and xiphosurans occurring within the borders of our State. This work will be offered for publication as soon as the illustrative diagrams have been prepared, and will be followed shortly by the list of New York spiders compiled last year, which requires some additional keys, thus giving a complete index to the present knowledge of our arachnid fauna. In the prosecution of this labor he has been impressed by the need for systematic work upon our species of mites, and especially the gall mites, or Eriophyidae. As an appendix to the check list he is preparing a list of all the forms of mite galls and their host plants recorded from this country, together with a number of new forms occurring in the collections; of this list of nearly 150 forms of galls, only about one fifth have had their mites described and named. A collection of pressed specimens of these mite galls has been commenced and contains many interesting Cecidia. A large collection of the spiders, mites and other arachnids of the State is now available for study.

The reserve collection of Unionidae, or fresh-water mussels, has been partially rearranged and made available for use in illustrating the forthcoming report on those forms. This rearrangement should be completed as rapidly as possible. It is already evident that the State collection of these forms is unusually large and symmetrical, a fact which its scattered condition did not reveal.

The Zoologist terminated his official connection with the museum on September 15th, but his interest and good will still bind him to it, and he hopes to complete the check lists above mentioned at an early date.

Birds of New York. The first volume of this work covering the general and introductory discussion and specifically the accounts of the water birds with 39 plates in color, is practically ready to

communicate for printing. The scope of the work is such as to make it necessary to devote two volumes to the memoir. The preparation of the second volume is well forwarded and it is expected that the entire work will be in press during the coming year.

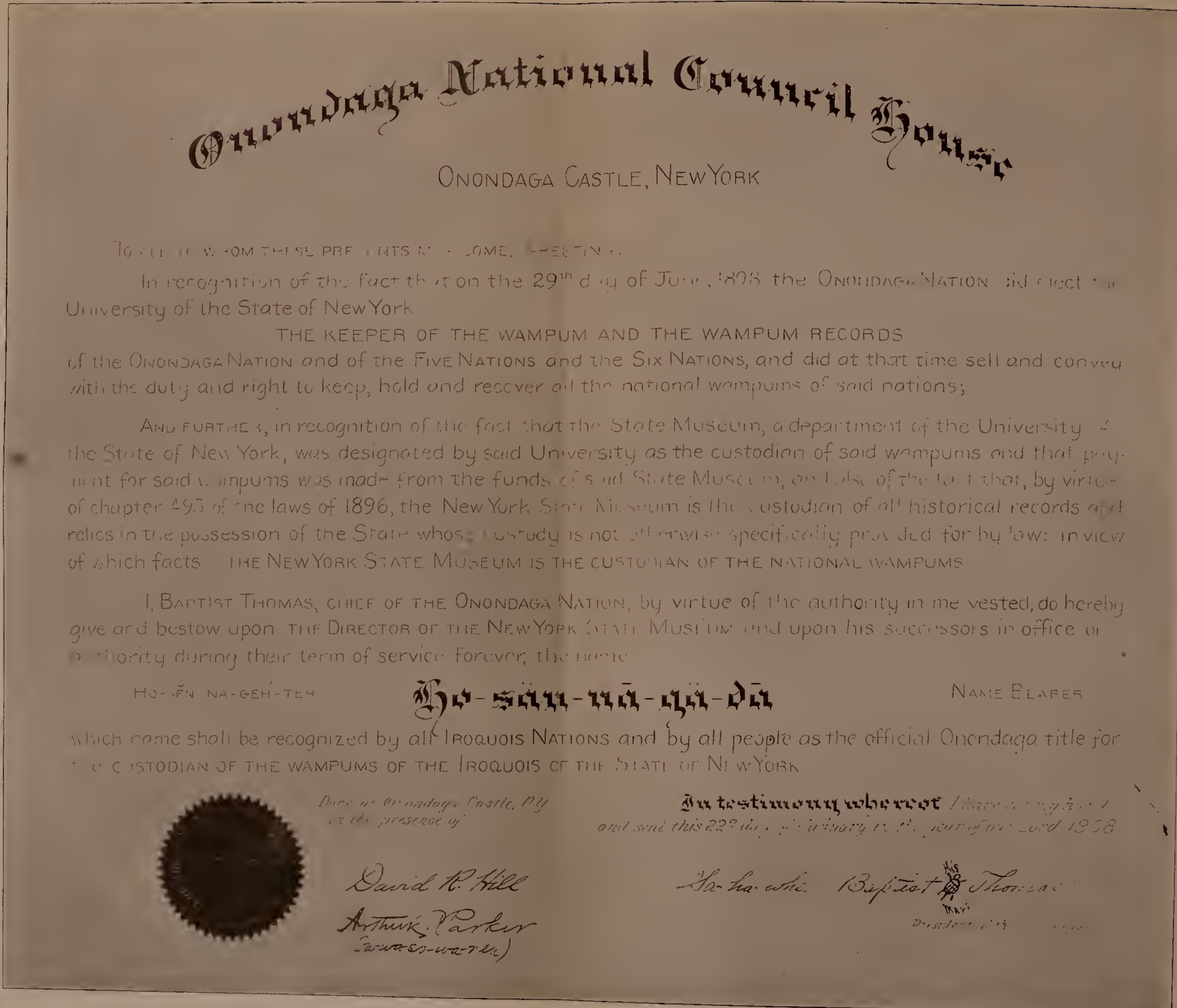
VI

REPORT ON THE ARCHEOLOGY SECTION

The wampums of the Iroquois Confederacy. By virtue of the action of the Onondaga Nation in 1898 in electing the University of the State of New York the wampum keeper of the "Five Nations and Six Nations, and each of them" and by the purchase of these wampums at that time through the Onondaga Nation as keeper of all the wampums of the Iroquois Confederacy from the funds of the State Museum, these invaluable archives of the Confederacy have come into the custodianship of the Director of the State Museum, to whom, by the action of the President of the Onondaga Nation, has been transmitted the historic title Ho-san-na-ga-da — Keeper of the Name. Although complete records of these wampums have been kept in the manuscript files of the museum it seems well to make the record more permanent and decisive by introducing in this place photographic copies of each piece of wampum received at that time from the chiefs of the Onondaga Nation. These illustrations are herewith given.

Work of the section. As an organized department of the State Museum, the Archeological section began on October 19, 1906. The work which devolves upon this section has necessitated its subdivision into several subsections as follows: archeology, ethnology, anthropometry and osteology, and philology and folklore.

Each of these branches is necessary for the preservation and study of the prehistoric and recent relics and remains of the New York aborigines. The work necessary to carry on each of these branches is nothing less than enormous as will be realized when it is stated that it is required that one person, the Archeologist, carry on field work in archeology for at least four or five months of the year, collect ethnologic specimens from the Indians, study, classify and catalogue all the archeologic and ethnologic material acquired, study, measure, record and catalogue all the features of the human remains exhumed from the ancient graves and ossuaries, to collect and record legends and ceremonial rituals and songs from the Indians, and to transmit proper reports covering these activities.



Onondaga National Council House

ONONDAGA CASTLE, NEW YORK

To [illegible] whom these pre[illegible]nts [illegible] come, [illegible]

In recognition of the fact th[illegible]t on the 29th d[illegible]y of Ju[illegible], 1898 the Onondaga Nation [illegible] elect [illegible] University of the State of New York

THE KEEPER OF THE WAMPUM AND THE WAMPUM RECORDS

of the Onondaga Nation and of the Five Nations and the Six Nations, and did at that time sell and convey with the duty and right to keep, hold and recover all the national wampums of said nations;

And further, in recognition of the fact that the State Museum, a department of the University [illegible] the State of New York, was designated by said University as the custodian of said wampums and that pay[illegible] [illegible]nt for said [illegible]ampums was made from the funds [illegible] said State Museum, [illegible] of the [illegible] that, by virtue of chapter 49[illegible] of the laws of 1896, the New York State Museum is the custodian of all historical records and relics in the possession of the State whose custody is not otherwise specifically provided for by law: in view of which facts [illegible] the New York State Museum is the custodian of the national wampums

I, Baptist Thomas, chief of the Onondaga Nation, by virtue of the authority in me vested, do hereby give and bestow upon the Director of the New York State Museum and upon his successors in office or [illegible]thority during their term of service forever, the name

Ho-[illegible]en na-geh-teh **Ho-sän-nä-gä-dä** Name Bearer

which name shall be recognized by all Iroquois Nations and by all people as the official Onondaga title for [illegible] Custodian of the wampums of the Iroquois of the State of New York

Done at Onondaga Castle, N.Y. in the presence of

In testimony whereof *[illegible] and seal this 22[illegible] day [illegible] [illegible] year of our Lord 1908*

David R. Hill

Arthur C. Parker (Ga-wa-so-wa-neh)

Ha-ha-whe [illegible]

Baptist (his mark) Thomas

[illegible]

It is also necessary for the Archeologist to instal new collections and rearrange old ones.

Condition of the collections. The archeologic material which has been accumulating for the past 60 years has never been systematized nor properly arranged. This is due largely to the fact that until now there has never been a permanent curator and, largely also, to the fact that there has not been adequate space nor proper cases for the arrangement and exhibition of the specimens. Probably two thirds of the material is in storage and has been packed so long that we are unfamiliar with our own resources.

The Archeologist has rearranged the ethnological collection in the Capitol so as to present a systematic exhibition of specimens illustrating costumes, weapons, ornaments, ceremonial objects, silver work, games and articles used in the preparation of food. An arbitrary arrangement of things by classes, such as wooden objects, metallic objects, etc., is objectionable. Of greater human interest and scientific value is the arrangement according to use. This system we are following.

Archeologic and modern ethnologic material should not be exhibited in the same cases. We have, therefore, endeavored to separate the two classes as far as crowded conditions would permit. The rearrangement of the archeologic material is a work which has just begun. The task of cataloguing the specimens is well under way. No museum serial catalogue has ever been prepared and nearly all of the specimens are without adequate data and means of identification. This is a matter which is to be remedied at once.

Publications. The value of the work of the archeological section of the museum depends upon the facts and specimens which it discovers in the field and upon the method by which knowledge of these facts and artifacts are brought to public notice. Bearing this in mind the Archeologist prepared a bulletin illustrating and describing the collection which he secured during the season of 1906. This work is entitled *Excavations in an Erie Indian Village and Burial Site at Ripley, Chautauqua Co., N. Y.* As a work it has had a very favorable reception among the recognized archeologists of the country.

Archeology as a science has often been regarded as having small practical bearing upon the needs and requirements of practical life. This is not entirely true and to awaken a wider interest in the work the Archeologist has in preparation a publication which it is believed will appeal to a wide circle of interests. This work, *Art*

1 Council summons, calling the clans to a meeting. This belt is said to be a memorial to the clan laws of Hiawatha. By some it is considered an alliance belt sealing a pact between the Seven Nations of Canada and the Iroquois.

2 Treaty belt. Originally there were five diagonal bars.

3 Remembrance belt. Records the treachery of a French missionary at Onondaga who sought to summon the French army from Canada. It is an admonition against the French religion.

4 Caughmauwaugua belt. Records an alliance between the Caughmauwauga tribe and the St Regis band. The crooked lines indicate that the former had forsaken the old ways for the white man's religion.

5 Condolence belt of the Senecas once held by Governor Blacksnake. It was used in mourning councils in the ceremony of raising the new names and new sachem to office.

6 Huron alliance belt, said to symbolize the alliance of the Hurons with some other tribe. After the overthrow of the Hurons in 1650 it became a Seneca belt and was taken to Canada after the Revolutionary War.

Plate 22

1 2 3 4 5 6

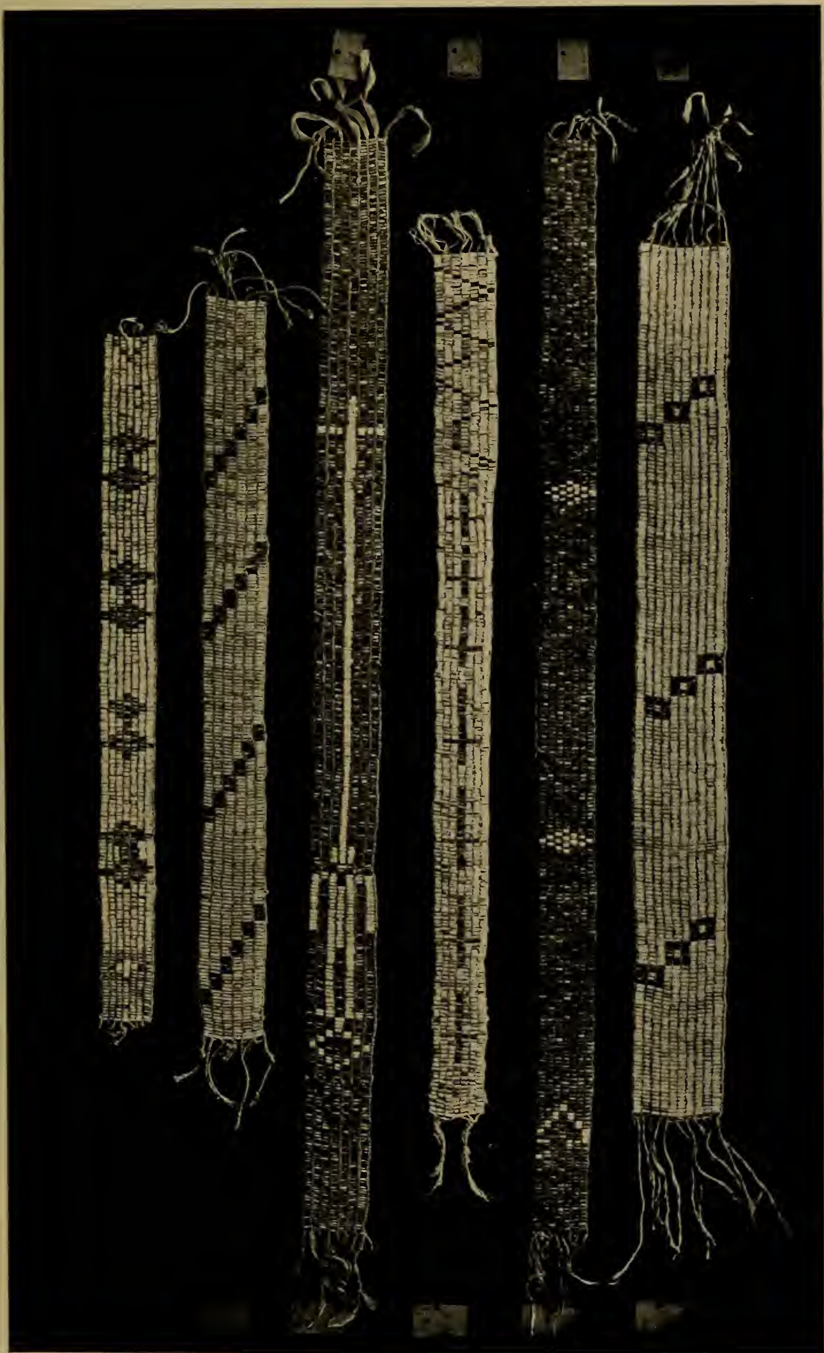
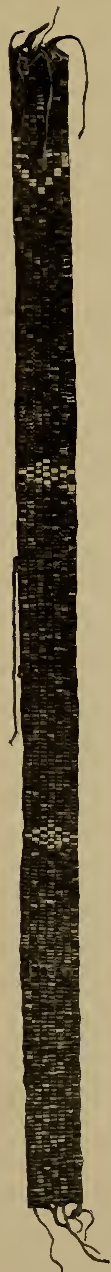


Plate 23

1

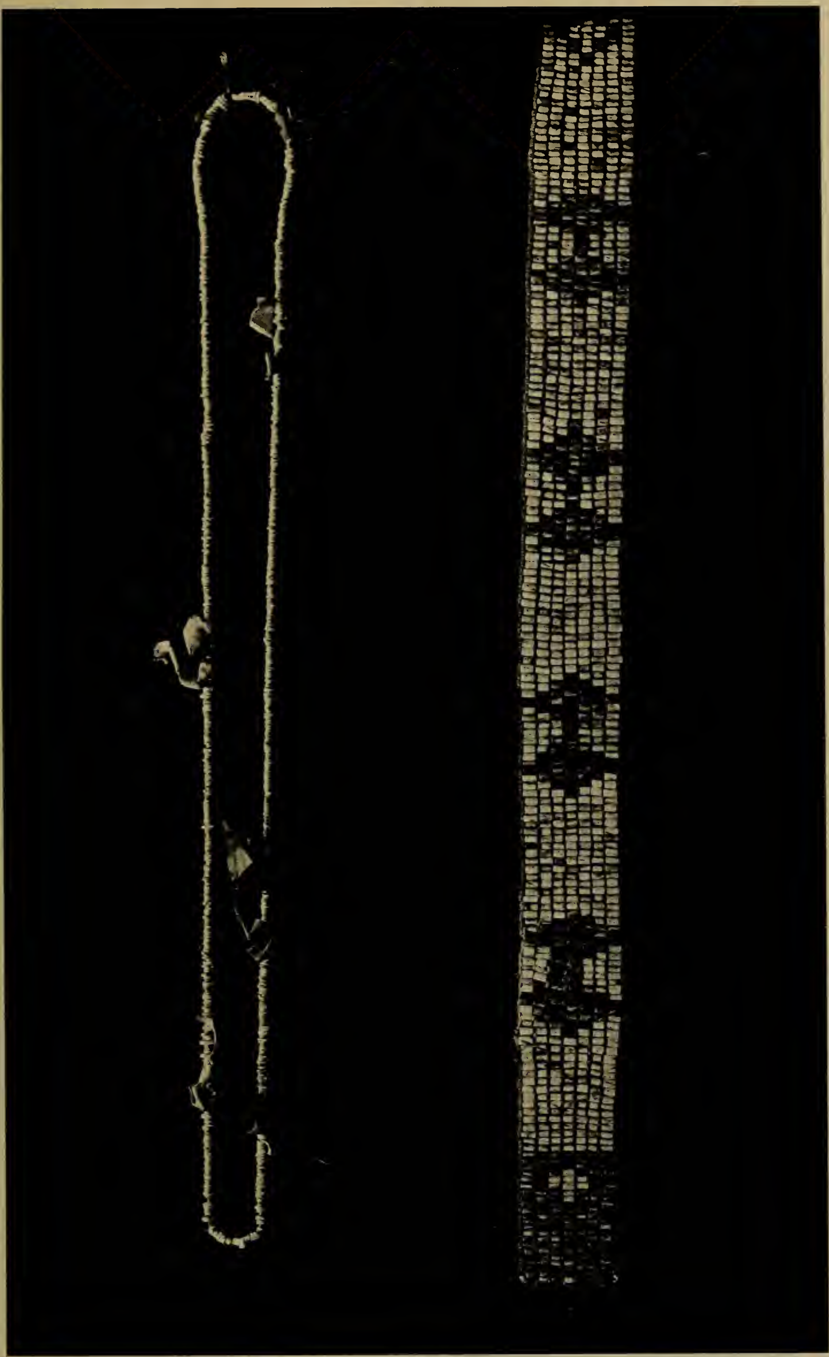
2



1 Same as figure 3, plate 22
2 Same as figure 5, plate 22

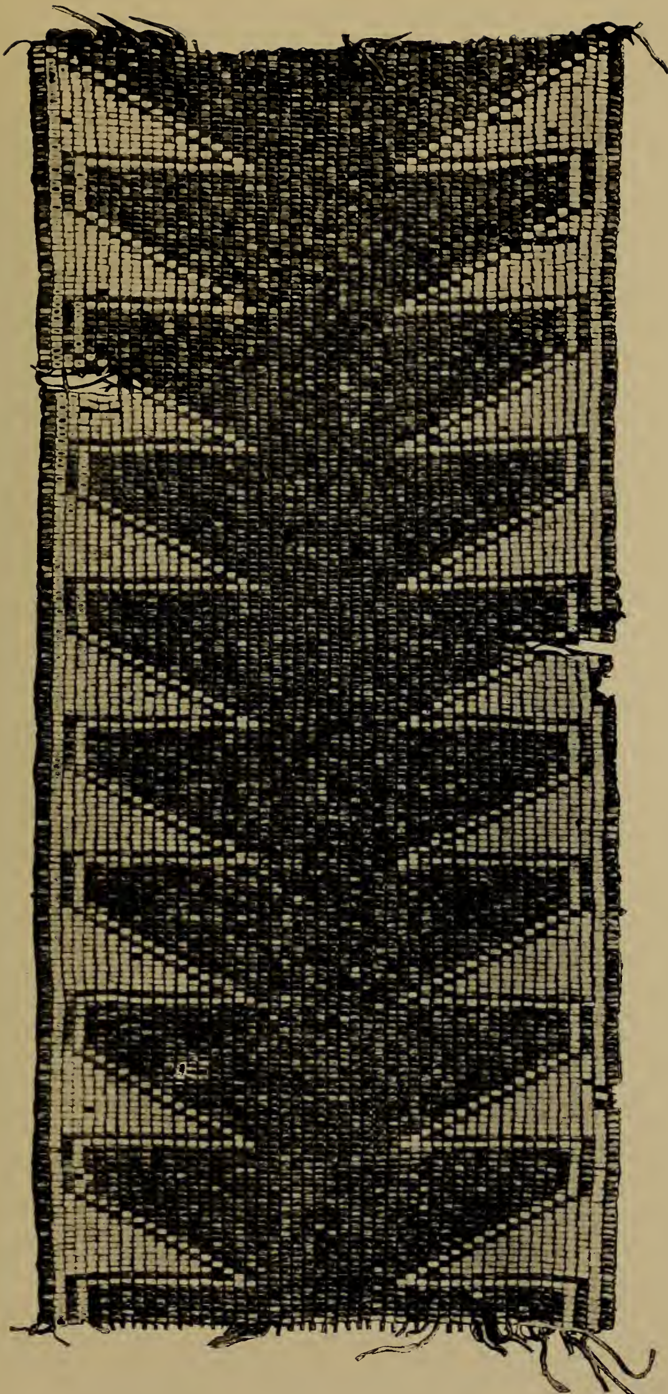
Plate 24

1 2

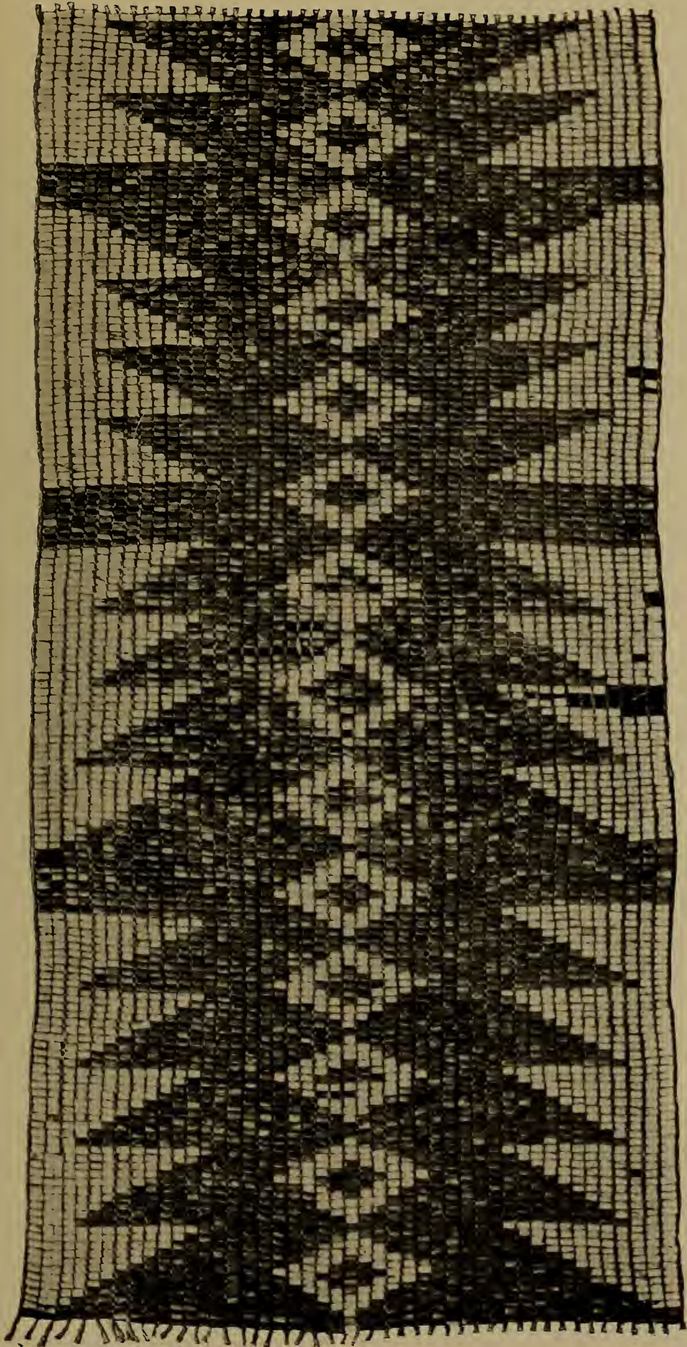


1 String of disk wampum used by the Canadian Delawares in naming ceremonies.

2 Same as figure 1, plate 22

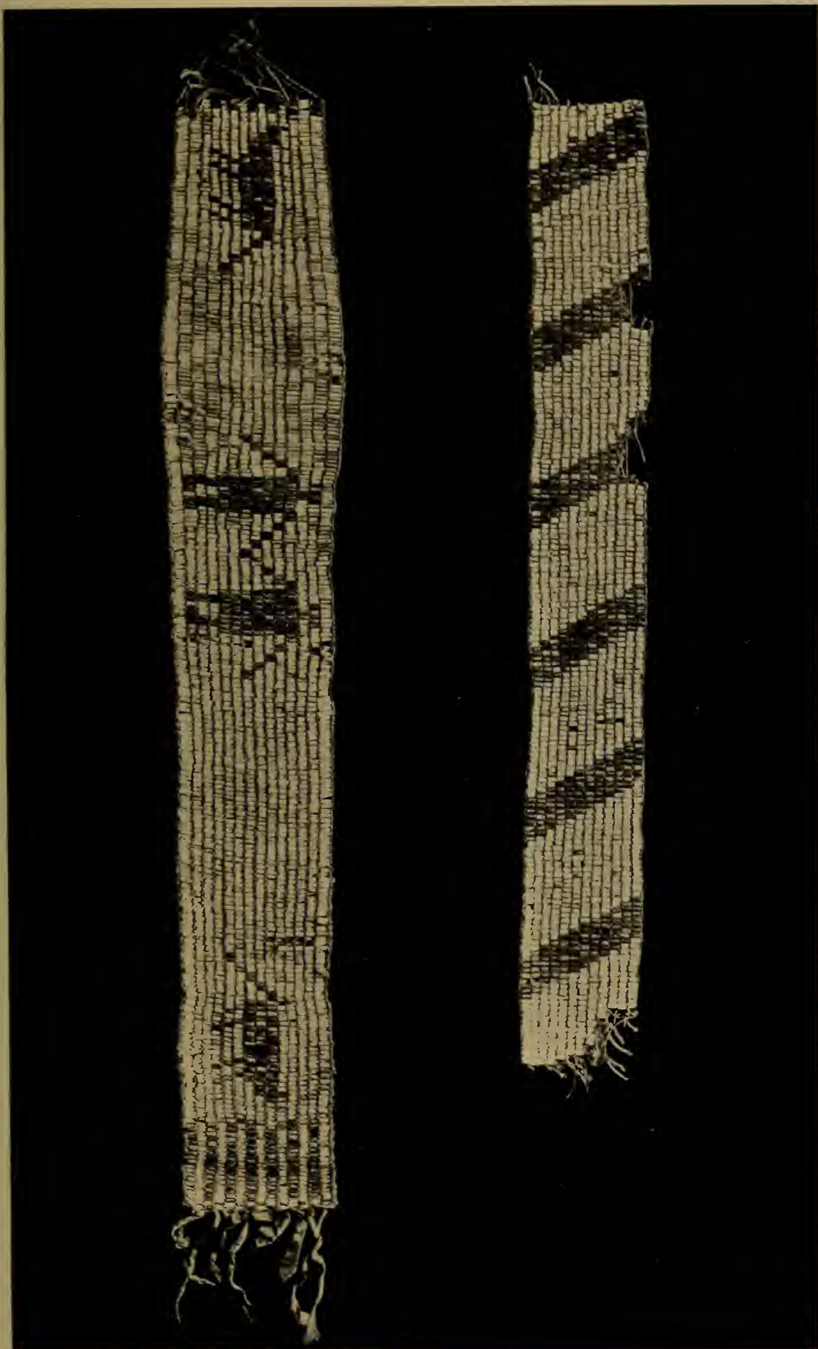


Wing, or Dust Fan of the President of the Council. This is an Onondaga national belt and the largest known, being 31½ inches long and 50 beads wide. The design is said to represent an endlessly growing tree which symbolizes the perpetuity of the league.



To-ta-da-ho belt. Sometimes called the Presidentia. It is the second largest belt known, being 27 inches long and 45 beads wide. The series of diamonds in the center is said to represent a covenant chain always to be kept bright.

Plate 27

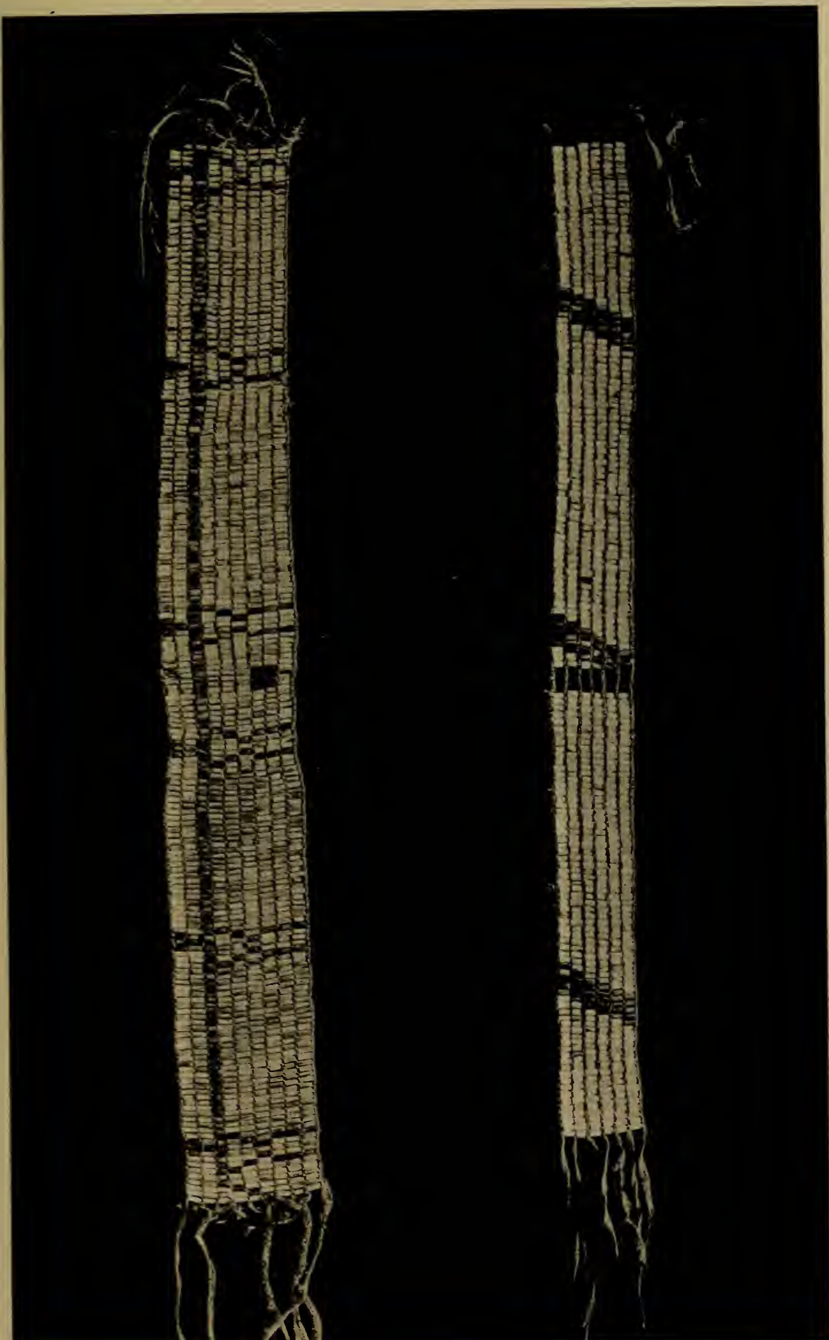


1 Wolf treaty belt. Said to represent the alliance of the Mohawks with the French. The wolves at either end symbolize the "Door Keepers" of the league. This was a Mohawk national belt.

2 Alliance belt, said to commemorate the entrance of the Tuscaroras in 1713. Onondaga national belt

Plate 28

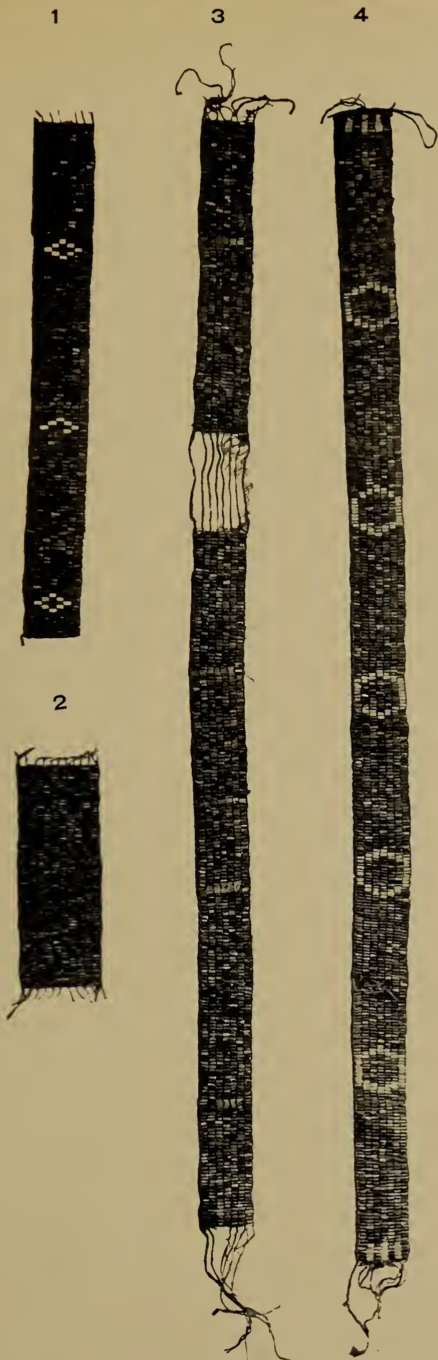
1 2



1 Nomination belt used by the Seneca women to confirm the nomination of the sachems which they chose for office. This was the Seneca women's national belt.

2 Hospitality or Welcome belt. Said to have been used in league councils by the presiding chief in welcoming the delegates.

Plate 29



1 The Five Nations alliance belt. A perpetual reminder of the national union. This belt is mutilated.

2 Gyantwaka treaty belt. A fragment of the belt passed to the Indians at the sealing of the Cornplanter reservation treaty. Other portions of the belt were cut up and divided among the heirs of Cornplanter.

3 Cornplanter's personal belt. This belt and a beautifully engraved tomahawk, both in the State Museum, are probably the only relics of the distinguished chief who destroyed all his effects for religious reasons.

4 Belt of the Keeper of the Western Door. Sometimes called the Parker belt, from Gen. Ely S. Parker who held it as the Do-ni-ha-ga-wa of the confederacy of the Five Nations.

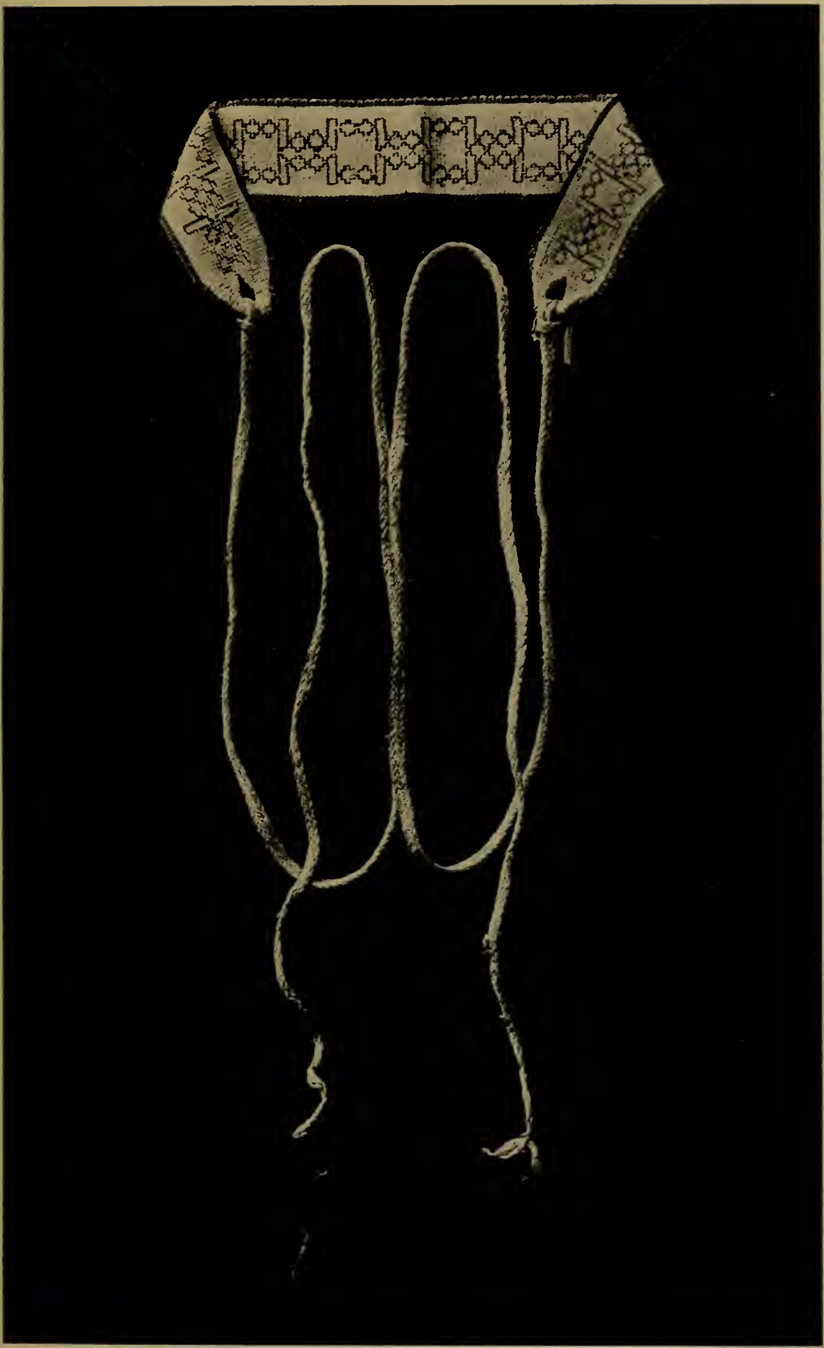
Plate 30

1

2

1 Ransom belt. If presented by the youngest unmarried female, the relative of a murderer, to the avenger of the slain it would ransom the life of the guilty party.

2 The Lewis H. Morgan belt. Made at Tonawanda in 1850. Said to symbolize the peace between clans and villages. This never was a national belt.

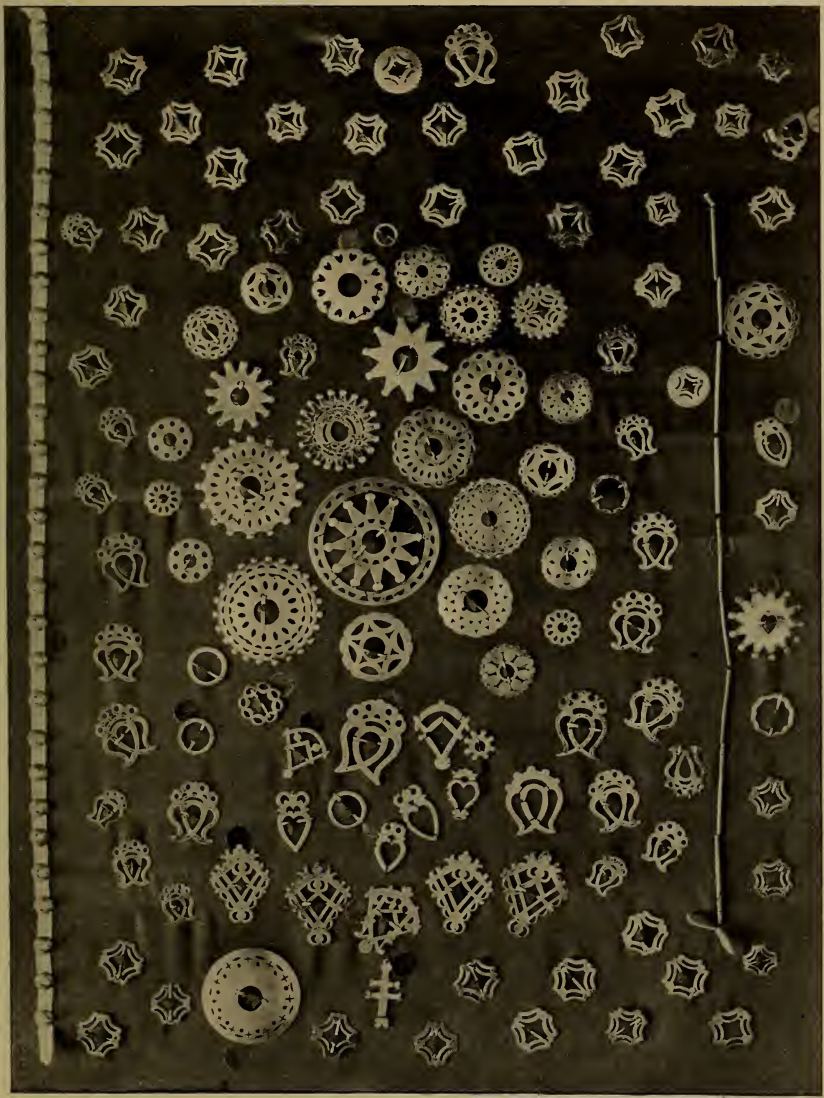


Pack strap woven from basswood bark fiber. Mohawk

Cayuga necklace of worked deer phalanges and knee rattles of deer hoofs

Red Jacket's side pouch and knife sheath. Buckskin, embroidered with porcupine quills

Plate 34



Part of the Harriet Maxwell Converse collection of silver brooches

Plate 35

Potsherds showing range of ornamentation of pottery; Luke I. Fitch collection

Plate 36

Maternity pipe from mound; two views. Probably post-Columbian

and Symbolism of the New York Indians, it is hoped, will fill a want felt by artists, designers and craftsmen in general. It will set forth the forms of artistic creations, decorations by incision, quill embroidery, bead work, carving, stamping, painting and metal work devised by the New York Indians.

Public interest. That public interest in the archeology of this State is steadily increasing is attested by the large numbers of inquiries received by mail and by the number of visitors who personally state the inquiries. Full replies in all cases have been given.

Collections acquired. Several valuable collections of archeologic and ethnologic material have been acquired for the museum during the past year.

Among these are collections from W. H. Hill and M. R. Harrington, of New York city; and L. I. Fitch of Manlius, N. Y.

The Hill collection embraces a number of valuable pieces of silver work such as disks and crowns, bead work and two pieces of wampum, one a belt and one a wristlet.

The Harrington collection is one of the most valuable acquired for many years and consists of ethnologic material purchased from the Iroquois on the Grand River reservation in Canada. Many of the specimens were lacking in our collections and could not be obtained among the New York Iroquois.

The Fitch collection consists of Onondaga archeologic material obtained from Pompey Hill, N. Y., and includes specimens that range from the prehistoric forms down to articles of modern time.

The Archeologist visited the Indian reservations during the summer and acquired a number of valuable objects which up to this time had not been represented among the ethnologic series. Among these objects may be mentioned prayer rattles, ceremonial headdresses, an Indian silversmith's outfit of tools, blow guns, ceremonial robes and mats.

FIELD WORK IN ARCHEOLOGY, 1907

Following out the plan to thoroughly examine each culture district in New York State, the field researches in archeology during the season of 1907 were made in the territory reputed to be that of the Eries. The coast or lake shore culture having been examined last year with splendid result, it seemed advisable to examine the region upon and about the Chautauqua hills. Numbers of sites had been noted here and for at least 60 years it had been a territory interesting to archeologists, although no excavation had ever been made systematically. Excavations made 30 years ago in some sites had yielded large quantities of human remains and the ploughing of other places had produced annual crops of relics in others. Nothing definite was known of the character of these places, nor of the stage of art and culture represented by them. Commonly they are described as being the remains and artifacts of the Eries whom history places in this region.

A survey of Chautauqua county led to the discovery that there were at least three distinct cultures or successive occupations of this region differentiated by very wide characters. There seems some evidence also of a fourth occupation. The oldest occupation definitely traceable is that characterized by the notched and shouldered arrow point and spear point, by the total absence of pottery and bone implements, by the absence of pits except a few shallow ones containing charcoal only. The village sites of this culture and occupation are situated alike on hills and in valleys and seem to have been spread out rather than close together. On sites of this description the gorget, bird and banner stone and other polished slate articles have been found, although most of the celts are of the common type, that is, symmetrical and equilateral. Stone pipes are sometimes found, some of which are of the mound-builder type. Mounds in which these same articles have been discovered seem to indicate that the mounds are relics of this occupation. These mounds are nowhere as large as those of Ohio and Wisconsin, and seldom exceed 50 feet in diameter and 8 or 10 feet in hight. On sites of this description grooved axes are sometimes found although they seem to have been acquired from another culture elsewhere by trade or otherwise. The human remains of the occupation are extremely rare and probably none have ever been found suitable for measurement or comparison.

The second distinct culture is that known as the Huron-Iroquois and is susceptible of two divisions, the prehistoric and historic. The historic or second stage of this culture is undoubtedly Erian, but the prehistoric or first stage is better termed Huron-Iroquois and differs from the second in several material points.

The third culture or occupation traceable is that of the Confederated Iroquois, presumably the Senecas who held tracts of land here during the late part of the 18th and early part of the 19th centuries. This occupation was not of long duration nor are its evidences widely traceable.

The early Huron-Iroquois occupation is characterized by inclosures surrounded by low walls of earth, by ossuary burials, by triangular arrow points, by a lack of notched spears, by a lack of objects buried in the graves, by their pottery, by shallow pits containing no bone objects nor bone refuse, but frequently some pottery and flint chippings. The earth inclosures vary in area from less than an acre to 5 or even 7 acres. When convenient, points of land extending from a terrace out into the valleys were fortified at the neck and cut off from the general plane. The earth circles or inclosures and fortified necks are locally termed " Indian forts " and some undoubtedly were such. Some old writers have called them " ceremonial rings " and have expatiated on the wonders of the " true circles." Investigation, on the contrary, demonstrated that only a few approach true circles and adduces no evidence to prove them of a ceremonial character. Often they have been erroneously regarded as works of the Mound Builders.

The later Huron-Iroquoian occupation becomes more specific and is recognizable as the Erian. It differs from the older occupation in that the burials contain flint and shell objects, pottery of different form and decoration. Refuse, that is broken bone implements, potsherds, rejected flints and entire objects, evidently swept in accidentally, is found in abundance in pits and sunken fireplaces.

The later Erian occupation, the historic, that is to say those sites which yield objects of European manufacture, differ noticeably from the earlier sites in several respects. The pottery seems to have undergone a gradual change until the Eries were destroyed, the most varied forms and decorations being of the historic period.

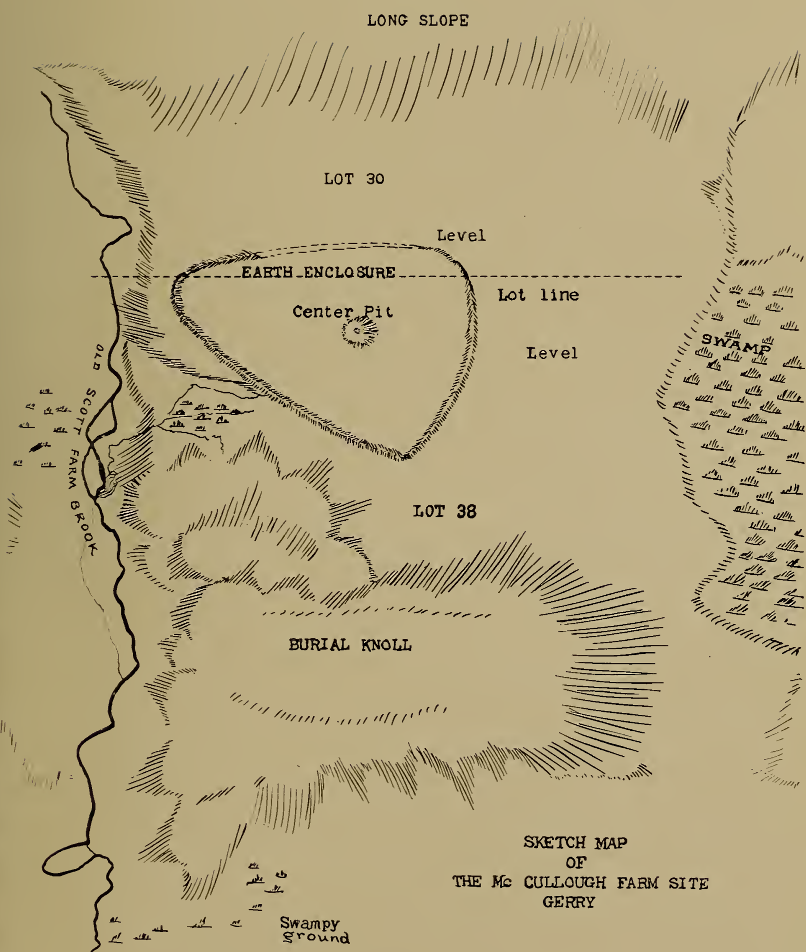
Early in the month of May a preliminary examination was made of some of the earthworks in that part of Chautauqua county lying south of the Chautauqua range of hills in the Allegheny-Ohio watershed. The outlook seemed a promising one, judging from the abundance of earthworks visited and reported. The Cassadaga valley was of especial interest and a season's campaign of investigation was planned for this region. Upon the uneven stream-cut hills that rise from the ancient lake bottoms were found everywhere traces of an early people which seemed eminently worthy of study. How numerous are the fort sites may be suggested when it is stated that from a hill just over the town line in Charlotte are to be seen the sites of seven and possibly eight fort and camp sites.

McCullough earth inclosure. One of the sites to which considerable attention was devoted is situated in a sugarbush on the Martin McCullough farm, lot 38, Gerry township. Here surrounded by a swamp from which rise sloping hills is a rise of land some 3 feet above the swamp level. Upon this rise of ground is an oval or rather kite-shaped earthwork 1297 feet in circumference. The wall is now from 22 inches to 24 in hight and is composed of the earth which was scooped from an outer ditch bordering the wall. This earthen ridge first attracted the attention of Obed Edson who some 50 years ago was engaged in running the lot lines. Some mention of it is contained in the various county histories to which he has contributed or written. Numbers of men distinguished in archeologic science have visited the place and more than a dozen years ago representatives of the Smithsonian Institution made some investigations there. To the west of the earth wall rises a small knoll which appeared to be composed of glacial sand and to the north running through a little valley is a brooklet. Within the wall are numerous pits or depressions 5 or 6 feet in diameter and 3 to 9 inches deep. These, upon examination, proved to be shallow refuse pits with an original depth of from 1 to 2½ feet. A rather remarkable pit is situated almost in the center of the inclosure and measures 157 feet in circumference with a depth of 5 feet. The earth wall is surrounded on its outer side by a ditch which is at present but little more than a foot below the normal level of the surface. The wall at present is on the average 8 or 9 feet through at the base and the crest of the ridge rises 2 feet in places. The ditch and wall are entirely visible in lot 38 and the wall may be traced in lot 30 where the ground has been cultivated for several years. An enormous white pine stump stands on the northwestern side of the wall. A cross-section of this stump was made by Hon. Obed Edson and more than 400 rings were counted. At the northwest corner of the earthwork where the stump stands, the surface of the ground is 20 feet higher than the brook bed which lies to the north 25 feet distant. At the lot line on the east the earth wall takes an abrupt turn almost at right angles and runs about parallel to the line for 450 feet.

Within the inclosure at about its mid point is the bowl-shaped depression, previously mentioned. This pit is 5 feet deep and 50 feet in diameter. In area the inclosure is about 3 acres.

It was found after some expenditure of time that very little in the line of movable material data bearing on the original inhabitants could be hoped for. Specimens of the arts and manufactures were few and fragmentary. However, bearing in mind that the problem was to discover the identity and characters of the builders of the

Plate 37



SKETCH MAP
OF
THE Mc CULLOUGH FARM SITE
GERRY

The central pit in the McCullough earth inclosure

View looking over the burial knoll. Ossuary 5 was found near the stump shown in the left-hand corner of the picture.

earthworks, it was deemed advisable to continue until it could be thoroughly studied and every important fact obtainable brought to light. Since the area within the inclosure refused to divulge all the desired information, it was sought to discover the burials and wring from the crumbling bones of these swamp dwellers some word or fact to dispel the mystery.

Burials

Post holes were dug in the ridge to the west of the earth-walled inclosure to discover, if possible, whether or not there were any burials, it being the spot most suited for graves, in point of accessibility. The surrounding ground was swampy and the loam but a few inches in depth when a stiff clay or hard pan was encountered. The knoll on the other hand was dry and sandy.

After 40 tests had been made, running from the brook on the north in a southerly direction, an area of disturbed earth was found and a trench staked out for systematic excavation. Following the rule the trench was 1 rod wide. Trench 1 was run over the crest of the ridge from south to north.

Burial 1, was found at 16′ in the middle of the trench 20″ below the surface. A root-eaten skeleton of a young female was discovered. The skull was crushed at the top. Only the skull and upper ribs and upper arm bones were found. The other bones were not to be found. The head lay to the northeast, face northwest. 28″ southeast and above the head was an ash pit 18″ deep. It was filled with white ashes. The superincumbent soil was sandy and intermixed with bits of charcoal.

Burial 2. At 16′ on the west side of the trench, 36″ below the surface and opposite burial 1, burial 2 was discovered. The skeleton was that of an adult male and lay in a flexed position. Measurements of the skeleton as it lay led to the following data: 33″ from top of skull to heel; knee to back, 9″; pelvis to top of head, 33″. The soil was strewn with charcoal bits and potsherds. A black fibrous phosphate was noticeable in the grave soil.

Two empty graves were found between this burial and the next (No. 3). Their character as graves was shown by the soft, loose and disturbed soil which lay surrounded by the hard, undisturbed grit. It was an easy matter to shovel out the grave soil because of its looseness, without disturbing the wall of the grave. Only a few fragments of bones were discovered in these empty graves.

Burial 3. Discovered at 34′ on the west side of trench 1, 26″

down. Skeleton was that of an infant 8 or 9 years old. The skull was crushed. The body lay in a grave outlined by a row of flat stones placed upright on edge. Orientation: head, east-southeast; face north-northwest; right side, flexed. Body lay east-southeast by north-northwest. From top of head to end of toes 2′ 3″. Black phosphate in grave. Ash pit south of skull at 18″. Grave soil much disturbed.

Burial 4, was found at 33′ on the east side of the trench. The depth was 25″ and the grave outline 60″ by 35″. A decayed male skeleton lying in the usual flexed position. Orientation: head, south-southeast; face west-southwest, left side. The skeleton as it lay measured 36″ from top of head to heel and 15″ from knee to back. The superincumbent grave soil was much disturbed. An ash pit 2½′ in diameter and 1′ deep was found just south of the grave.

Between graves 3 and 4 there was a streak of disturbed earth 30″ deep, as if the entire ground had once been turned over to this depth. There was a thin separating wall as if there had been two other graves here.

Burial 5. At 40′ on the east side of trench 1 the tops of two boulders were struck and a few inches north of them a heavy bed of white ashes. Beneath the ash bed, 11″ from the surface of the ground the tops of several skulls were touched. Careful excavation revealed a small ossuary containing the remains of parts of 14 skeletons.

The bones were placed in a rectangular heap measuring northeast to southwest, 2′ 4″, by northwest to southeast, 1′ 8″. The large bones, femora, tibiae, etc., lay northwest and southeast. Six skulls were arranged around the top of the ossuary and beneath them were four others, all broken. When the bones were removed 27 femora were found which would indicate parts of 14 individuals. The earth had packed about the outer bones and had not fallen into the interstices of the bone heap below. The area of the disturbed earth was, in diameter, 4′ 6″. The two boulders south of the ossuary had probably been placed as hidden markers. Large stones had not been encountered before in the sand of the knoll.

Just beyond the ossuary to the south was a large ash pit 48″ in diameter.

In depth the ossuary was 16″, or from the top of the ground to the bottom, 27″.

Burial 6. This grave was discovered at 37′ outside of trench 1, on the west side. It was 36″ deep, 36″ wide and 55″ long.

Grave 2, McCullough site

Grave 3, McCullough site

Grave 6, McCullough farm site, Gerry, N. Y.

Ossuary 5, McCullough site

This grave unlike the others seems to have been an original burial, that is to say, the earth had not been overturned more than once. The other graves seem to have been used several times, the bones being removed for ossuary burial or other disposition, and a new body interred therein.

The skeleton was that of an adult male of mature years, (about 60). A heron's lower mandible was found at the forehead as if it had been used as a hairpin.

The earth had packed about the limbs and neck and left in the clay-mixed sand a cast of the body. A black phosphate surrounded the bones, the remains of the animal tissue.

Measurements of position gave the following data: knee to back, 17″; atlas to *os innominata* 2′ 5″; atlas to end of tarsus, 3′ 2″.

Orientation: head east; face, south; left side, flexed.

Bones in good condition except those of the two lower arms.

Burial 7. Another grave was opened at 44′ on the west side. It was 30″ deep and contained only a few decayed vertebrae and a deposit of grave dirt. The larger bones had probably been removed for ossuary burial.

Burial 8. At 49′ on the west side, grave 8 was found. It was 19″ deep and contained a few decayed bones, part of a femur and the crushed remains of a child's skull. Over this grave was a layer of shale slabs. At the south end of the grave was a boulder 12″ in diameter. It was 18″ below the surface.

The skull lay with the top east. A large piece of shale lay directly beneath the pelvis. Between this grave and the next was an ash bed 7″ deep.

Burial 9. At 50′ in trench 1 touching the line on the east side, 20″ below the surface, the top of another ossuary was uncovered. Excavation disclosed a bone pile 48″ from north to south and 33″ from east to west.

Unlike burial 5, the first ossuary, this was a promiscuous heap of bones cast without order upon a group of 20 skulls arranged in an oval. Four inferior maxillae, 6 broken femora, 5 humeri, a number of ulnae, radii, vertebrae, an astragalus, tarsus, ribs and pelvis were found in the heap over the skulls.

Of the 20 skulls, 10 were male and 9 female. Parts of another skull were found, but the sex could not be determined.

Over the ossuary was a glacial boulder about 18″ by 18″ and a covering of shale and fossiliferous Chemung rock.

Four craniums from the ossuary were in good condition and four others in condition for measurements. All are interesting for the characters they exhibit.

Burial 10. At 50′ on the west side of trench 1 was an empty grave 24″ deep. Over it had been cast a quantity of broken stone.

From the north wall of the ossuary, running north for a foot was a top layer of burned stone. The earth here had not been disturbed.

Trench 1 was temporarily abandoned at 54′ and a parallel and adjacent trench run on the west side.

Burial 11. At 5′ in the middle of trench 2 burial 11 was discovered. The grave area was 4′ by 4′ and the depth 2 feet. The skeleton was that of a female. The skull was crushed. The arms were flexed to face, the left hand being under the left cheek.

Orientation: head, east; face, south; left side, flexed. Head thrown back.

Burial 12. Burial 12 was at 10′ in the middle west side of trench 2. It was an empty grave with disturbed earth to the depth of 48″

Burial 13. Grave 13 was on the east side of trench 2 at 31′. It was 28″ deep and contained the decayed root-eaten skeleton of an adult female.

Area of grave, 3′ by 4′.

Orientation: head, east; face, north; flexed.

There was a small ash pit at the head of the grave.

Burial 14. Found at 43′ in the middle of trench 2.

This grave was 28″ deep and 3′ by 3′ in area and contained a male skeleton in a poor state of preservation. The tibiae were noticeably platycnemic.

Trench 3 ran parallel with 2 on the west.

Burial 15. Grave 15 at 4′ on the west side of trench 3 was 19″ deep, 19″ wide and 30″ long. There were no bones except the broken skull and the neck vertebrae.

Orientation: head, east-southeast; face, south-southwest.

Burial 16. Burial 16 at 44′ on east side of trench 2 was 36″ deep and contained the pelvic bones and sacrum of a young adult. No other bones were in the grave. This fact seems to point to a removal of the skull and larger bones for reburial.

Burial 17. At 36′ in trench 3, 18′ south of ossuary 1, pit 5, the third ossuary was discovered.

Six skulls were arranged in the form of an ellipse and the other bones thrown in the opening. These bones besides arm and leg bones, included ribs, pelves, phalanges, astragali tibiae, and vertebrae. There were two female skulls.

Burial 18. This burial was in the middle of trench 3 at 19′ and 18′ south of the ossuary (17). On the bottom of the grave a few potsherds were discovered but no visible trace of bone.

The problem of the many empty graves in the burial knoll was at first a puzzling one. Some graves contained a few ribs, some a pelvis, one or two arm bones and teeth and others were entirely empty except for traces of bone dust.

As a hypothesis the theory was then advanced that the parts of skeletons, the larger limb bones and skulls had been removed from the graves and deposited in the ossuaries; that the graves had been left, open or filled, for use again. The ossuary burial is a Huron, or perhaps more properly a Huron-Iroquois custom, and has usually, perhaps entirely, been held a mere matter of superstition or ceremonial custom. The presence of empty graves and overflowing ossuaries suggested the theory of the *economic utility of the ossuaries.* The virgin earth being difficult to dig, but once disturbed never packing as hard as before, it would have been a matter of labor, time and space saving to exhume the remains of the dead and reinter them in an ossuary, and to use the empty graves again as burial places.

These theories are only tentative and not to be regarded as established until numbers of other places shall have shown the same characteristics. It is also of importance that more than one observer should have noted them.

Excavations within the inclosure. The ground within the earth wall has not been disturbed since its aboriginal occupation except in places where sugar boilers had been erected.

Over 120 basinlike depressions were scattered over the surface and varied in diameter from 3′ to 10′, and in depth, from 6″ to a foot. These pits were examined to discover their purport. Only six yielded anything in the way of relics. These consisted of flint chips, fire broken stones, pottery fragments and arrowheads. The earth was not disturbed in any case, except in that of the deep middle pit, for a depth of more than 30″, the underlying soil being hard and impenetrable by crude implements.

Middle pit. This pit was carefully excavated. The soil was disturbed for about 9″ below its modern surface except at the bottom where there was an ash pit 4′ in depth and 4′ in diameter. Mingled through the soil of the large pit was found a quantity of pottery, flint and jaspar chips, heat cracked stones and a number of triangular flint points. In the ash pit at the bottom, objects of the same character were found.

The presence of this large central excavation presents the problem of its purpose. To solve this question a number of hypothetical answers are adduced for consideration:

1st, it may have been a central refuse pit; 2d, it may have been a place of assembly, its gradual slope affording a seating place; 3d, it may have been an inner stockade; 4th, it may have been a reservoir into which water was conducted from the spring on the hillside to the east; 5th, it may have been excavated to obtain earth for filling in the northwest corner of the inclosure which is low and sloping toward a small gully which drains a spring marsh.

A careful examination of the ground showed that the northwest corner had been filled in, presumably with the soil excavated from the central pit. This examination also led to the several considerations. That the pit was not a reservoir is shown by the fact that ashes and refuse matter were found within it, though not in large quantities. That it was not a reservoir is also indicated by the fact that no ditch or outlet could be discovered. However, one may have existed and the pit been a reservoir previous to its use as a refuse dump, if such it was. The refuse matter in the pit did not occur in such quantities that it would be differentiated from "occupied soil" elsewhere, so that it may have been an inner stockade or place of assemblage.

Extent and character of occupation. There is evidence enough to point out that there was no long occupation of the site, the surface soil being but slightly disturbed to any depth. This evidence also suggests a settled occupation only in winter. The shallow pits seem to have been dug during the frozen season by alternately thawing and digging and in many instances also, to have been the sunken floors of lodges. If animal bones had been buried some would have remained as human bones did elsewhere in the site. This suggests that they were cast on the surface and afterward devoured by animals or lost by decay.

Purpose of the earth wall. The earth wall and trench are palpably parts of a fortification. From the crest of the wall, without doubt, rose a line of palisades which surrounded the inclosure. Indeed traces of these post holes were discovered all along on the ridge.

One of the strange facts which at once appears a curious anomaly is that if this inclosure had been a fortification why such a position should have been selected, when, from the hillock to the west, arrows and stones or other missiles could have been easily thrown into the wall-protected inclosure. This very thing would have rendered the fort of little use in times of war or invasion. Two considerations then appear: first, that it was not a true fortification designed to protect the inhabitants from men only, but made for a protection from the wolves and other wild beasts which infested the region even in historic times; or second, that the enemies of the age held the acres of the dead as sacred spots and would not under any provocation desecrate the burial ground on the hill to use it as a vantage point from which to assail the living within the inclosure which the burial knoll overlooked.

Camp site outside of inclosure. To the southwest of the burial knoll rises another glacial kame which in length runs east and west. This kame contained 10 large ash pits, the one on the summit being 5′ deep and filled with carbonaceous earth, burnt sandstone and charred corn. Between this kame and the inclosure, the earth had almost everywhere been disturbed and there was a heavy mixture of white ash and charcoal as if the vegetation and trees had been burned over many times. No implements were found here except a celt at the west end of the kame.

The soft mellow loam here also suggests its employment as a garden spot, possibly a cornfield. Charred corn was found in some of the pits.

Age of the remains. Several considerations determine the age of the remains. The absence of European articles at this place is a good indication that it is prehistoric. The difference between the characters of the occupation and those of the early historic Eries points out a pre-Erian or early Erian people. That they were early Iroquoian is evident from an examination of the artifacts but that they were early Erian is manifest by certain differences in form of culture and occupation. The remains would seem to be at least 500 years old and even a greater age may be ascribed.

No detailed description of the osteological remains of the aboriginal inhabitants of New York has even been attempted. It is the plan of the archeological section, therefore, to begin a systematic study of all the human remains which can be obtained within the limits of the State and finally issue a more or less complete report upon the subject. There is indeed a great need for such a guide, for the scientific value of such data has been almost entirely overlooked. A detailed study of the osteological remains found at the locality described (Gerry) is being made in the laboratory, all the approved osteometric measurements and indexes being taken. Although this work is but partially completed at this writing, it is possible to give some of the figures and a few descriptions of the various morphological characters which the bones exhibit.

Crania. The crania, for convenience in study, have been ranged in three classes as follows: brachycephalic, with indexes above 80; mesaticephalic, with indexes between 75 and 80; and dolichocephalic, with indexes below 75.

It is not possible in a preliminary report of this kind to describe at length each skull or give the various minor measurements. Type skulls of each group will, therefore, be taken.

Specimen 4503, a male taken from burial 5. This skull is the best preserved of any found and is the heaviest, weighing 24 ounces. It is that of a person of mature years, between 50 and 60. The teeth which remain are well preserved, but there are cavities in the superior right canine and in the adjoining premolar. On the right side in the upper jaw the molars are entirely lacking and the matrices filled. The third molar on the left seems to have been lost a short time before death. The first premolar on the left is abnormal in that it grows out at an angle. This has resulted in it being worn obliquely and protruding over the premolar beneath. On the opposite side the premolar is normal in form, but between it and the canine there is a supernumerary tooth. The denture of the lower jaw is normal and there are no cavities in the teeth which remain. On the left side all the premolars are gone and the matrices healed and closed. On the right side one molar and the other teeth remain.

The inferior maxillary is well preserved. It is remarkable for the squareness of the chin, the mental tubercules on either side being pronounced. They flare out from the body of the maxillary and give the chin a width of 57 millimeters.

The sigmoid notch is crescentic and not parabolic. In breadth, measuring from the crests of the coronoid processes, the jaw is 107 millimeters, and a line drawn from a point midway between the angles to the point of the chin gives a length of 70 millimeters.

The palate is worthy of note because of its several peculiarities. The transverse suture has entirely united and several spinous processes have formed on each side of the sagittal suture. The posterior palatine canal on the right is larger than that of the left due to the absorption or the retarded growth of the septum. These

Two views of skull 4503, from grave 6, McCullough site. Breadth index, 71.6

canals are not normal in form. The external base of the skull presents several other interesting features, one of which is the form of the *foramen magnum.*

An examination of the upper portion of the skull shows that the sutures have begun to amalgamate. This is especially noticeable in the coronal suture where it disappears after touching the temporal ridge. On the left side, however, there is an excrescence formed by two spinous processes that arise a millimeter above the plane of the alesphenoid. These excrescences are thin and calcareous and appear to be the result of an injury.

The supraciliary ridges are heavy and their surface covered with fine convolutions. The frontal bone slopes back and the forehead is low. The occipital region is full but asymmetric, the left side being larger. The nasal bone curves sharply out from the face lifting *rhinion* above the plane of *dacryon.* This suggests a wide and prominent probocis which must have appeared in life formidable as accentuated by the beetling brows. The whole appearance of the skull with its many ridges indicates an extraordinary musculature. A list of the principal rectilinear measurements follows:

Maximum length, 187 mm
Maximum width, 134 mm
Basal hight, measured from basion to bregma, 141 mm
Auricular hight, 120 mm
Horizontal circumference, 525 mm
Auriculo-nasal length, 95 mm
Auriculo-prosthionic length, 100 mm
Basi-nasal length, 108 mm
Basi-prosthionic length, 98 mm
Nasi-prosthionic length, 76 mm
Bi-zygomatic breadth, 137 mm
Bi-stephanic, 118 mm
Orbital hight, 38 mm
Orbital width, 45 mm
Nasal hight, 55 mm
Nasal width, 26 mm

INDEXES

Part	Measurement	Decimal indexes	Classification
Breadth	134/187	71.6	Dolichocephalic
Hight	141/187	75.4	Metriocephalic
Alveolar	98/108	90.79	Orthognathous
Nasal	26/55	47.3	Leptorrhine

Part	Measurement	Decimal indexes	Classification
Facial	76 / 137	48.1	Chamaeprosope
Stephano-zygomatic	118 / 137	86.1	Phenozygous
Orbital	38 / 45	84.4	Mesosmic

Capacity 1649.2 ccm

Specimen 4550; an adult mature male. The facial portion is missing and was probably lost during the process of ossuary burial. The sutures are distinct but the coronal is in an advanced stage of synostosis. On either side this suture is not visible below the temporal ridge except for a centimeter on the right side. The left orbit has a wide supraorbital notch which the right does not present. The supraorbital ridges are similar to those on the other male skulls and the glabella full. The frontal dome slopes back and there are no eminences. On the right side of the temporal, the squamous suture has united posteriorly with the parietal for a distance of 25 millimeters. On either side the alesphenoid has united with the parietal. On the right the temporal ridge is not well developed although on the left it is plainly visible. There is a Wormian bone at the point of union between the parietals and the occipital bone, and two a centimeter above the point where the superior temporal line touches the lambdoid suture.

Below are enumerated the principal measurements possible in this specimen.

	Millimeters
Maximum length	185
Maximum breadth	140
Basion bregma	140
Circumference	510
Basion-nasion	109
Bi-stephanic	113
Auricular hight	125

The only indexes possible follow:

Part	Data	Index	Classification
Breadth	140 / 185	75.5	Dolichocephalic
Hight	140 / 185	75.5	Metriocephalic

Capacity 1531.7 ccm

Plate 42

Two views of skull 4548 from ossuary. Index, 77.7

Specimen 4548; a mesaticephalic female skull found in ossuary 9. It is in a fair state of preservation although it is very fragile. It is that of a female of perhaps mature years. The teeth are entirely lacking, those on the upper jaw having undoubtedly been lost during the process of reinterment. In the lower jaw the canines and incisors were the only ones remaining at the time of death. The matrices of the other teeth have closed. Upon the cranium, the sutures though distinct have lost their intricacies, but none of the bones have affected synostosis.

The measurements in millimeters of this specimen follow:

DIMENSIONS

	Millimeters		Millimeters
Maximum length	175	Basi-prosthionic length	170
Breadth	136	Bi-zygomatic breadth	136
Basal hight	132	Bi-stephanic breadth	111
Circumference	502	Orbital hight	37
Auricular hight	120	Orbital width	41
Auriculo-nasal length	89	Nasal hight	50
Auriculo-prosthionic length	98	Nasal width	25
Basi-nasal length	106		

These measurements give the following indexes of proportions:

Part	Data	Index	Classification
Breadth	136/175	77.7	Mesaticephalic
Hight	132/175	77.4	Metriocephalic
Aveolar	95/102	93.1	Orthognathous
Nasal	25/50	50	Mesorrhine
Facial	71/136	52.9	Leptrosope
Stephano-zygomatic	113/136	83	Phenozygous
Orbital	37/41	90.2	Megasemic

Capacity 1437 ccm

Specimen 4554; female skull, brachycephalic in form. Almost the entire top has been destroyed by the pressure of the superincumbent earth, but not enough to prevent most of the measurements. Only three teeth remain, the others having been lost in process of reburial. The palate is wide, having a length of 50 millimeters and a width of 42, which gives an index of 84.

The orbits of this skull differ from most of the others. They more nearly approach a circular form and have no angles at the turns.

	Millimeters		Millimeters
Length	163	Orbital high	38
Breadth	133	Orbital width	42
Nasion to prosthion	72	Bi-zygomatic breadth	133
Nasal length	48	Basion to prosthion	98
Nasal width	26	Basion to nasion	102

These measurements give the following indexes:

Part	Data	Index	Classification
Breadth	133/163	81.6	Brachycephalic
Aveolar	98/102	96	Orthognathous
Nasal	26/48	58.3	Platyrrhine
Orbital	38/42	95	Megasemic

Capacity indeterminate

Femora. There are a number of morphological variations in the collection of femora which command attention at once. The more striking anomalies only will be mentioned here. They are those termed the third or supernumerary trochanter and platymeria. Each of these characters is found in a large percentage of the femora, the supernumerary trochanter in about 40 per cent and platymeria in 60 per cent. For the several variations which these femora present a brief description of several is here appended.

Specimen 4522; right femur, probably male, weighs 9½ ounces. It is heavily built and has a heavy gluteal ridge for a distance of 6 centimeters below the lesser trochanter. The superior extremity is normal (Indian) though the digital fossa is deep.

Plate 43

Two views of skull 4551. Index, 76.6

Plate 44

Two views of skull 4552. Index, 74.1

There is a tuberosity of slight elevation resembling a third trochanter and below it and extending within 35 millimeters in a diametrical plane of the superior arterial foramen is the hypotrochanteric fossa. Its depth is accentuated by a flangelike projection of the shaft. The femur is not especially platymeric, index 74.3.

The lower portion of the femur is apparently normal although the external tuberosity is large, but this seems a characteristic of many of the femora.

Specimen 4505; a typical shaft. It is 428 millimeters in length and weighs 10½ ounces. In color it is a straw yellow and like all the other bones bears no sign of fossilization. The neck is long and the ball bears a deep lozenge-shaped fossa of the interarticular ligament. The *linea aspera* is heavy and above the arterial foramen becomes the gluteal ridge, the width of which is accentuated by the flangelike projection on the anterior border of the shaft. Above this ridge is the third or supernumerary trochanter. The sagittal diameter of the shaft is 24 millimeters and the transverse 34, which gives the platymeric index 70.6.

Specimen 4516; a short heavy femur with a length of 435 millimeters and a weight of 11 ounces. The upper portion is heavy and abnormal in several characters. The neck is short and the great trochanter heavy. These characters give the upper portion of the femur a wide, heavy appearance and the upper part of the head or ball rises scarcely a centimeter above the top of the great trochanter. The portion of the ball surrounding the fossa of the interarticular ligament is flattened and the fossa is small. On the internal side of the ball at its juncture with the neck there is a depression 12 millimeters in length and a millimeter wide. The digital fossa is deep, wide and filled with small tubercles. The cavity reaches down along the intertrochanteric ridge to the lesser trochanter. The shaft is not platymeric.

Specimen 4513; a large shaft, probably male, with a length of 470 millimeters and a weight of 11 ounces. It is noticeably platymeric and has an index of 63.1. Part of the great trochanter is broken and with it the upper part of the external border of the shaft. An elevation in the bone just where it is broken seems to indicate that a third trochanter had been broken off.

Tibiae. One of the peculiarities of the tibiae which is at once apparent to the most superficial observer is the transverse flattening of the tibial shaft which gives it a saberlike appearance. This anomaly is present in 75 per cent of the tibiae from Gerry and therefore must be regarded as a character normal to the race. The platycnemic tibiae are all those of adults, those of adolescents being less pronounced. The indexes taken from specimens range as follows:

Number	Length	Diameters	Index
4540	broken	20 –39	51.3
4700	broken	19 –34	55.8
4546	broken	23 –39	56.4
4536 B	390	21.5–38	56.6
4536 A	381	21.5–38	56.6
4538	402	23 –38	60.5
4541	376	22 –36	61.1
4542	355	22 –36	61.1
4544	367	22 –35	62.09
4543	398	25 –38	68.4
4547	336	24 –33	72.7
4545	365	24 –33	72.7

Humeri. An examination of the humeri from the Gerry site revealed a percentage of 40 with the perforated olecranon cavity. In the Edson-Reed donation from the Dennison site are 19 humeri, 12 perforated and 7 nonperforated. This gives a percentage of 58.3 perforated. The tibiae from the site are greatly flattened, some giving an index of 18mm–35mm = 51.7. That the perforations are natural and not due to a decay of the septum is patent from a microscopical examination of the edges of the perforations where the external osseous surface appears unbroken. In some of the nonperforated specimens the osseous septum is of tissue thinness and is translucent when held to the light. Where one of these has become broken the fracture line is radically different from the border of natural perforation. Some superficial investigators have endeavored to explain these perforations by the disappearance of the septum by decay, but even a hasty examination fails to justify this assumption.

Artifacts. Pottery. The specimens of pottery secured in the Cassadaga valley consist entirely of fragments. Several crushed pots, however, may be restored. In thickness this pottery is less than that from the shore of Lake Erie. It is mostly tempered with pulverized shell and is comparatively light in weight. The incised designs are few and simple in character and are of the early Iroquoian style. Nearly all the specimens were found in ash pits, although a few fragments were found in a grave filling.

Plate 45

Platymeric femora. The third trochanter is especially noticeable in the hird and fourth specimens.

Plate 46

Platycnemic tibiae from the McCullough site. The fourth tibia has an index of 54.

Plate 47

Perforated humeri from the McCullough site, Gerry, N. Y.

Plate 48

Humeri from the Dennison site. All but the last two have the olecranon fossa perforated.

Stone objects. Articles of stone were not numerous and at the Gerry site only three celts were found and these outside the inclosure on the higher ground.

No hammer stones or anvils were found but arrow chippings and triangular flint points were fairly numerous.

Bone objects. No bone implement or object of any description was found in the village site and the only bone object found whatever was the heron bill near the forehead of the male skeleton in grave 6.

Sites examined

A list of the earthworks and village sites examined in Chautauqua and Cattaraugus counties follows. From two to five days or more were spent in the examination of each in order to determine their character and the culture represented.

1 An earthwork situated on a bluff at the confluence of a small brook with Mill creek is described by the old inhabitants as a circular work with a deep depression in the center. This is situated on the Margaret Harris farm. No part of the earth wall remains although the excavation in the center is yet visible. It however seems natural rather than artificial. Few traces of occupation could be discovered although several days were spent in testing and excavating. Some flints and fire-cracked stones were strewn on the bank above Mill creek, but there were no pits or pottery.

This work is mentioned in State Museum bulletin 32, *Aboriginal Occupation of New York,* as no. 24 in Chautauqua county.

2 There was an extensive earthwork and village site in the heart of the village of Sinclairville. Cheney's plan and description are erroneous. The site was examined and a map made from an actual survey by Hon. Obed Edson of Sinclairville. This earthwork belongs to the prehistoric Huron-Iroquois, and triangular points and pottery are found each year as the lawns are graded and gardens tilled.

3 **The Edmunds site.** An interesting camp site, discovered on Pine hill is situated on the Edmund's farm in the town of Charlotte. 27 pits were opened here and a quantity of pottery found. Two crushed pots were found in pits on the nose of a sandy projection that ran out from Pine hill into the valley of Edmund's brook. One large pit had a stoned floor and was walled with slabs of shale. This was evidently a cache or storage cellar. The Edmund's site is about one mile from Cassadaga creek and is situated between the Dunkirk, Allegany Valley & Pittsburgh track

and the Dunkirk road. At the foot of the hill just above the little flat washed out by the brook a large ash bed was discovered. This ash bed is 27′ by 47′ in dimensions and 36″ deep. It was filled with carbonized material and disintegrated sandstone and drift boulders. Several of these large ash beds were examined in the locality but nothing which would give a clue as to their purpose could be discovered.

4 The Dennison site in the township of Gerry lies about a quarter of a mile from the Charlotte township line. It is crossed by the old Chautauqua road, but now may only be traced by careful examination. This work was explored and partially excavated in 1887 by Hon. Obed Edson of Sinclairville who donated to the museum some of the human remains which he had taken from a large ossuary here. The site is of the early Iroquoian type and no occupied soil could be discovered.

5 A site on which a group of 12 pits are still visible is situated on the Sears farm near the site previously described. Nothing could be discovered in the pits although all were excavated.

6 The McCullough site on Gerry hill has already been described at length.

7 A glacial kame near Cassadra lake has a row of pits across the top. These were opened, but nothing except a few kernels of charred corn, a few flint chips and fire-broken stones remains to tell of their Indian origin.

8, 9, 10 Three places near Cassadaga lake were examined. All were old sites of early Iroquois culture.

11 At the head of Cassadaga lake upon the dividing ridge of the watershed a small camp site was discovered.

12 An interesting ash bed situated on the H. Carlson farm in lot 46, Gerry, was examined. This bed is upon a little promontory that juts out into the valley of a small stream sometimes called Phelps pasture brook and is easily discovered by the low mound of black earth which rises a foot or two above the surrounding surface.

The bed is 40′ by 45′ in dimensions and 4′ deep. It is composed of a light sandy soil intermixed and colored black by large quantities of pulverized carbonaceous material. Large numbers of sandstone blocks and granite boulders cracked and crumbling are distributed through the mass. A large white pine stump 4½ feet in diameter crowns the bed so that the work is plainly not that of white people. Numbers of these ash heaps are found throughout the county and form a problem yet to be solved.

13 One of the largest earthworks in Chautauqua county was situated on the old Partridge-Harris farm in the village of Gerry. The wall of this work has been plowed down but originally inclosed an area of about six acres. Excavations here revealed deep disturbances, but none of the pits contained bone objects nor pottery in any quantity. Hammerstones, celts, potsherds, arrowheads and a pipe stem were found in the occupied layer.

14 Some most interesting sites are to be found in the valley of Clear creek in the township of Ellington. The "Old Fort" in Ellington village is one of the most notable in Chautauqua county. Several days were spent here examining the inclosure for pits and burials. Several large ash pits were opened and a quantity of pottery and a dozen arrow points, triangular type, were found. The culture is early Iroquoian and prehistoric.

The earthwork is oval in form with a gate at the eastern end. It is situated upon a steep hill which runs out into the valley and as a strategic position is almost ideal. An examination of the map herewith presented demonstrates this fact.

15 The Boyd site is situated near the line of lots 47 and 39 in Ellington and is found upon a level plateau which forms the edge of a stream-cut terrace just above the valley of Clear creek. This fort was described by T. A. Cheney in the 5th Annual Report of the State Museum, but his survey does not appear entirely accurate.

No deep pits were found here and the occupied layer was thin. Culture: Early Iroquoian, prehistoric.

16 Opposite this site upon the terrace on the opposite side of the valley, 1700 feet distant, is another earthwork. This work, however, is a circular one. Excavation revealed that it was of the early Iroquoian culture with triangular arrow points and early pottery. No long occupation.

17 A circular fort in the town of Clear Creek had a large central pit but was not available for excavation.

18 Between the "Old Fort" and Ellington and the Clear Creek fort is a glacial kame which contains what appear to be old burials. Here notched and shouldered points and a gorget were found.

19 Several small camp sites were visited and examined in Conewango in Cattaraugus county.

20 A site on the Marshall farm in Sherman.

21 A mound at Findley lake on the Hill farm.

22 Large pits in numbers at the head of Findley lake.

23 Pits in Kennedy near the Randolph town line.

24 A large mound on the Cheney farm in Poland.

25 Two mound sites at Falconer.

26 An old burial site in Victoria on Chautauqua lake.

27 Two mounds at Vandalia, at the confluence of Chipmunk creek and the Allegany river.

28 The sites of the mounds at the mouth of Olean creek.

29 Mound on the Sunfish property in Great Valley.

30 Earthwork site at Point Peter on Cattaraugus creek.

31 Village site in Elko.

32 Burial site at Old Town in Elko.

33 Village site at Onoville on the Allegany.

34 Village site on the banks of Clear creek in Erie county.

35 Earthwork on Zoar hill in Otto.

36 Earthwork on the McNeil farm in Westfield.

37 Village and burial site on Chautauqua creek, Westfield.

38 Two fort sites on the Almey farm in Gerry.

39 Earth ring site and occupied kame 40 rods distant from 38.

40 Site at High Banks near Irving.

41 Silverheel's site on the Cattaraugus reservation. Probably early Seneca.

Excavations conducted here by the owner of the property yielded some interesting specimens of entire pottery and bone objects. These objects will be acquired for the State Museum.

The results of the examination of the foregoing sites are reserved for fuller description. Two important facts may here be stated with propriety.

1st, That the Senecas occupied western New York west of the Genesee, having fixed villages long before the Revolutionary War. The date of these sites may be fixed shortly after 1656. This fact is supported alone by the testimony of archeology and the evidence is too overwhelming to be disputed.

2d, That the Senecas in western New York, west of the Genesee, made pottery and flints at the same time when they used European articles extensively. Iron, glass, broken china ware, flint chips, broken pottery and bone implements have all been found in the same pits.

Notable accessions

Wampums. A wampum belt 22 inches long and 8 rows wide was purchased from W. C. Hill of New York city. The design consists of six diagonal bars of white beads, three bars on each side of a central cross, the arms of which radiate from a central square composed of eight white beads. The beads are strung on a vegetable twine, probably hemp.

The belt is said to have come from Oldtown, Maine, where it had been held by the Penobscot Indians. It is said to be of Iroquois manufacture and to be a "condolence belt." It is a command and summons to a condolence council at Onondaga, represented by the central cross.

A wristband of modern stringing is another wampum piece of interest. It is said to have been an old Mohawk wristband which has been restrung to preserve the design, the original warp having decayed and become broken.

The Archeologist secured on the reservations several ceremonial wampum strings of considerable interest. One is a string of purple beads hung from a streamer of black ribbon in five strands of thirty-two beads each. At the end of each string is a small piece of deer-skin. This wampum is said to have been a Seneca condolence string, that is a string used in the ceremony of a mourning council. Another string of purple wampum divided in two strands is represented as the "death horns." It was held by a sachem until his death when it was passed to his successor in office as a symbol of name and office.

A string of mixed purple and white beads arranged in two strands is a "name." One strand consists of beads arranged as follows: 2 purple, 1 white, 2 purple, 1 white, 2 purple, 2 white, 4 blocks the same, then 5 purple, 2 white, ending with 1 purple bead held on the string by a small knot of yellow ribbon. The other strand consists of bars of 4 purple beads with a white bead interposed between. A faded purple ribbon holds the beads on the linen string.

A "runner's" or messenger's summons composed of 50 purple beads strung on gut and tied to a notched stick is a condolence council call. There are four notches on the stick which mean that four days' time is given in which to appear at the council.

A Canadian string of mixed disk wampum and colored beads forms an interesting mate of the disk string secured in 1898 by Mrs H. M. Converse. The string is strung on heavy cotton thread and there are knots of colored ribbon tied at intervals. Mr M. R. Harrington who secured this piece says that it is the last Tutelo name string and obtained with great difficulty. The Tutelos are an adopted captive tribe originally of Siouxan culture.

Silver ornaments. The Archeologist secured nearly a hundred silver brooches of various sizes from the Allegany Senecas. These brooches are of various sizes and forms and furnish a valuable addition to the State collection.

A collection of 19 large silver disks ranging from 6 inches in diameter down to 2 inches was included in the Hill collection. These disks are represented as Algonquin ornaments secured at Oldtown, Maine. In this collection were two silver crowns one of which is the largest in the State collection.

Some rare brooches were included in the M. R. Harrington collection. In this collection also was a pair of earrings very similar to those figured by Morgan in the early Museum reports.

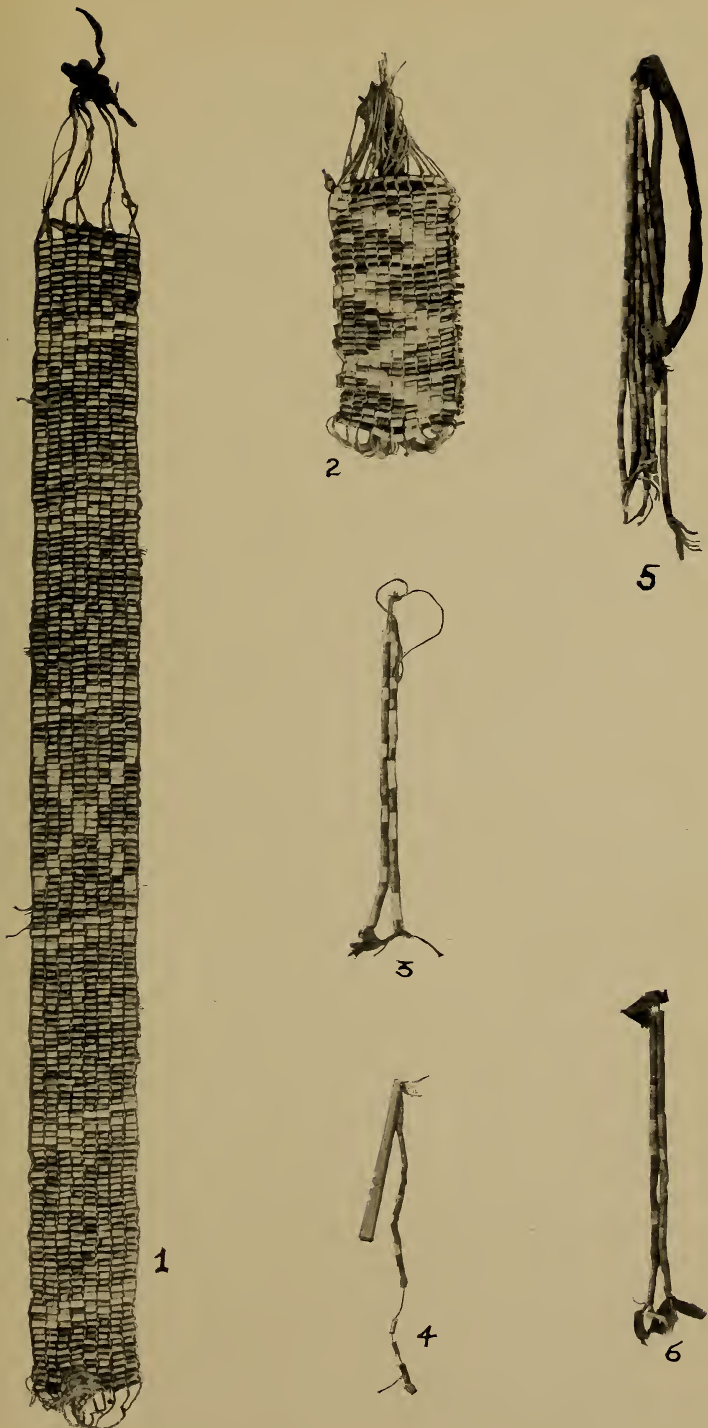
Several pairs of silver earrings of interesting form were purchased from the Indians by the Archeologist. Some of the specimens have glass gems in settings.

Possibly the most valuable ethnological acquisition was a set of Indian silversmith's tools, purchased from a brother of the last Allegany brooch maker, George Silversmith. The outfit consists of small iron and steel chisels, made by the silversmith himself. A massive blowpipe of brass, store hammers and files were included. The silver used for brooch making was obtained by beating Canadian silver coins to the desired thinness when the pattern was traced on and cut out with the chisels. A set of earring and ring punches form an important part of the outfit.

Several Indian made finger rings were also acquired and are the only specimens in the State collection.

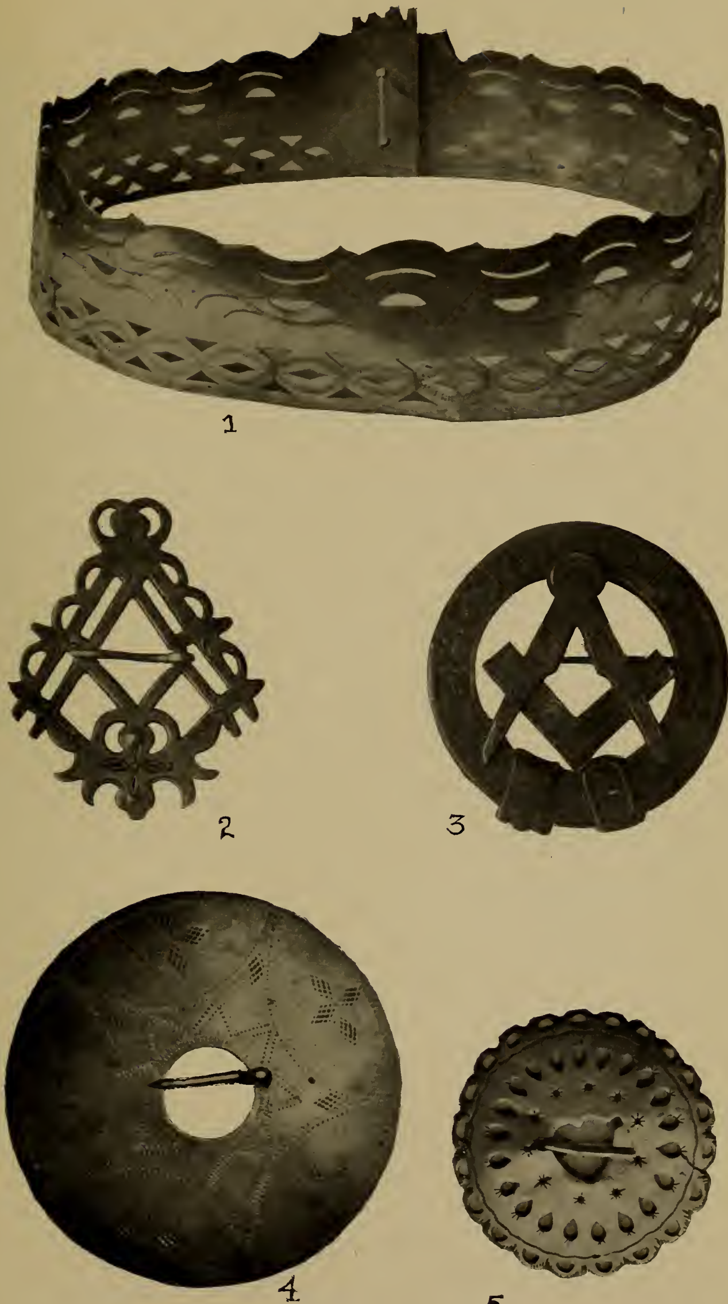
Masonic emblem. One of the most interesting specimens of the white man's art found on an Indian site is a large Masonic emblem of copper found by Luke I. Fitch on an old Onondaga site near Pompey, Onondaga co. The square and compasses in the emblem are surrounded by a belt embossed with the roses of York and the Scottish thistles. Several Iroquois Indians late in the 18th century and early in the 19th were Free Masons, notably Brant and Red Jacket. Whether the emblem was worn by some Indian or by a white man is not known, but the probabilities are that it was lost by some colonial soldier or agent sent among the Onondagas.

Several Masonic brooches of Indian make are in the museum collection of Iroquois silver work.



Wampum articles acquired during 1907
1 Council belt. 2 Wrist band. 3 Name string. 4 Messenger's summons. 5 Condolence wampum. 6 Chief's horns

Plate 50



Metallic ornaments acquired during 1907
1 Silver head band. 2 Silver brooch. Pattern conventionalized from Masonic emblem. 3 Masonic emblem in copper from village site near Pompey. 4 Algonquin disk brooch in silver. 5 Seneca brooch in silver.

VII

A STATE HISTORICAL MUSEUM

Section 22 of the University Law as amended to 1904 reads in part as follows:

State Museum: how constituted. 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 of New York has made provision for the acquisition and preservation of historical records but these only in the form of documents, written or printed, of which the State Library has now become a vast treasure-house. The Bureau of Military Statistics pertaining to the department of the Adjutant General has brought together by voluntary cooperation an extensive store of military relics, in very large part memorials of the Civil War; the State Historian is authorized by law to "collect, collate, compile, edit and prepare for publication all official records, memoranda and data relative to the Colonial Wars, War of the Revolution, War of Eighteen Hundred and Twelve, Mexican War and War of the Rebellion, together with all official records, memoranda and statistics affecting the relations between this commonwealth and foreign powers, between this State and other States and between this State and the United States." He is not empowered to acquire other historical materials than the data above referred to, nor has he authority of law or appropriations to acquire historical "objects" as distinguished from records, memoranda and documents. There is thus no department of the State which has adequate authority, breadth of scope and available funds for acquiring and conserving "objects" of historical importance, in distinction from historical "documents," except the Education Department through the agency of the State Museum.

Importance of a State historical museum

Throughout the history of the commonwealth no systematic effort has ever been made on the part of the State to conserve the relics of its history. In the early career of the State Museum a good many objects pertaining to the early culture of the community came into its possession, but in the development of the museum, materials regarded as of more purely scientific character were considered as the proper field of the institution and its activities in acquisition were restricted to that scope. The sphere of its functions is now broadened by the University law above cited.

The State has shown an appreciative spirit and most laudable activity in the acquisition or protection of places with historic associations. With or without volunteer private cooperation, it has taken over historic property, marked with commemorative monuments sites of momentous and critical events in its history, raised imposing memorials on its battlefields and statutes to some of its distinguished sons. The spirit which has inspired these results has been born and nursed into expression by a multitude of patriotic societies, some of general, others of more local scope. But further than this in the conservation of its historical materials the State has not gone. It has left wholly to local civic associations the conservation of the relics of its history. There is scarcely an intelligent community in the State which has not an historical society engaged not merely in retelling the often half remembered story of local events but conserving the materials associated with the early stages of its progress and the personal careers of its distinguished citizens.

It would be impossible to estimate the value of the collections of these societies to the student of New York history and the edification, satisfaction and pride with which these are contemplated by the citizens of this State. But these results have been achieved alone by private organizations moved by the same proper spirit which may justly require of the State that it conserve the monuments of its own cultures.

If there is ever to be a State Historical Museum certainly it is time to inaugurate it and if the effort is made it should be made persistently, with a clearly defined purpose in view. Time is passing. New York has behind it 300 years of successive cultures and back of that the cultures of the aborigines. It is no longer easy to acquire the relics of these cultures. In another generation they will all have passed into the possession of public or private museums.

It is with the relics of the different settlements rather than with its critical events that an historical museum should concern itself. Such collections of historical objects should depict in the truest and most realistic fashion the modes and means of living in each successive phase of culture, should reproduce by proper association a faithful picture of domestic life and habitudes. The educational value of such demonstrative collections would be of high quality and an essential supplement to the training of the schools.

New York need not, because of its relative youth, invite the difficulties which have confronted other countries with longer histories, in the formation of historical museums. The making of such collections has always been too long deferred. But New York may well follow the example and hope for the results which other nations have achieved in this direction, for in all the countries of Europe are no collections of whatever character of so general interest and instructiveness to the public as the Historical Museums such as those of Amsterdam, Hamburg, Berlin, Nuremberg, Zürich and Basel.

Plan for a State historical museum

There is a vast difference between a miscellaneous assortment of historical objects, each out of its proper association with only its individual story to tell or its personal associations to invite attention, and an historical museum scientifically arranged with its objects all brought into their proper historic perspective. There are thousands of valuable historic relics in local collections of the State, which must by the very nature of the conditions under which they are brought together be left to tell their story as best they can by themselves. There is but one method however in which such objects can be made adequately to present their full signficance and that is the method of proper association. As an outline of what a State historical collection might be the following suggestions are made.

In general, a portrayal of the successive or contemporaneous cultures in this State by a reproduction of the mode of life and dress in the various phases of our civilization. For such purposes a series of rooms assigned to the various cultures would display

1 The domestic life of the aborigines: an Indian lodge appropriately equipped with the daily utensils of the aborigines, the squaw at the hand-mill; the potter molding clay vessels and pipes, the brooch maker and the arrow maker with their equipments. It would be vastly to the credit of a State like New York, the home of the Iroquois Confederacy, the earliest and mightiest of all aboriginal leagues, the seat of momentous events in Indian and frontier history, the founder and supporter of the State Museum which is the possessor of priceless and unexampled collections of Iroquois culture relics and the official custodian of the archives of the Six Nations, to go still further into the realistic portrayal of Indian life

and customs by the reproduction of certain important ceremonials and councils of which there remain today but stories on printed pages. New York could afford to keep this romantic period of its history before the eye and transmit it in reasonable fulness and force to posterity.

2 The domestic life of the Dutch culture, represented by one or two rooms, say a living room and kitchen equipped with the utensils and materials appropriate to the period of the Dutch settlement.

3 Some portrayal of the German culture of the upper Hudson, Schoharie and Mohawk valleys — a culture which though transient left a recognizable impress on the community. Also of the Huguenot settlements in Ulster county and the lower Hudson valley.

4 Rooms equipped with the furnishings of the English colonial revolutionary period before the invasion of the French influence.

5 An adequate representation of life on the frontier of Central Western New York before the extinction of the Indian land titles and the Massachusetts claims.

Such a carefully coordinated collection would naturally be supplemented by other materials which could not be placed in such associations but would help to complete the portrayal of past cultures.

In the geological department of the State Museum an earnest effort is being made to bring together materials which will demonstrate the historical development and present working of such industries as depend upon the natural mineral resources of the State. In this undertaking a willing and appreciative cooperation with the producers of the State has been elicited. With the very best reason the State Museum may hope for an equally zealous cooperation of the citizens in the formation of an historical collection.

There are still to be had from the descendants of the older families of this State many historical relics; few are treasured, more are not. Some are merely harbored for their associations, many are lying in garrets and barns. An appeal to the patriotic instinct coupled with an assurance that such relics if placed in the State's custody will not only never be deprived of their personal associations, but be placed in their proper surroundings, should not fail to be effective.

It is submitted that such an historical collection as is here outlined for New York should exist and that the acquisition of such materials by the State should not be delayed. There is no historical collection in America arranged on such a basis as here suggested.

VIII

PUBLICATIONS

A list of the scientific publications issued during the year 1906–7 with those now in press and treatises ready for printing is attached hereto. The publications issued are 14 in number on a variety of topics covering the whole range of our scientific activity. They embrace 2472 pages of text, 213 plates and 38 maps (3 colored).

The labor of preparing this matter, verifying, editing and correcting is onerous and exacting. Taken altogether it excellently indicates the activity and diligence of the staff of this division.

Annual report

1 Third Report of the Director, State Geologist and Paleontologist for the fiscal year ending September 30, 1906. 186p.

Contents:

Memoirs

2 No. 8 Insects Affecting Park and Woodland Trees. By E. P. Felt. v.2, 548p. 22pl.

Contents:

3 No. 10 The Devonic Fishes of the New York Formations. By C. R. Eastman. 236p. 15pl.

Contents:
- Introduction
- Conspectus of species, arranged according to their geological occurrence
- Tabular key to systematic descriptions
- Systematic account of Devonic fishes, principally from New York and Pennsylvania
- Summary and conclusions
- Zoological conclusions
- Geological conclusions with remarks on the distribution of Devonic fishes
- Explanation of plates
- Index

Bulletins

Geology

4 No. 106 Glacial Waters in the Lake Erie Basin. By H. L. Fairchild. 88p. 14pl. 9 maps.

Contents:
- Introduction
- Literature
- Area. Maps
- Geography. Topography
- Outline of glacial history
- Ice margins; moraines
- Glacial drainage channels
- Local glacial lakes
- Greater glacial lakes
- Shore lines of the greater lakes
- Deltas and lake plains
- Index

5 No. 107 Geological Papers. 388p. 56pl. 1 map.

Contents:
- Postglacial Faults of Eastern New York. J. B. WOODWORTH
- Stratigraphic Relations of the Oneida Conglomerate. C. A. HARTNAGEL
- Upper Siluric and Lower Devonic Formations of the Skunnemunk Mountain Region. C. A. HARTNAGEL
- Minerals from Lyon Mountain, Clinton County. HERBERT P. WHITLOCK
- On Some Pelmatozoa from the Chazy Limestone of New York. GEORGE H. HUDSON
- Some New Devonic Fossils. JOHN M. CLARKE
- An Interesting Style of Sandfilled Vein. JOHN M. CLARKF
- The Eurypterus Shales of the Shawangunk Mountains in Eastern New York. JOHN M. CLARKE
- A Remarkable Fossil Tree Trunk from the Middle Devonic of New York. DAVID WHITE
- Structural and Stratigraphic Features of the Basal Gneisses of the Highlands. CHARLES P. BERKEY
- Index

6 No. 111 Drumlins of Central Western New York. By H. L. Fairchild. 58p. 28pl. 19 maps.

Contents:
- Introduction: general description
- Areal distribution
- Orientation
- Relation to larger topography
- Relation to underlying rock strata
- Form and dimensions
  - Dimensions
- Composition and structure
  - Rocdrumlins
  - Concentric bedding

Contents:

7 No. 115 Geology of the Long Lake Quadrangle. By H. P. Cushing. 88p. 20pl. 1 map.

Contents:

8 No. 112 Mining and Quarry Industry of New York. 3d report. By D. H. Newland. 82p.

Contents:

Paleontology

9 No. 114 Geologic map of the Rochester and Ontario Beach Quadrangles. By C. A. Hartnagel. 38p. 1 map.

Contents:

Entomology

10 No. 109 White Marked Tussock Moth and Elm Leaf Beetle. By E. P. Felt. 34p. 8pl.

Contents:

11 No. 110 Report of the State Entomologist for the fiscal year ending September 30, 1906. 152p. 3pl.

Contents:

Botany

12 No. 116 Report of the State Botanist for the fiscal year ending September 30, 1906. 108p. 12pl.

Contents:

Archeology

13 No. 108 Aboriginal Place Names of New York. By W. M. Beauchamp. 336p.

Contents:

14 No. 113 Civil, Religious and Mourning Councils and Ceremonies of Adoption. By W. M. Beauchamp. 118p. 7pl.

Contents:

Geological maps

15 Rochester and Ontario Beach quadrangles

16 Long Lake quadrangle

IN PRESS

Memoirs

17 Early Devonic of Eastern North America
18 Graptolites of New York. Pt 2, Graptolites of the Higher Beds

Bulletins

Geology and paleontology

19 Later Glacial Waters in Central New York
20 Geology of the Geneva-Ovid quadrangles

Archeology

21 An Erie Indian Village and Burial Site

PREPARED

Maps of the following quadrangles showing rock geology

Cazenovia	Honeoye-Wayland	Phelps
Auburn	Theresa	Remsen
Morrisville		

IN PREPARATION

Maps of the following quadrangles showing rock geology

Caledonia	Moravia	Chittenango
Alexandria	Highlands	Genoa

Maps of the following quadrangles showing rock geology
Amsterdam-Broadalbin-Fonda-Gloversville
Rouse Point
Schuylerville

Paleontology

Monograph of the Devonic crinoids
Genera of the Paleozoic corals
Descriptions of Devonic plants

Entomology

Report of the State Entomologist for the fiscal year ending September 30, 1907

Botany

Annual Report of the State Botanist for the fiscal year ending September 30, 1907

IX

STAFF OF THE SCIENCE DIVISION AND STATE MUSEUM

The members of the staff, permanent and temporary, of this division as at present constituted are:

ADMINISTRATION

John M. Clarke, *Director*
Jacob Van Deloo, *Director's clerk*

GEOLOGY AND PALEONTOLOGY

John M. Clarke, *State Geologist and Paleontologist*
David H. Newland, *Assistant State Geologist*
Rudolf Ruedemann Ph.D., *Assistant State Paleontologist*
C. A. Hartnagel B.S., *Assistant in Economic Geology*
D. Dana Luther, *Field Geologist*
Herbert P. Whitlock, C.E., *Mineralogist*
George S. Barkentin, *Draftsman*
William S. Barkentin, *Lithographer*
Joseph Morje, *First clerk*
H. C. Wardell, *Preparator*
Anna M. Byrne, *Stenographer*
C. J. Robinson, *Clerk*
Martin Sheehy, *Machinist*

Temporary assistants

Precambric geology

Prof. H. P. Cushing, Adelbert College
Dr C. P. Berkey, Columbia University

Stratigraphic geology

Prof. T. C. Hopkins, Syracuse University
H. O. Whitnall, Colgate University
G. H. Hudson, Plattsburg State Normal School
Prof. W. J. Miller, Hamilton College

Geographic geology

Prof. Herman L. Fairchild, Rochester University
Prof. J. B. Woodworth, Harvard University
Prof. A. P. Brigham, Colgate University

Paleontology

Dr C. R. Eastman, Harvard University
David White, United States Geological Survey
Dr T. Wayland Vaughan, United States Geological Survey
Edwin Kirk, Columbia University

BOTANY

Charles H. Peck M.A., *State Botanist*
Stewart H. Burnham, *Assistant,* Glens Falls

ENTOMOLOGY

Ephriam P. Felt B.S. D.Sc., *State Entomologist*
D. B. Young, *Assistant State Entomologist*
I. L. Nixon, *Assistant*
Anna M. Tolhurst, *Stenographer*
J. Shafer Bartlett, *Page*

Temporary assistants

Dr James G. Needham, Lake Forest College
Cornelius Betten, Lake Forest College
John R. Gillett, Albany

ZOOLOGY

George H. Chadwick, *Zoologist*
George L. Richards, *Taxidermist*

Temporary assistants

E. Howard Eaton, Canandaigua
Dr E. J. Letson, Buffalo

ARCHEOLOGY

Arthur C. Parker, *Archeologist*

Maintenance. The provision made by the Legislature of 1907 for the maintenance of the scientific work in all its branches and for the payment of all permanent and temporary services was $46,840.

X

ACCESSIONS

ECONOMIC GEOLOGY

Donation

Picton Island Red Granite Co. New York. Cubes (12") of red and pink granite, polished, from quarries on Picton Island, near Clayton	2
Ross, James. McCormick, S. C. Specimens of manganese ores from McCormick, S. C.	27
Warren, *Prof.* **C. H.** Boston, Mass. Specimens of titaniferous magnetite from Cumberland, R. I.	8

Collection

Assistant State Geologist. Iron ores and associated rocks, Minerva, Essex county	3
Iron ores and rocks, Port Leyden, Lewis county	6
Assistant in Economic Geology. Clinton hematite, Furnaceville Iron Ore Co., Ontario	6
Clinton hematite, Fair Haven Iron Co., Sterling Station	5
Specimens of shale showing fauna from layers directly above the Clinton ore at Sterling Station	50
Clinton hematite, specimens from iron bed directly above the Pentamerus limestone, Second creek, Sodus	5
Clinton hematite, from Mareness Cagwin farm, Verona	10
Clinton hematite, from Timothy Smith's farm, Verona	2
Clinton hematite, from James Wilson farm, (Klein ore bed) Verona	3
Clinton hematite (fossil ore from upper bed) E. W. Claus farm, Verona	10
Total	137

PALEONTOLOGY

Donation

Gillard, John. Stafford. Fossils from Stafford limestone, Stafford	250

Purchase

Breger, C. L. Ithaca. Fossil sponges from the Ithaca beds, Cornell Heights, Ithaca	40
Grebel, Wendler & Co. Geneva, Switzerland. Eurypterus fischeri	4
Series of graptolites	97
Krantz, *Dr* **F.** Bonn, Germany. Crustacea from various horizons and localities in Europe	98
Ward's Natural Science Establishment. Rochester. Trilobites from various formations in Europe	5
Olenellus thompsoni Hall. Lower Cambric, Swanton, Vt.	4
Trilobites from various formations and localities in the United States and Europe	12

Collection

Assistant State Paleontologist. Lower Siluric and Siluric fossils from Lake Champlain, Black River and Mohawk regions	250
——— **& Cushing,** *Prof.* **H. P.** Lower Siluric fossils from Theresa quadrangle	200
Fossils, mostly from the Pamelia limestone in Jefferson county	45

Cushing, *Prof.* **H. P.** Lingula from the Potsdam (Beekmantown passage zone) of the Theresa quadrangle	24
Luther, D. D. Gomphoceras from concretion in Cashaqua shale	1
Wardell, H. C. Crustaceans from shaly layers in Shawangunk grit, Erie Railroad quarry, Otisville, Orange county	400
Fossils from Erie Railroad cut, western side of Pine hill near Highland Mills, Orange county	200
Fossils from the Onondaga and Stafford limestones near Leroy and Stafford, Genesee county	150
Total	1780

MINERALOGY

Donation

Carpenter, F. Silver and niccolite, Cobalt, Quebec, Can		1
Calcite (stalactitic), Camillus valley		1
Smith, J. A. Bisbee, Ariz. Gypsum, New Mexico		2
Dutcher, Louis, O. Albany. Pyrite, Colorado		6
Gilmore, Chas. M. Albany. Hypersthene, pyrites		1
Cameron, Thomas. Hermon. Calcite, Caledonia mine		1
Ross, J. McCormick, S. C. Psilomelane and barite, McCormick S. C.		3
Hindshaw, H. H. New York. Cyanite, Chester, Mass		1
Calcite, Smith's Basin		1
Quartz,	Lyon Mountain	314
Quartz and asbestos	"	4
Quartz and hematite	"	3
Amphibole (hornblende)	"	24
Amphibole (hornblende) and asbestos	"	3
Hornblende, asbestos and calcite	"	1
Hornblende and orthoclase	"	1
Amphibole (asbestos)	"	1
Calcite	"	49
Apatite	"	19
Apatite in orthoclase	"	4
Magnetite	"	5
Magnetite in amphibole	"	3
Microcline	"	8
Microcline and quartz	"	1
Pyroxene	"	2
Pyroxene in microcline	"	1
Titanite	"	1
Epidote and stilbite	"	1
Epidote in microcline	"	1
Pruyn, *Mrs* **J. V. L.** Albany. Pyrite, Elba, Italy		7
Quartz	"	6
Hematite	"	26
Amphibole (asbestos), Corsica		2
Celestite and biotite in lava, Monte Somma, Italy		1
Epidote, Croce di Monde, Italy		1
Wollastonite and amphibole, Vesuvius crater, Italy		2
Vesuvianite and muscovite, Bosco Reale, Italy		1
Gypsum, Remita, Italy		1
Pyroxene in lava, Torre del Greco, Italy		1
Chrysolite in lava, vicinity of Vesuvius, Italy		1
Quartz, orthoclase and biotite, Sorrento, Italy		1
Chrysolite, Capo di Sebastiano, Italy		1
Volcanic rock, vicinity of Vesuvius, Italy		1
Limestone, vicinity of Vesuvius, Italy		1
Muscovite, Capo di Quaglia, Italy		1

Garnet, vesuvianite and anorthite, Capo di Quaglia, Italy	1
Biotite and chrysolite, vicinity of Vesuvius, Italy	1
Garnet and vesuvianite, Vesuvius, Italy	1
Gypsum, Monte Somma, Italy	1
Epidote, Torre del Greco, Italy	1
Chrysolite and quartz, Capo di Monte, Italy	1
Galena in limestone, Vesuvius, Italy	1
Hematite (specular), Monte Somma, Italy	2
Vesuvianite, garnet and anorthite, vicinity of Vesuvius, Italy	1
Vesuvianite and garnet, Vesuvius, Italy	2
Chrysolite in lava, St Giorgio a Cremano, Italy	1
Vesuvianite and calcite, Vesuvius, Italy	1
Calcite, Vesuvius, Italy	1
Vesuvianite and epidote, Vesuvius, Italy	1
Meionite, Vesuvius, Italy	1
Muscovite and hematite, Vesuvius, Italy	1
Epidote and garnet, Vesuvius, Italy	1
Leucite in lava, Monte Somma, Italy	1
Wollastonite and amphibole, Vesuvius, Italy	2
Vesuvianite, Vesuvius, Italy	1
Wollastonite and muscovite, Vesuvius, Italy	1
Nephelite, Sebastiano, Italy	1
Stilbite, Vesuvius, Italy	1
Calcite (calcareous tufa), Vesuvius, Italy	1
Leucite in lava, Monte Somma, Italy	1
Leucite in lava, Capo di Sebastiano	1
Amphibole in lava, Vesuvius, Italy	1
Garnet and muscovite, Vesuvius, Italy	1
Chrysolite and biotite, Vesuvius, Italy	1
Leucite in lava, Torre del Greco, Italy	1
Vesuvianite, Vesuvius, Italy	2
Amphibole (hornblende), Vesuvius, Italy	1
Vesuvianite, Vesuvius, Italy	1
Anorthite, Vesuvius, Italy	1
Chrysolite and pyroxene, Sebastiano, Italy	1
Biotite and feldspar, Capo di Monte, Italy	1
Garnet and muscovite, Vesuvius, Italy	1
Chrysolite and muscovite, Vesuvius, Italy	1
Sulphur, Vesuvius, Italy	2
Sulphur in lava, Vesuvius, Italy	2
Leucite (crystals), Capo di Sebastiano	10
Sal ammoniac on lava, Vesuvius, Italy	1
Vesuvianite and muscovite, Vesuvius, Italy	1
Nephelite and amphibole, Vesuvius, Italy	1
Amphibole (tremolite), vicinity of Mont Blanc, Switzerland	1
Dolomite and pyrite " " "	1
Rhodochrosite " " "	1
Amphibole (bissolite) " " "	1
Epidote " " "	1
Galena and sphalerite " " "	1
Garnet " " "	2
Axinite " " "	1
Tourmalin " " "	1
Pyrite " " "	5
Fluorite " " "	1
Quartz " " "	2
Quartz (smoky) " " "	1
Serpentine " " "	1
Epidote " " "	1
Siderite " " "	1
Galena " " "	1
Realgar " " "	1
Calcite " " "	2

Malachite, vicinity of Mont Blanc, Switzerland	1
Staurolite and cyanite " "	1
Lapis Lazuli " "	1
Amphibole " "	1
Aragonite " "	1
Chalcopyrite " "	2
Molybdenite " "	1
Siderite " "	1
Azurite, Chessy, France	1

Purchase

Hodge, *Capt.* **R. S.** Antwerp. Millerite, Antwerp	18
Hematite, Antwerp	20
Ankerite "	19
Chalcodite "	25
Quartz "	8
Dolomite "	3
Goethite "	5
Calcite "	10
Newbury, J. O. Ripley. Garnet in gneiss, Ripley	1
Comptoir Min. et. Geol. Suiss. Geneva. Danburite, Piz Casanel, Spain	1
Krantz, F. Bonn, Germany. Calcite, Egremont, England	2
Barite and dolomite, Egremont, England	1
Calcite, Ith, Brunswick, Germany	1
Annabergite, Laurium, Greece	1
Apatite adularia and quartz, Rhone glacier, Switzerland	2
Aximite, Obira, Province of Bango, Japan	1
Hessite and gold, Botes, Transylvania	1
Opal (precious) pseu. after glauberite, White Cliffs, South Australia	1
Beryl (aqua marine) Minas Geraes, Brazil	1
Liroconite, Wheal Garland, Cornwall	1
Wagnerite, Werfen Salzburg, Austria	1
Boracite, Hohenfels, Hanover, Germany	2
Halite with liquid inclusions, Hildesia, Hildesheim, Germany	1

Collection

Members of the Museum staff. Calcite, Sterlingbush	1000[1]
Assistant State Geologist. Amphibole (tremolite), Gouverneur	4
Assistant in Economic Geology. Calcite in limestone, Accord	1
Mineralogist. Zircon in orthoclase and quartz, Crown Point	49
Biotite in orthoclase and quartz "	8
Mica (altered) "	1
Quartz "	8
Pyroxene (large), Lead hill mine, Ticonderoga	2
Pyroxene and graphite " "	7
Wernerite " "	1
Zircon in microcline, Spar bed "	5
Muscovite in microcline " "	1
Tourmalin (large), Buck Mt pond, Ticonderoga	2
Tourmalin " "	8

[1] This number is estimated. The material is contained in packages (barrels and crates) and weighs 12 tons.

Amphibole (tremolite) Buck Mt pond, Ticonderoga	3
Serpentine in calcite " "	1
Amphibole altering to serpentine, Buck Mt pond, Ticonderoga	1
Calcite, Alsen	19
Calcite (large), Smith's Basin	1
Calcite " "	10
Calcite, Fort Miller	5
Quartz, Crystal rock, Lansingburg	33
Quartz, Glenmont	7
Amphibole (tremolite), Gouverneur	51
Amphibole " loose crystals, Gouverneur	30
Amphibole (actinolite), Gouverneur	5
Cushing, H. P. Cleveland, O. Corundum (crystals), Craigmont, Ontario, Can	4
Corundum in syenite, Craigmont, Ontario, Can	1
Wernerite in syenite " " "	1
Wernerite " " "	2
Nephelite altering to sodalite, Bancroft "	2
Total	2041

ENTOMOLOGY

Donation

Hymenoptera

Hilton, *Miss* **Hazel C.** Old Chatham. Sphex ichneumonea Linn., adult, Aug. 20

Brown, L. F. Cobleskill. Pelecinus polyturator Dru., adult, Sept. 5

Mitchell, *Miss* **E. G.** Washington, D. C. Andricus seminator Harr., wool sower, gall on oak, June 10; A. ?petiolicola Bass., oak leaf stalk gall, June 23, from East Orange, N. J.

Burnham, S. H. Albany. Andricus singularis Bass., oak leaf apple gall on oak, June 17; Rhodites bicolor Harr., spiny bullet gall on rose, June 17, from Shushan, N. Y..

Coleoptera

Bogue, Virgil. Albion. Xyleborus dispar Fabr., pear blight beetle, adult on peach, June 4

Pettis, C. R. Lake Clear Junction, N. Y. Lachnosterna ?fusca Froh., May beetle, larvae attacking roots of seedling pines, Aug. 19

Woodruff, E. S. Wawbeck. Lachnosterna ?fusca Froh., May beetle, larvae on roots of evergreens, Aug. 27

Peck, C. H. Albany. Plesiocis cribrum? Casey, adult on Polyporus on spruce, May 21, from Woburn, Mass.

Pearsall, R. F. Brooklyn. Acoptus suturalis Lec.; Piazurus oculatus Say; Conotrachelus anaglypticus Say; Iphthimus opacus Lec.; Oncideres cingulata Say; Dorcus parallelus Say; Corymbites hamatus Say; Geopinus incrassatus Dej.; Dicaelus dilatatus Say; Notiophilus sibiricus Mots.; Calosoma externum Say; Carabus serratus Say, Jan. 21

Alexander, Charles P. Gloversville, has contributed a number of species, some extremely desirable, in return for numerous identifications.

Diptera

Alcott, D. W. East Greenbush. Olfersia americana Leach, adult on barred owl, Oct. 25

Clarke, *Miss* **C. H.** Boston, Mass. Agromyza (?) aeneiventris Fall., larvae, Nov. 11

Cockerell, T. D. A. Boulder, Col. Trypeta bigeloviae Ckll., galls, June 24, from Florissant, Col.

Joutel, L. H. New York. A number of Cecidomyiid galls

Thompson, *Dr* **M. T.**, lately deceased, formerly of Clark University, Worcester, Mass. A number of Cecidomyiidae, mostly bred species

Clarke, *Miss* **Cora H.** Boston, Mass. Cecidomyiid galls taken mostly in the vicinity of Magnolia, Mass., a few near Boston

Bryant, Owen. Cohasset, Mass. Numerous Cecidomyiidae

Mitchell, *Miss* **Evelyn G.** Washington, D. C. Cecidomyiid galls, mostly from the vicinity of Washington

Tucker, E. S. Plano, Texas. Cecidomyiidae from Kansas and Texas

Cockerell, *Prof.* **T. D. A.** Boulder, Col. Cecidomyiid galls and adults

Fletcher, *Dr* **James.** Central Experimental Farms, Ottawa, Can. Several Cecidomyiid galls

Jarvis, *Prof.* **T. D.** Ontario Agricultural College, Guelph, Ont. Numerous Cecidomyiid galls

Willing, T. N. Regina, Sask, N. W. T. A number of Cecidomyiid galls

Criddle, Norman. Treesbank, Manitoba, Can. A number of Cecidomyiid galls and bred adults

Howell, J. Highland Falls. Cecidomyia verrucicola O. S., linden leaf galls on linden or basswood, Nov. 14

Fisher, W. S. High Spire, Pa. Asphondylia conspicua O. S., galls and larvae on Rudbeckia laciniata, Aug. 18

Forbes, *Prof.* **S. A.** Urbana, Ill. Neocerata rhodophaga Coq., adult and larvae, Dec. 8

Stowell, E. Channing. Dublin, N. H. Taeniorhynchus perturbans Walk., adults, July 30; Eucorethra underwoodi Undw., larvae, Aug. 28

Marshall, D, T. Hollis, L. I. Culex pipiens Linn., house mosquito, adults, Sept. 23; Culicada sollicitans Walk., salt marsh mosquito, adults, Aug. 3

Pearsall, R. F. Brooklyn. Tipulidae, several species; Pediscia albivitta Walk.; Xylota vecors O. S., Jan. 21

Lepidoptera

Hill collection

This is an exceptionally valuable addition to the State collections, consisting of some 10,000 specimens, representing approximately 3500 species. It is in excellent condition and was donated by Erastus D. Hill, Carrie J. Hill Van Vleck and William W. Hill, heirs of the late William W. Hill of Albany. The catalogue of this collection is given in the Entomologist's report.

Booth, A. J. Manila, P. I. Attacus atlas Linn., adult, Sept. 17

Greene, F. J. Centre Berlin. Anisota rubicunda Fabr., green striped maple worm, on maple, Aug. 12; Heterocampa guttivitta Walk., on maple, Aug. 12

Hill, *Mrs* Alex. Hiland. Palenville. Epizeuxis denticulalis Harv., adult, July 31

Stearns, W. A. Centre Berlin. Heterocampa guttivitta Walk., larvae, on maple, Aug. 22

Chew, J. M. Newburgh. Ennomos subsignarius Hubn., snow-white linden moth, adults, Sep. 9

Bailey, *Dr* T. P. Albany. Leucobrephos brephoides Walk., adult, April, from St Lawrence county

Lackay, W. E. Rensselaer. Phobetrom pithecium Abb. & Sm., hag moth caterpillar, larvae on maple, Sept. 17.

Huested, S. B. Blauvelt. Zeuzera pyrina Fabr., leopard moth, on apple, Oct. 30

Alexander, C. P. Gloversville. Eucosma scudderiana Clem., larvae on solidago, Feb. 27

Eldridge, C. E. Leon. Ancylus nubeculana Clem., apple leaf folder, larvae on apple, Sept. 17

Knox, *Miss* A. A. New York city. Mompha brevivittella Clem. and M. eloisella Clem., adults on Oenothera grandiflora, Oct. 16

Pearsall, R. F. Brooklyn. Philopsia nivigerata Walk.; Euchoeca exhumata Pears cotype; Mesolueuca immanata Haw.; Petrophora fluctuata Linn.; Orthofidonia exornata Walk.; Sicya macularia Harr.; Therina endropiaria Walk.; Plagodis serinaria H-S; P. phlogosaria Guen., Jan. 21, from Indian Valley, Catskill Mts

Hemiptera

Barger, *Mrs* Milton. St Lawrence county. Phylloxera caryaecaulis Fitch, hickory gall aphid, galls on hickory, May 27

Hagen, C. W. Sparrowbush. Empoasca mali LeB., apple leaf hopper, adult on apple, July 1

Kidder, G. S. Port Henry. Myzus cerasi Fabr., cherry aphis, adults on cherry, July 12

Guyett, F. E. Rensselaer. Nectarophora pisi Kalt., pea aphid, adults on peas, July 13

Howe, C. D. Pisgah Forest, N. C. Chermes pinicorticis Fitch, pine bark aphis on pine, Apr. 30

Cockerell, *Prof.* **T. D. A.** Boulder, Col. Phoenacoccus marlatti Ckll., on date palm, Mar. 30, from Tempe, Arizona

Fletcher, *Dr* **James.** Central Experimental Farms, Ottawa, Can. Aspidiotus forbesi John., cherry scale, adults on basswood, Apr. 25

Wohlers, R. Williamsville. Aspidiotus ostreaeformis Curtis, European fruit scale, adults and young on plum, May 8

Courtney, N. J. Cornwall-on-Hudson. Aspidiotus perniciosus Comst., San José scale on apple, Apr. 15

Stone, D. D. Oswego. Aspidiotus perniciosus Comst., San José scale, adults on currant, May 30

Peck, C. H. Albany. Aulacaspis rosae Bouché, rose scale, adults and larvae on raspberry, Mar. 29

Hicks, Isaac & Son. Westbury Station. Chionaspis pinifoliae Fitch, pine leaf scale, eggs on pine, Nov. 9

Merritt, *Mrs* **Douglas.** Rhinebeck. Gossyparia spuria Mod., elm bark louse, females on elm, June 15

Orthoptera

Fairman, C. E. Lyndonville. Nyctobora holosericia Klug., giant cockroach, adult, July 1, from Albany

Mallophaga

Alcott, D. W. East Greenbush. Docophorus syrnii? Pack. adult on barred owl Oct. 25

Chadwick, G. H. Docophorus syrnii? Pack. on barred owl, Nov. 13; Haematopinus antennatus? Osb. on gray squirrel, Nov. 8; Lipeurus baculus Nitzsch on pigeon, Nov. 4; Lipeurus sp. on Gadwall duck, Nov. 4; Goniocotes compar Nitzsch on pigeon, Nov. 4; Trinoton luridum Nitzsch on Gadwall, Oct. 30; same, on duck, Nov. 8; same Burrow Golden eye

Corrodentia

Voelckel, Emil. Wakefield, New York city. Atropos divinatoria Fabr., book louse, adult, Oct. 30

Mairs, *Mrs* **Edwin H.** Irvington-on-Hudson. Psocus venosus Burm., adult on decayed vegetable matter, Aug. 24, from Washington, Conn.

Exchange

Diptera

Johnson, *Prof.* **C. W.** Boston, Mass. Neaspilota achilleae Johns., N. albidipennis Loew., N. vernoniae Loew., Trypeta palposa Loew., Stenomyia tenuis Loew., Chaetopsis apicalis Johns., Tetanops luridipennis Loew., Melieria obscuricornis Loew., Rivellia brevifasciata Johns., R. quadrifasciata Macq., Thelaira leucozona Panz., Paraprosena apicalis Desv., Echinomyia florum Walk., Opsidia gonioides Coq., Chaetoplagia atripennis Coq., Sturmia nigrita Town., Epigrymyia polita Town.; Actia pilipennis Fall., Trichopoda plumipes Fabr., Alophora aeneoventris Will., Hydrophorus eldoradensis Wheeler, H. viridiflos Walk., Neurigona lateralis Say, Agonosoma unifasciatum Say (bicolor Loew.), Psilopodinus comatus Loew., Mallophora orcina Wied., Erax maculatus Macq. (lateralis Macq.), Laphria canis Will., L. sericea Say, Atomosia puella Wied., A. sayii Johns., Cerotainia macrocera Say, Nicocles pictus Loew., Deromyia platyptera Loew., Stichopogon argenteus Say, Holopogon guttula Wied., Holcocephala calva Loew., Lasiopogon terricola Johns., Cyrtopogon lutatius Walk., Psilocurus nudiusculus Loew., Laphystia sexfasciata Say, Leptogaster annulatus Say, L. pictipes Loew., Geron calvus Loew., G. sigma Coq., Systoechus solitus Walk., Anthrax ceyx Loew., A. edititia Say, A. lucifer Fabr., Exoprosopa eremita O. S., Tabanus fuscopunctatus Macq., T. recedens Walk., T. sparus Whitney, Chrysops nigrilimbo Whitney.

Melander, *Prof.* **A. L.** Pullman, Wash. Caenia spinosa Loew., Parydra quadrituberculata Loew., P. limpidipennis Loew., Hydrellia hypoleuca Loew., Paralimna appendiculata Loew., Tephritis variabilis Doane, T. finalis Loew., Ensina humilis Loew., Spilographa diffusa Snow, Sepedon armipes Loew., Tetanocera plumosa Loew., T. pallida Loew., Sciomyza pubera Loew., S. nana Fall., S. humilis Loew., Criorhina scitula Will., Xylota flavitibia Bigot, Eristalis temporalis Thom., E. occidentalis Will., E. bastardii Macq., Volucella esuriens Fabr., Mesogramma boscii Macq., Syrphus diversipes Macq., Platychirus chaetopodus Will., Chrysogaster stigmata Will., C. lata Loew., Chrysotoxum derivatum Walk.

Orthoptera

Britton, *Dr* **W. E.** New Haven, Conn. Spharagemon bolii Scud., S. saxatile Morse, Psinidia fenestralis Serv., Scirtetica marmorata Harr., Paroxya floridana Thom., Orphulella speciosa Scud., O. pelidna Burm.

ZOOLOGY

Donation

Mammals

Alexander, C. P. Gloversville. Say's bat, Myotis subulatus (Say) 1

Paine, J. A. Tarrytown. Deer mouse, Peromyscus leucopus noveboracensis (Fischer) 1

Wales, *Mrs* **L. J.** Kenoza Lake. Little brown bat, Myotis lucifugus (Le Conte) 2

Birds

Alexander, C. P. Gloversville. Winter wren, Anorthura hiemalis (Vieill.) 1
Saw-whet owl, Nyctala acadica (Gmel.) 1
Ashbury, L. O. Auburn. American hawk owl, Surnia ulula caparoch (Müll.) 1
Northern pileated woodpecker, Ceophloeus pileatus abieticola Bangs 1
Badger, Geo. B. Amityville. Turnstone, Arenaria interpres (Linn.) 1
Richard, Will. Cody, Wyoming. Northern phalarope, Phalaropus lobatus (Linn.) 3
Wilson's phalarope, Steganopus tricolor (Vieill.) 1
American avocet, Recurvirostra americana (Gmel.) 1
Western willet, Symphemia semipalmata inornata Brewst. 1
Townsend's solitaire, Myadestes townsendii (Aud.) 1
Rothaupt, Geo. Jerusalem, Albany co. English sparrow, passer domesticus (Linn.), albinistic specimen 1
Thayer, Gerald. Monadnock, N. H. European linnet, Acanthis cannabina (Linn.), taken at Scarboro, N. Y., in 1894; *first N. Y. State record* 1
Vroman, Wilson N. State Department of Agriculture. American goshawk, Accipiter atricapillus (Wils.) 1
Ward's Nat. Sci. Estab. Rochester. Ring-necked pheasant, Phasianus torquatus (Gmel.) 1
Whaley, Robert. Sterlingbush. Red-shouldered hawk, Buteo lineatus (Gmel.) 1

Reptiles and batrachians

Alexander, C. P. Gloversville. Ring-necked snake, Diadophis punctatus (Linn.) 1
Brown snake, Storeria occipitomaculata (Storer) 1
Red-backed salamander, Plethodon cinereus erythronotus (De Kay) 3
Striped-backed salamander, Spelerpes bilineatus (Green) 2
Dusky salamander, Desmognathus fuscus (Raf.) 3
Wood frog, Rana sylvatica (Le Conte) 1
Cook, John. Albany. Ring-necked snake, Diadophis punctatus (Linn.) 1
Young, D. B. Albany. Blue-spotted salamander, Plethodon glutinosus (Green)? 1

Fish

Higgins, T. F. Schenectady. Common gurnard, Prionotus carolinus (Linn.) 1

Arachnida

Alexander, C. P. Gloversville and Johnstown. Numerous sendings of spiders and mites, including many forms new to the collection, and some undescribed species. Not yet fully listed.

Beach, *Mrs* **Chas.** Catskill Mountain House. Spider, Epeira displicata (Hentz), yellow var.......... 1
Chadwick, *Miss* **Nathalie.** Catskill. Spider, Steatoda borealis (Hentz) 1
Congdon, *Miss* **L. C.** Catskill. Grass spider, Agelena naevia (Walck) 1
Spider. Pardosa sp. 1
Cook, John. Albany. Crab spider, Xysticus sp.......... 1
Dobbin, Frank. Shushan. Galls of Eriophyes on alder leaves.......... 3
Duncan, George T. Rochester. Heteropoda venatoria (Linn.) and other spiders.......... 7
Fletcher, *Dr* **James.** Ottawa, Canada. Gall of Eriophyes on Spiraea salicifolia, and spiders.......... 5
Foster, *Miss* **Marion.** New Paltz. Galls of Eriophyes acericola (Garman).......... 2
Hall, C. K. East Schodack. Spider, Epeira strix (Hentz).......... 1
Joutel, L. H. New York city. Galls of Eriophyes on ash and poplar.......... 2
Little, *Miss* **E. W. C.** Menands. Triangle spider, Hyptiotes cavatus (Hentz) 1
Mirguet, John, and **Laird, James.** Rochester. Spiders and phalangids, not fully listed.......... 17
Mitchell, *Miss.* East Orange, N. J. Galls of Eriophyes acericola (Garman) 3
Weeks, A. H. Jamaica, L. I. Two sendings of spiders, not fully listed.......... 15
Wilke, A. F. T.. Paterson. Golden-rod spider. Misumena aleatoria (Hentz).......... 1

Myriapoda and crustacea

Alexander, C. P. Gloversville. Several sendings not yet classified.
Chadwick, *Mrs* **C. S.** Catskill. Shrimps, Asellus communis

Mollusca

Alexander, C. P. Gloversville. Zonitoides arboreus (Say) 1
Polygyra albolabris (Say).......... 1
Polygyra palliata (Say).......... 1
Philomycus carolinensis (Bosc.).......... 1
Agriolimax campestris (Binney).......... 2
Succinea ovalis Say (obliqua).......... 2
Succinea ovalis totteniana Lea.......... 1
Limnaea desidiosa Say.......... 1
Physa niagarensis (?) Lea.......... 5
Aplexa hypnorum (Linn.).......... 1
Planorbis bicarinatus Say.......... 2
Letson, *Dr* **E. J.** Buffalo Society of Natural Science. Polygyra tridentata (Say) 2
Polygyra albolabris (Say) 2
Polygyra thyroides (Say).......... 2
Polygyra palliata (Say).......... 2
Polygyra exoleta (Say).......... 2

Lampsilis ventricosus (Barnes) 1
Lampsilis luteolus (Lamk.) 2
Lampsilis ligamentinus (Lamk.) 1
Lampsilis alatus (Say) 2
Lampsilis gracilis (Barnes) 1
Obovaria ellipsis (Lea) 1
Strophitus edentulus (Say) 1
Symphynota compressa (Lea) 1
Symphynota costata (Raf.) 1
Alasmidonta calceolus (Lea) 2
Unio gibbosus Barnes 2
Quadrula undulata (Barnes) 1

Purchase

Birds

Ashbury, L. O. Auburn. Gyrfalcon, Falco rusticolus gyrfalco (Linn.) 1

Coale, H. K. Chicago. Black rail, Porzana jamaicensis (Gmel.) 2

Eaton, E. H. Rochester. Blue geese, Chen caerulescens (Linn.) 2

American egret, Ardea egretta (Gmel.) 1

Langille, *Rev* J. H. Kensington, Md. Yellow-billed tropic bird, Phaethon americanus (Grant) taken at Knowlesville, N. Y.; *first N. Y. State record* 1

Parker, Foster. Cayuga. Black-bellied plover, Squatarola squatarola (Linn.) 1

Turnstone, Arenaria interpres (Linn.) 1

Rose-breasted grosbeak, Zamelodia ludoviciana (Linn.) 1

Van Valkenburgh, Edward. West Ghent. (per H. J. Richardson) Red-shouldered hawk, Buteo lineatus (Gmel.), albino 1

Ward's Natural Science Establishment. Rochester. Ivory gull. Pagophila alba (Gunn.) 1

Little gull, Larus mintus (Pall.) 1

Yellow-billed tropic bird, Phaethon americanus (Grant) 1

Pintail, Dafila acuta (Linn.) 1

Rufous-crested duck, Netta rufina (Pall.) 1

White-winged scoter, Oidemia deglandi (Bonap.) 1

White-bellied brant, Branta bernicla glaucogastra (Brehm) 1

Red phalarope, Crymophilus fulicarius (Linn.) 1

Red-backed sandpiper, Tringa alpina pacifica (Coues.) 1

Passenger pigeon, Ectopistes migratorius (Linn.) 1

Red headed woodpecker, Melanerpes erythrocephalus (Linn.) 1

Webster Co., F. B. Hyde Park, Mass. Whooping crane, Grus americana (Linn.) 1

Gray kingbird, Tyrannus dominicensis (Gmel.) 1

Chestnut-collared longspur, Calcarius ornatus (Towns.) 1

Worthen, C. K. Warsaw, Ill. Pied-billed grebe, Podilymbus podiceps (Linn.) 2
Parasitic jaeger, Stercorarius parasiticus (Linn.) .. 1
Sabine's gull, Xema sabinii (Sab.) 1
Royal tern, Sterna maxima (Bodd.) 1
Arctic tern, Sterna paradisaea (Brünn) 1
Black tern, Hydrochelidon nigra surinamensis (Gmel.) 1
Fulmar, Fulmarus glacialis (Linn.) 1
Sooty shearwater, Puffinus fuliginosus (Strickland) 1
Scaled petrel, Aestrelata scalaris (Brewst.) 1
Brown pelican, Pelecanus fuscus (Linn.) 1
Man-o'-war bird, Fregata aquila (Linn.) 1
Red-breasted merganser, Merganser serrator (Linn.) .. 1
European widgeon, Mareca penelope (Linn.) 2
Cinnamon teal, Querquedula cyanoptera (Vieill.) 1
Harlequin duck, Histrionicus histrionicus (Linn.) 1
Brant, Branta bernicla (Linn.) 1
White ibis, Guara alba (Linn.) 1
Glossy ibis, Plegadis autumnalis (Hasselq.) 1
Snowy heron, Ardea andidissima Gmel 1
Little blue heron, Ardea caerulea Linn 2
Northern phalarope, Phalaropus lobatus (Linn.) 1
Dunlin, Tringa alpina (Linn.) 1
Red-backed sandpiper, Tringa alpina pacifica (Coues) 1
Semipalmated sandpiper, Ereunetes pusillus (Linn.) 1
Western sandpiper, Ereunetes occidentalis (Lawr.) 1
Sanderling, Calidris arenaria (Linn.) 2
Greater yellow-legs, Totanus melanoleucus (Gmel.) .. 1
Western willet, Symphemia semipalmata inornata (Brewst.) 1
Black-bellied plover, Squatarola squatarola (Linn.) .. 1
Semipalmated plover, Aegialitis semipalmata (Bonap) .. 1
Willow ptarmigan, Lagopus lagopus (Linn.) 1
Swallow-tailed kite, Elanoides forficatus (Linn.) 1
Sharp-shinned hawk, Accipiter velox (Wils.) 1
Sainson's hawk, Buteo swainsoni (Bonap.) 2
Northern hairy woodpecker, Dryobates villosus leucomelas (Bodd.) 1
Alder flycatcher, Empidonax trailli alnorum Brewst. 1
Starling, Sturnus vulgaris Linn 1
Bullock's oriole, Icterus bullocki (Swains.) 1
European goldfinch, Carduelis carduelis (Linn.) 1
Sharp-tailed sparrow, Ammodramus caudacutus (Gmel.) 2
Nelson's sparrow, Ammodramus nelsoni (Allen) 2
Painted bunting, Cyanospiza ciris (Linn.) 1
Orange-crowned warbler, Helminthophila celata (Say) 2
Northern parula warbler, Compsothlypis americana usneae (Brewst.) 1
Cape May warbler, Dendroica tigrina (Gmel.) 1

Batrachia

Ward's Natural Science Establishment. Rochester. Hellbender, Cryptobranchus allegheniensis Daudin............ 1

Fish

Duncan, George T. Rochester. Wall-eyed pike, Stizostedion vitreum (Mitch.) 1

Exchange

Tucker, E. S. Lawrence, Kan. Spiders.......................... 16

Collection

Mammals

Red squirrel, Sciurus hudsonicus loquax (Bangs)......... 2
White-footed mouse, Peromyscus leucopus noveboracensis (Fischer) 1
Meadow mouse, Microtus pennsylvanicus (Ord.)............ 1
Muskrat, Fiber zibethicus (Linn.) (with material for mounted nest) 1
Woodland jumping-mouse, Napaeozapus insignis (Miller)..... 1
Big brown bat, Vespertilio fuscus (Beauvois.)............... 1

Birds

Ring-billed gull, Larus delawarensis (Ord.).................. 1
Mallard, Anas boschas (Linn.)................................ 1
Black duck, Anas obscura (Gmel.)............................ 1
Red-legged black duck, Anas obscura rubripes................ 1
Gadwall, Chaulelasmus streperus (Linn.)..................... 1
Green-winged teal, Nettion carolinensis (Gmel.).......... 2
Blue-winged teal, Querquedula discors (Linn.)............ 1
Pintail, Dafila acuta (Linn.)................................ 1
Lesser scaup duck, Aythya affinis (Eyt.).................... 2
American golden-eye, Clangula clangula americana (Faxon) 3
Barrow's golden-eye, Clangula islandica (Gmel.).......... 2
Old squaw, Harelda hyemalis (Linn.)........................ 1
American coot, Fulica americana (Gmel.).................... 1
American woodcock, Philohela minor (Gmel.)............... 1
Knot, Tringa canutus Linn.................................... 1
Least sandpiper, Tringa minutilla (Vieill.).................. 1
Semipalmated sandpiper, Ereunetes pusillus (Linn.)...... 1
Sanderling, Calidris arenaria (Linn.)...................... 1
Solitary sandpiper, Helodromas solitarius (Wils.)........ 2
Bartramian sandpiper, Bartramia longicauda (Bechst.)... 1
Spotted sandpiper, Actitis macularia (Linn.)............... 1
Black-bellied plover, Squatarola squatarola (Linn.)...... 3
American golden plover Charadrius dominicus (Müll.)...... 1
Semipalmated plover, Aegialitis semipalmata (Bonap.)...... 2
Turnstone, Arenaria interpres (Linn.)........................ 2

English pheasant, *Phasianus colchicus* (Linn.)	1
Sharp-shinned hawk, *Accipiter velox* (Wils.)	1
Yellow-bellied sapsucker, *Sphyrapicus varius* (Linn.)	1
Ruby-throated hummingbird, *Trochilus colubris* (Linn.)	1
Alder flycatcher, *Empidonax trailli alnorum* (Brewst.)	1
Least flycatcher, *Empidonax minimus* (Baird)	2
Meadowlark, *Sturnella magna* (Linn.)	1
Redpoll, *Acanthis linaria* (Linn.)	2
Greater redpoll, *Acanthis linaria rostrata* (Coues)	1
Savanna sparrow, *Ammodramus sandwichensis savanna* (Wils.)	1
Grasshopper sparrow, *Ammodramus savannarum passerinus* (Wils.)	1
Sharp-tailed sparrow, *Ammodramus caudacutus* (Gmel.)	2
Seaside sparrow, *Ammodramus maritimus* (Wils.)	1
White-throated sparrow, *Zonotrichia albicollis* (Gmel.)	3
Song sparrow, *Melospiza fasciata* (Gmel.)	1
Towhee, *Pipilo erythrophthalmus* (Linn.)	1
Scarlet tanager, *Piranga erythromelas* Vieill	1
Cedar waxwing, *Ampelis cedrorum* (Vieill.)	2
Nashville warbler, *Helminthophila rubricapilla* (Wils.)	1
Yellow warbler, *Dendroica aestiva* (Gmel.)	1
Myrtle warbler, *Dendroica coronata* (Linn.)	3
Magnolia warbler, *Dendroica maculosa* (Gmel.)	1
Black-throated green warbler, *Dendroica virens* (Gmel.)	1
Pine warbler, *Dendroica vigorsii* (Aud.)	1
Yellow palm warbler, *Dendroica palmarum hypochrysea* Ridgw.	1
Water-thrush, *Seiurus noveboracensis* (Gmel.)	1
Northern yellow-throat, *Geothlypis trichas brachydactyla* (Swain.)	2
Wilson's warbler, *Wilsonia pusilla* (Wils.)	1
Brown thrasher, *Harporhynchus rufus* (Linn.)	1
Winter wren, *Anorthura hiemalis* (Vieill.)	1
Golden-crowned kinglet, *Regulus satrapa* (Licht.)	3
Ruby-crowned kinglet, *Regulus calendula* (Linn.)	1

Reptiles and batrachians

Wood tortoise, *Chelopus insculptus* (Le Conte)	1
A number of salamanders not yet identified	

Invertebrates

Several hundred specimens of spiders, mites and mite-galls have been collected, with incidentally some myriapods, entomostraca and mollusca.

Total	323

ARCHEOLOGY

Donation

Hartnagel, C. A. Stone pipe stem from Union Springs
Cleveland, A. A. Triangular "bear's head" stone
Parker, A. C. String of condolence wampum
Edson, Obed & Reed, Richard. Parts of 5 skeletons

Purchase

Woodworth, A. R. Springboro, Pa. The following from Ithaca

35 arrow and spearheads
1 pestle
4 celts
1 pipe with 4 stem holes

Fitch, Luke I. Manlius

7 smooth perforated coins
1 Martin Van Buren token
1 penny of 1804
1 copper point
11 brass arrowheads
1 iron gun wormer
4 iron awls
1 lead spiral
3 small lead spirals
1 thimble
1 copper scrap
1 part of a hinge
2 lead seals
2 lead rings with knobs
14 Jesuit rings
1 Masonic brooch
6 "hawk" bells
7 iron knives
1 flint lock
1 bullet mold
1 gun wormer
1 pair shears
4 potsherds
2 awls
1 beaver tooth
1 chunk of antler
9 iron awls
1 pick, iron
5 thimbles
1 lead cylinder
4 copper points
2 brass jinglers
1 phalanx bone
2 bone fishhooks, fine specimens
2 jew's-harp handles
8 kaolin pipe bowls
2 iron hooks
7 string Indian trade beads
1 string of shell beads
1 wolf's tooth, perforated
1 elk's tooth, perforated
1 string of beads
1 bone pipe bowl
1 pendant
1 disk
1 string of beads
1 double-pointed awl, bone
1 knife or awl of bone
1 fish bone awl
3 perforated teeth
12 bone beads
2 wolf teeth
19 awls, bone

Hill, Walter C. New York

1 old Iroquois beaded cap used in 1847
1 set of 19 old Penobscot silver disks, Oldtown, Me.
2 Iroquois silver crowns
1 bark basket, Algonquin
1 wampum belt, called the condolence belt. Purple background and six bars of white, cross and square in the middle
1 game, platter dice; platter and 6 dice

Harrington, M. R. New York

1 false face. Onondaga
1 pack strap, Canadian type
1 drum and 3 sticks
1 large flute, cedar. Cayuga
1 bone necklace. Cayuga
1 gorget with shell string attached. Cayuga
1 pair deer hoof knee rattles
1 necklace of buckskin, etc.
1 knife sheath and knife. Cayuga
1 pair shoe packs. Cayuga
1 scraper for removing snow from clothing
1 string Tuteli adoption wampum
1 wooden bowl

ARTICLES FROM ST REGIS RESERVATION

1 woman's legging
1 fragment of legging, beaded
1 carved cradle board
1 bean or sugar bos, bark

ARTICLES FROM MUNCEYTOWN, ONT.

2 bark bowls
1 coiled basket
1 bark bag
1 bark spoon

ARTICLES FROM MORAVIANTOWN, ONT.

2 bowls
4 wooden spoons
1 pack strap
1 pudding stick
1 tomahawk fragment
5 brooches, silver
1 pair earrings
1 knife
8 baskets
1 wooden bowl
1 pack frame
1 splint cutter

Collection

20 skulls
40 femora
Parts of 65 skeletons from McCullough farm, Gerry
125 potsherds, in 2 boxes
50 arrow points
5 spears
2 celts
1 crushed pot
1 small celt
5 hammerstones
1 pipe stem
1 heron's bill, from grave
2 pottery vessels, crushed
1 bag pottery from central pit, Gerry
1 bag pottery from ash deposits
1 bag stone implements
2 celts
10 arrow points
1 pottery vessel
1 pipe
1 pestle
1 net sinker
2 gorgets from Cassadaga
1 bag flints
1 gorget, Irving

Purchase and collection in the field

1 wampum string, runner's announcement
1 pair baby moccasins
1 wampum string, condolence or "horns"
1 pair women's leggings
1 burden strap
40 silver brooches
2 ladles
1 paddle
1 Eagle dance rattle
1 Prayer rattle
1 pair women's leggings
1 woman's dress, ceremonial
20 brooch maker's tools
1 large round brooch
23 square brooches, silver
1 ceremonial overdress
1 earring and pendant
1 silver and glass ear pendant
1 flute
1 Eagle dance headdress, heron feathers
2 deer skin gambling mats
1 buffalo skin ceremonial robe
1 turtle shell rattle
1 flute, Logan
1 blow pipe
1 corn seive basket

Total .... 722+

XI

Appendix A

NEW ENTRIES ON GENERAL RECORD OF LOCALITIES OF AMERICAN PALEOZOIC FOSSILS BELONGING TO STATE MUSEUM

Alphabetic list of localities

Brownsville (Jefferson co.), 3589
Buffalo (Erie co.), 3565
Chazy (Clinton co.), 3580, 3584
Clinton (Oneida co.), 3598, 3599
Crabb island (Clinton co.), 3586
Delhi (Delaware co.), 3557
East Canada creek (Fulton co.), 3587
Eskdale, New Brunswick, Can., 3563
Evans Mills (Jefferson co.), 3568, 3572, 3588, 3593, 3608, 3610, 3611
Griswold (Wyoming co.), 3560
Highland Mills (Orange co.), 3600, 3601, 3602
Indian river (Jefferson co.), 3610
Ingham Mills (Herkimer co.), 3594
Ithaca (Tompkins co.), 3556
La Fargeville (Jefferson co.), 3604, 3605, 3609
Lebanon, Ohio, 3567
Le Raysville (Jefferson co.), 3570, 3574, 3603
Lorraine gorge (Jefferson co.), 3596
Otisville (Orange co.), 3564
Perch lake (Jefferson co.), 3571, 3575
Plattsburgh (Clinton co.), 3576
Pulaski (Oswego co.), 3597
Sandy Hill (Saratoga co.), 3595
Sanfords Corners (Jefferson co.), 3588, 3590, 3591
Saratoga Springs (Saratoga co.), 3573
Sloop island (Clinton co.), 3586
Smith's Landing (Greene co.), 3561
Stafford (Genesee co.), 3559
Stone Mills (Jefferson co.), 3606, 3607
Swanton, Vt., 3562
Theresa (Jefferson co.), 3558, 3569, 3612
Valcour island (Clinton co.), 3579, 3581, 3585
Valcour (Clinton co.), 3578
Watertown (Jefferson co), 3582, 3583, 3592
Waterville (Oneida co.), 3366

New York localities according to counties

Names in italics are new to the record.

CLINTON CO.
Chazy
Crabb island
Plattsburg
Sloop island
Valcour
Valcour island

DELAWARE CO.
Delhi

ERIE CO.
Buffalo

GENESEE CO.
Stafford

GREENE CO.
Smith's Landing

HERKIMER CO.
East Canada creek
Ingham Mills

JEFFERSON CO.
Brownville
Evans Mills
Indian river
La Fargeville
Le Raysville
Lorraine
Lorraine gorge
Pamelia Four Corners
Perch lake
Sanfords Corners
Stone Mills
Theresa
Watertown

ONEIDA CO.
Clinton
Waterville

ORANGE CO.
Highland Mills
Otisville

OSWEGO CO.
Pulaski

SARATOGA CO.
Sandy Hill
Saratoga Springs

TOMPKINS CO.
Ithaca

WYOMING CO.
Griswold

Index to formations

Lower Cambric, 3562
Potsdam, 3610, 3612
Greenfield limestone, 3573
Fort Cassin beds, 3578

Theresa limestone, 3570, 3571, 3572, 3617, 3620
Potsdam sandstone, 3558, 3568, 3569
Chazy limestone, 3576, 3577, 3579, 3581
Pamelia limestone, 3574, 3575, 3604, 3605, 3606, 3607, 3608, 3609, 3611, 3613, 3614, 3615, 3616, 3618, 3619, 3621, 3622, 3623, 3624, 3625
Lowville limestone, 3588, 3589, 3590, 3591, 3592, 3593, 3594, 3603, 3626
Black river limestone, 3582, 3583, 3584
Trenton limestone, 3580, 3585, 3586, 3587
Utica shale, 3595
Lorraine, 3596, 3597
Hudson river group, 3567
Clinton, 3598, 3599
Salina, 3564
Bertie waterlime, 3565, 3566
Becraft limestone, 3561
Oriskany sandstone, 3600, 3601
Schoharie, 3602
Stafford limestone, 3559
Ithaca beds, 3556
Oneonta sandstone, 3557
Portage (Cashaqua shale), 3560
Carbonic, 3563

Record of new localities

3556 Ithaca beds. Cornell Heights, Ithaca. Abandoned quarry on the south side of the highway at the foot of the slope below the trolley loop; 270 feet above Spirifer laevis zone, 672 ft A. T. C. L. Breger purchase, 1906

3557 Oneonta sandstone. Delhi, Delaware co. H. J. Alden purchase 1906

3558 Potsdam. Beekmantown passage zone of the Theresa quadrangle. H. P. Cushing coll. 1907

3559 Stafford limestone. Stafford. John Gillard, donor, 1907

3560 Portage (Cashaqua shale). From concretion in Cashaqua shale in bank of Murder creek near Griswold, Wyoming co. D. D. Luther coll. 1906

3561 Lower Becraft (Scutella). Catskill Cement Co.'s quarry, Smith's Landing, Greene co. G. H. Chadwick, coll. and donor

3562 Lower Cambric. Swanton, Vt. Ward's Natural Science Establishment purchase

3563 Carbonic. Eskdale, New Brunswick, Can. F. Krantz purchase 1907

3564 Salina. Upper layers of Shawangunk grit along Erie Railroad, 2½ miles from Otisville toward Port Jervis. H. C. Wardell coll. 1907

3565 Bertie waterlime. Buffalo. Ward's Natural Science Establishment purchase 1907

3566 Bertie waterlime. Waterville. Ward's Natural Science Establishment purchase 1907

3567 Hudson river group. Lebanon, Ohio. Ward's Natural Science Establishment purchase 1907

3568 Potsdam (Beekmantown passage beds). Evans Mills, Jefferson co. H. P. Cushing & R. Ruedemann coll. 1907

3569 Potsdam (Beekmantown passage beds). Theresa, Jefferson co. H. P. Cushing & R. Ruedemann coll. 1907

3570 Theresa limestone. Le Raysville, Jefferson co. H. P. Cushing & R. Ruedemann coll. 1907

3571 Theresa limestone (top of). 1¼ mile east of Perch lake, Jefferson co. H. P. Cushing & R. Ruedemann coll. 1907

3572 Theresa limestone. Evans Mills, Jefferson co. H. P. Cushing & R. Ruedemann coll. 1907

3573 Greenfield limestone. Beeler quarry, Saratoga Springs. R. Ruedemann coll. 1907

3574 Pamelia limestone (near base). Le Raysville, Jefferson co. H. P. Cushing & R. Ruedemann coll. 1907

3575 Pamelia limestone. 1¼ mile east of Perch lake, Jefferson co. H. P. Cushing & R. Ruedemann coll. 1907

3576 Middle Chazy (base). 1 mile north of Plattsburgh. R. Ruedemann coll. 1907

3577 Middle Chazy. Sloop island, Lake Champlain. R. Ruedemann coll. 1907

3578 Fort Cassin beds. Valcour, Clinton co. R. Ruedemann coll. 1907

3579 Lower Chazy. South shore of Valcour island. R. Ruedemann coll. 1907

3580 Trenton (lower 50 ft). Below sawmill on Little Chazy river, Chazy. R. Ruedemann coll. 1907

3581 Upper Chazy (bottom of). Valcour island. R. Ruedemann coll. 1907

3582 Black river (cherty beds). Diamond island, Watertown. R. Ruedemann coll. 1907

3583 Black river (middle bed). Diamond island, Watertown. R. Ruedemann coll. 1907

3584 Black river (top). Jones's quarry, Chazy, Clinton co. R. Ruedemann coll. 1907

3585 Trenton (loose). Valcour island, Clinton co. R. Ruedemann coll. 1907

3586 Trenton. Crabb island, Clinton co. R. Ruedemann coll. 1907

3587 Trenton (upper third). East Canada creek, Fulton co. R. Ruedemann coll. 1907

3588 Lowville (upper). Between Evans Mills and Sanford's Corners, Jefferson co. H. P. Cushing & R. Ruedemann coll. 1907

3589 Lowville. 3½ miles north of Brownville, Jefferson co. H. P. Cushing & R. Ruedemann coll. 1907

3590 Lowville. Section along railroad and south of Sanford's Corners (bottom of cliff). H. P. Cushing & R. Ruedemann coll. 1907

3591 Lowville (near top). 1 mile south of Sanford's Corners, Jefferson co. H. P. Cushing & R. Ruedemann coll. 1907

3592 Lowville (upper). Quarry opposite filter plant, Watertown. H. P. Cushing & R. Ruedemann coll. 1907

3593 Lowville. Evans Mills, Jefferson co. H. P. Cushing & R. Ruedemann coll. 1907

3594 Lowville. Inghams Mills, Herkimer co. R. Ruedemann coll. 1907

3595 Utica shale (base). Sandy Hill, Saratoga co. R. Ruedemann coll. 1907

3596 Lorraine. Lorraine gorge, Lorraine, Jefferson co. R. Ruedemann coll. 1907

3597 Lorraine beds. Pulaski. R. Ruedemann coll. 1907

3598 Clinton shale (overlying upper iron ore bed). Clinton. R. Ruedemann coll. 1907

3599 Clinton shale (overlying lower iron bed). Clinton. R. Ruedemann coll. 1907

3600 Oriskany. Erie Railroad cut, Pine hill near Highland Mills, Orange co. H. C. Wardell coll. 1907

3601 Schoharie (upper layers). Erie Railroad cut, Pine hill near Highland Mills, Orange co. H. C. Wardell coll. 1907

3602 Schoharie. At edge of woods about 300 yards north of Erie Railroad cut at Pine hill near Highland Mills, Orange co. H. C Wardell coll. 1907

3603 Lowville (base). ½ mile northeast of Le Raysville, Jefferson co. H. P. Cushing coll. 1907

3604 Pamelia limestone (base). La Fargeville, Jefferson co. H. P. Cushing coll. 1907

3605 Pamelia limestone (base). ½ mile east of La Fargeville, Jefferson co. H. P. Cushing coll. 1907

3606 Pamelia limestone. 2 miles south of Stone Mills, Jefferson co. H. P. Cushing coll. 1907

3607 Pamelia limestone. 1 mile east of Stone Mills, Jefferson co. H. P. Cushing coll. 1907

3608 Pamelia limestone (base). Evans Mills, Jefferson co. H. P. Cushing coll. 1907

3609 Pamelia limestone. 2 miles southwest of La Fargeville, Jefferson co. H. P. Cushing coll. 1907

3610 Potsdam sandstone. Indian River 3 miles north of Evans Mills, Jefferson co. H. P. Cushing coll. 1907

3611 Pamelia limestone (base). ¼ mile south of Evans Mills, Jefferson co. H. P. Cushing coll. 1907

3612 Potsdam sandstone. 2 miles west of Theresa, Jefferson co. H. P. Cushing coll. 1907

3613 Pamelia limestone (base). 1 mile east of Perch lake, Jefferson co. coll. 1907

3614 Pamelia limestone (base). 1 mile northeast of Perch lake, Jefferson co. H. P. Cushing coll. 1907

3615 Pamelia limestone (base). 3 miles east of Perch lake, Jefferson co. coll. 1907

3616 Pamelia limestone. 1 mile east of Pamelia Four Corners, Jefferson co. H. P. Cushing coll. 1907

3617 Theresa limestone. 2 miles north of Perch lake, Jefferson co. H. P. Cushing coll.. 1907

3618 Pamelia limestone (base). 1 mile east of Perch lake, Jefferson co. H. P. Cushing coll. 1907

3619 Pamelia limestone. 1 mile northeast of Evans Mills, Jefferson co. H. P. Cushing coll. 1907

3620 Theresa limestone. 2 miles northeast of Perch lake, Jefferson co. H. P. Cushing coll. 1907

3621 Pamelia limestone (base). 1 mile northwest of Perch lake, Jefferson co. H. P. Cushing coll. 1907

3622 Pamelia limestone (base). 2 miles northwest of Evans Mills. Jefferson co. H. P. Cushing coll. 1907

3623 Pamelia limestone (base). 2 miles east of Perch lake, Jefferson co. H. P. Cushing coll. 1907

3624 Pamelia limestone (base). 2½ miles north of Evans Mills, Jefferson co. H. P. Cushing coll. 1907

3625 Pamelia limestone. 1 mile west of Evans Mills, Jefferson co. H. P. Cushing coll. 1907

3626 Lowville limestone (base). 1 mile west of Le Raysville, Jefferson co. H. P. Cushing coll. 1907

Record of foreign localities

Specimens bearing lemon yellow tickets

255 Siluric. Lövenich, Rhenish Prussia. F. Krantz purchase

256 Lower Siluric. Königshof, Germany. Ward's Natural Science Establishment purchase

257 Cambric. Skrej, Bohemia. Ward's Natural Science Establishment purchase

258 Lower Siluric. Osek, Bohemia. Ward's Natural Science Establishment purchase

259 Siluric. Beraun, Bohemia. Grebel, Wendler & Co. purchase

260 Siluric. Gothland, Sweden. Grebel, Wendler & Co. purchase

261 Siluric. Dudley, England. Grebel, Wendler & Co. purchase

262 Devonic. Ferrones, Spain. Grebel, Wendler & Co. purchase

263 Siluric. Drabow, Bohemia. Grebel, Wendler & Co. purchase

264 Siluric. Rotziküll, Island of Oesel, Baltic sea. Grebel, Wendler & Co. purchase

265 Upper Siluric. Rotziküll, Island of Oesel, Baltic sea. F. Krantz purchase

266 Devonic. Forfarshire, Scotland. F. Krantz purchase

267 Siluric. Gera, Thuringia, Germany. Grebel, Wendler & Co. purchase

268 Siluric. Westmoreland, England. Grebel, Wendler & Co. purchase

269 Siluric. Skellgill Beck, Ambleside, England. Grebel, Wendler & Co. purchase

270 Siluric. Goni, Sardinia Island, Mediterranean sea. Grebel, Wendler & Co. purchase

271 Siluric. Vallongo, Portugal. Ward's Natural Science Establishment purchase

272 Lower Siluric. Isvos on the Walchow, Russia. Ward's Natural Science Establishment purchase

273 Lower Siluric. Angers, France. Ward's Natural Science Establishment purchase

274 Cambric. Andrarum, Sweden. Ward's Natural Science Establishment purchase

275 Lower Devonic. Eifel, Germany. Ward's Natural Science Establishment purchase

276 Lower Siluric. Hostin, Bohemia. Ward's Natural Science Establishment purchase

277 Lower Siluric. Étage D, d1 sta. Benigna, Bohemia. Ward's Natural Science Establishment purchase

278 Lower Siluric. Étage D, d5. Lejckov, Bohemnia. Ward's Natural Science Establishment purchase

279 Devonic. St German le Fouilloux, Mayenne, France. F. Krantz purchase
280 Devonic. Rhisnes, Belgium. F. Krantz purchase
281 Cambric (Shineton shales). Shropshire, England. F. Krantz purchase
282 Lower Siluric. Girvan, Scotland. F. Krantz purchase
283 Upper Siluric. Muirkirk, Scotland. F. Krantz purchase
284 Siluric. Naninne, Namur, Belgium. F. Krantz purchase
285 Lower Permic. Nürschan, Bohemia. F. Krantz purchase

THE BEGINNINGS OF DEPENDENT LIFE

BY JOHN M. CLARKE

For a number of years the writer has endeavored to assemble material from the older faunas which might illuminate the incipient expressions of dependent life. It is through this avenue only that the problem of the origin of the symbiotic conditions which now pervade all nature can ultimately be approached with hope of resolution.

The dependent condition of individual existence is one of the manifold presentments of organic adaptation which is to be comprehended best by comparison of the complicated conditions prevalent today with their simpler expressions in the early life of the earth. Adaptation is in large measure a sociological problem of immediate concern. It is not proper to consider the more serious features of sociological adaptation as merely analogous to organic adaptation. In human society dependence means simplicity, that is, loss of complexity; it reduces moral independence and induces idleness, beggary, misery and crime. Here is no question of analogy, but rather of continuity of mode, of cause and effect, penetrating human society. Such laws as govern its fundamental and primary manifestations are to be sought in the primitive life of the earth.

I am fully aware of what extensive data are essential to adequate conclusions in this inquiry and how far-reaching the bearings of the inquiry must be. At this time I should go no further perhaps than to point out some of the very numerous and most instructive expressions of these conditions which it has been practicable to bring together, abiding in the hope of eventually collating more copious data. I shall not go too far, however, in suggesting certain obvious inferences which seem entirely justified by these data and by the general principles of adaptation.

Dependent life, whether expressed in the often extraordinarily complicated conditions of parasitism, or in more simple symbiotic manifestations such as commensalism or mutualism or still more simply in the merely fixed condition of the individual through the whole or a part of its life, involves conditions of degeneration. These degenerative effects are relative; they may involve an individual in most of its essential organs and functions, a genus, a family or an entire class of organisms. Such effects may be restricted to only a part or certain parts of an organism and special degenerate organs are recognized throughout the higher forms of nature.

Degeneration follows adaptation. It may be primarily the result of special adaptation in the individual for its own protection producing no more than a condition of fixation. This is degeneracy in essence because it involves dependence. Discovered and perfected by the organism as helpful against its enemies or in the winning of food, it continues into atrophy of organs no longer needed; such atrophy once begun extends to other organs as the adaptation and dependence become more complete, till in the end all the organs in succession become involved in accordance with the lessened demand upon them; the alimentary, the locomotive, the sensory, all except those involving the function of reproduction. Nature is permeated with such degeneration. Few, probably no members of the whole vast fauna and flora of the earth are free of the bond of supporting others at the cost of their own effort and vitality. From the protozoa and bacteria to man and the oak every greater or less division of nature is riddled with these dependent organisms.

The path of evolution is specialization, chiefly by adaptation; only occasionally is evolution progress. The upward march of organic nature is before the eye, palpable, pleading and perspicacious, but degeneracy is largely unseen, impalpable, sequestered and ignored. Often though expressed openly, even throughout great natural divisions, it is not apprehended. Progress involves complication of structure; simplicity of structure too often means derivation by degeneration from the complex rather than initiation of upward advance.

The total result of degeneracy in nature and in human society presents itself to us as the outgrowth of a primitive miscarriage in the normal upward trend of nature which has grown in intensity with the passage of time till now it presents to the philosophic mind the appalling condition of a widespread downward impetus throughout the living world whose tendency is to undermine that which still stands upright. Degenerative tendencies in organic and in social life increase and intensify by their own impetus, like a stone rolling down hill. It has not been shown that there is in nature any power to redeem itself when degenerative adaptation has once begun, any hope of salvation within the organism or group of organisms, of turning back, recouping and starting again on the upward path. In the face of the counter evidence here set forth, the conclusion is unavoidable that, for a large part of humanity ethical philosophies are inefficient and illusive.

The lines of progress in organic life have steered wide of these dependent existences or have maintained their charted course in spite of them.

Great groups of organisms, classes, orders and subkingdoms have been so permeated by degeneracy of growth that their life, lasting, it may be, from almost the dawn of existence to the present, has had no other outcome than to perpetuate a depraved race. Such a race, however broad its boundaries and long its perdurance, has been entirely outside the general path of that upward advance which has led to the higher expressions of life. I would cite the mollusks as such a great division of organisms. Created free and independent, their almost universal acquisition of shell protection has kept them down to earth or made them grubbers in the mud of the ocean. Only a few of them, by acquirement rather than by endowment, sail the seas, and the floating habit, says a well known writer, is nearly related to the sessile. They have progressed only within the narrow limitations of their own race. Out of them has come nothing better. No lines of progressive evolution lead from the higher organisms back to them, but all pass them by. We do not even know the real relations of the great subdivision of the Mollusca to the molluscoids — the brachiopods and bryozoans; whether these are not degenerative expressions from the early mollusks rather than stages along the line of development to higher molluscan forms. We do know that all have filled the earth and sea of today with representatives in no substantial degree different from their ancestors of the Silurian.

Were we to begin an investigation of the degenerate condition pervading nature and to start with man and his more than one hundred species of parasites, there would be but one conclusion of our excursion; it was clearly stated long ago:—the whole creation groaneth and travaileth.

In the more innocent expressions of symbiosis termed mutualism and commensalism, where associations of organisms are purely social and apparently harmless or even mutually advantageous to the participants, it is probable that the outcome is infallibly deleterious.

The glass rope sponge (Hyalonema) has its coil of rope, by which it anchors itself to the sea bottom, incrusted and shielded by a coral (Polythoa), which spreads like a thin wrap of felt all about it, while its ally the Venus Flowerbasket (Euplectella) imprisons a crab in its interior behind the bars it throws across its aperture but feeds it with ever changing water currents; worms and anthozoan corals grow together, with the tubes of the former surrounded by the cells of the latter, both sweeping the water currents together for food which may go to either mouth; dead snail shells in which hermit crabs have taken residence are often beset with sea anemones (Sagartia and Adamsia) whose stinging cells may scare away the enemies of the crab, while the crab favors the fixed anemones by moving his establishment from place to place, thus to new feeding grounds. All these conditions seem on the surface entirely harmless or positively advantageous to all parties involved; that is advantageous in the sense that they make life easier, less arduous, discourage activity and perfect adaptation. Perfect adaptation, however, advantageous to the individual concerned, is the very expression of degeneration in symbiotic life. Throughout nature complete adaptation makes for stability and long life, incomplete adaptation for the restless activity which leads to progress.

The general effect then of all symbiotic conditions is degenerative. They themselves arise from degenerate tendencies and could not exist save that degeneration had already set in. They are expressions of this condition and serve to confirm and transmit this tendency. The fact is tremendously evident that even the most innocent of symbiotic, dependent or attached conditions of growth is the leaven of progressive degeneracy.

It is well known that the critical methods of morphology and embryology have been requisite to determine the original ancestral independence of the most debased of parasites. While the doctors of the middle ages wondered over the barnacles and pictured them as growing on trees, dropping thence to the ground transformed into geese, their real nature as debased crustaceans was not unfolded till the life history of the creatures showed that their early stages were free and predatory, and the adult condition one of extreme adaptation by progressive loss of functions and organs. Thus the parasitic and dependent habit is always preceded by a free and predatory condition. Once the dependent habit is established the capacity for reaction grows weaker; degenerative adaptation creeps still further back in the life of successive generations and the degradation of the adult state becomes more profound.

The all pervading conditions of symbiosis and dependence in living creatures are largely beyond the reach of our present inquiry. We are endeavoring to seek some clew to the origin of dependent life from its earliest and simplest expressions. The parasitic conditions of the present organic world are complicated in the extreme as a result of progressive and easy adaptation; often two, three and sometimes four hosts are necessary to the full life course of the dependent. Usually these present extreme conditions are expressed only by soft-bodied terrestrial organisms. The evidences of dependent life presenting themselves to the paleontologist must be chiefly of marine origin and wholly adapted to a single host; they must moreover be wholly simple in their expression or may be easily misconceived. There are certain of these simple expressions of long standing; we find them in existing nature and the ancient faunas show that such associations began far back in the history of life. To some of these we shall make special reference. Besides these a multitude of illustrations of dependent and attached forms of organisms can be drawn from every hand in the ancient as well as the recent faunas. They call for no special illustration but they nevertheless enforce our consideration of the origin of this condition.

So far as our facts go there are but few evidences of true parasitic conditions in the Paleozoic faunas. The oldest and clearest is the well known case of the coalition of the limpetlike snail Platyceras and the crinoids. The snail settles down at an early age on the dome of the crinoid, placing the aperture of the shell over the anal vent of its host and remains attached for an indefinite period of its subsequent life.

It is clear that the snail depends for its food on the waste from the crinoid and the fact that it remains attached for a very considerable period of its existence is shown by specimens of the crinoid dome bearing successive scars made by the enlarging growth of the mouth of the snail shell. Though this is the most extreme expression of ancient parasitism known to us, it was evidently of a very elastic kind and by no means affected all individuals of this genus of shells. This combination makes its first appearance in the early Devonic and seems to have become intensified in the great crinoid plantations of the early Carbonic but in either formation the examples of the actual dependent combination are in very slender proportion to the number of individuals of either snail or crinoid. Some of the snails acquired this habit of parasitic dependence, others evidently did not. Apparently it was in some measure an individual adjustment. Yet the more general dependence of this snail Platyceras on the crinoids is indicated by the fact that quite generally Paleozoic strata carrying an abundance of the one also abound in the other.

Time has not extinguished this affiliation, for the existing seas afford occasional evidence of similar relation between the limpets and the crinoids. Our material seems to throw some light on the inception of this dependent habit. A crinoid, Glyptocrinus, from the Lower Siluric is occasionally found inclosing in its arms a holostomatous snail, Cyclonema, not attached to the dome, for the shell had not the limpet habit of attachment, but lying free in such attitude as to get the full advantage of the crinoid's waste.

True dependence is also indicated by a similar association between the crinoids of the Carbonic rocks and the starfish Onychaster. The starfish adjusts itself, mouth downward over the anal aperture of the crinoid. Our specimens showing this condition have been caught in this act of feeding. The flexible character of the starfish made the attachment easily subject to change. This association too is one that time has not cured.

Much more abundant than these exhibitions of parasitism are those of the commensal habit as indicated by our illustrations of worms and corals, worms and sponges, barnacles and corals.

In the natural and expected course of procedure commensalism is the precursor of parasitism, and commensal associations became established more abundantly and at an earlier date than the other. Such mutual associations among members of the groups here indicated have been continued till today, not in precisely similar manifestation but in like alliances between individuals of the different divisions.

The protected sedentary condition, effected either by the agency of a special organ, as among most of the old brachiopods during a part or all of their life, or by the cementation of the shell to the rocks or some like object, is so widespread as to here command attention as a still simpler expression of dependent life. That the attached condition among organisms involves and expresses degeneration and necessarily promulgates still further decline, biologists are well agreed.[1] An argument therefore to show that groups of attached organisms like the corals, the sponges, the bryozoans, are degenerate and that their apparent simplicity of structure is less a primitive than a derived condition, is not here called for.

As we contemplate the earliest faunas of the earth we find that adherent and attached forms of life are in a notably less proportion than in the faunas succeeding. Bryozoans, crinoids, corals, sponges, attached worms are extremely rare; trilobites and brachiopods enormously predominate. The trilobites were crawlers and swimmers. The brachiopods however were of different habit. The predominating forms were the inarticulate species allied in structure to the living Lingula and, if allied also in habit, burrowed in the mud of the sea bottom with their fleshy pedicles, potentially not actually attached. Some of the genera with long pedicle sheaths may not have had this habit but have been actually attached to solid objects by their arm; this was undoubtedly the habit of the articulate brachiopods also until the time came with the maturity of these creatures when the arm was atrophied and they fell back on the sea bottom, free but still incapable of locomotion. In this condition, like many bivalves (e. g. Mya, the soft-shelled clam, which lies buried in the mud with no power to get any way but further in) they were potentially attached though actually independent.

To the faunas earlier than the Cambric with their probable decrease of attached organisms, we can not appeal. We can, however, still follow the line of our argument into those earlier faunas which still remain unrevealed.

In all shell bearing organisms the shell is not a primitive but a secondary development. Primitive organisms, as all considerations of biology insist, were shell-less throughout their existence — a conclusion not only indicated by ontogeny but by philosophy. The generally accepted conception that the archetype of organic life was a naked free-swimming pelagic creature may be supplemented by the proposition that the primitive condition of all organisms even after departure from the radicle was still naked and free. We must conceive that only as the independent soft-bodied animals of the earliest

[1]See especially Arnold Lang. Einfluss der festsitzenden Lebensweise.

faunas adapted themselves to life in shallow waters did the necessity for shell protection arise for with this change from a free-swimming to a creeping or stationary littoral habit came the lessened capacity for escape by locomotion. As Lang has said, the coast is full of dangers; the waves beat violently against it, the regularly returning tide keeps the waters ever moving. From these attacks of nature's blind forces the creatures must protect themselves. Some, in times of stress, seek deep water, some scuttle into protected spots or bury themselves in the sand, and others catch hold of stable bodies, attaching themselves by suction or fixation. But all these resorts are inefficient without the addition of shell protection; that once achieved, the animals may rejoice and flourish in the play of the waves which brings them nourishment with decreased exertion on their part. The primary step toward a degeneration which in the lapse of ages has led to the dependent life conditions of today would seem with reason to lie in the forced reduction of this locomotive power and adaptation to a sedentary condition resulting in the necessity for the formation of a protective shell.

ILLUSTRATIONS OF PALEOZOIC SYMBIOTIC ASSOCIATIONS

The instances here given are some of the more instructive occurrences of this sort that have come under my notice. They are not in all cases common though they exemplify consociations which are familiar in like groups of the living world. The record of their number will doubtless be much increased as such objects come under closer observation. The collection of such data from the early periods of the world's life is not likely to be carried too far for it is here, rather than in a profuser and much more complicated later development, that the factors of symbiosis are the more easily legible.

Worms and Corals

The coexistence of the tubicolous worms with the corals is one of the commonest phenomena of present seas. It became established at a very early stage in the earth's history and in the Devonic coral reefs the habitude had already become widespread and varied. It was palpably less frequent in Siluric times, at least our material would so indicate, and when it does present itself, the expression is quite simple. In most cases it is an elementary expression of commensalism. Worm and coral may start to grow together directly on settling down from the free larval state, or conjunction may be formed by attachment of the annelid larva after the growth of the coral has well progressed; in both cases the growth of the latter engulfs the former save at its tentacled aperture.

The coral Zaphrentis or Cystiphyllum and the worm Gitonia corallophila. I give this latter designation to what appear to be chiefly straight worm tubes found in simple cyathophylloids such as those mentioned. The worm has attached itself at any stage of the coral growth and quite often its tubes are found projecting in considerable number from the calyx of the coral disordering the septa by its thickened stereom and taking just the position most advantageous to its feeding with the help of the coral's tentacles [pl. 2, fig. 1]. Often these tubes seem to puncture the thecal walls of the coral where actually they have become overgrown or left behind by the increase of coral substance. It is not usual to find both of these conditions in one corallite. Plate 2, figure 3, shows a Zaphrentis with a series of small worm apertures at its base; figure 2 is an enlargement of the thecal wall of Zaphrentis with two apertures one of which shows distinctly the wall of the tube; figure 4 is a Cystiphyllum with apparently short-lived worm tubes established at different growth stages of the coral. In figures 5, 6 of the same plate are two views of a tube both ends of which seem to open into the calyx of a small Zaphrentis. If I interpret the growth of this worm correctly it started almost concurrently with the coral and like the worm on Pleurodictyum kept both ends up. It will be seen by examination of these figures that the course of the worm tube is singularly erratic; both branches have kept close to the margin of the calyx, one has come pretty straight up, while the other in its late stages made almost a half circuit of the calyx.

All the examples above cited are from the Onondaga limestone of the Lower Devonic.

The corals Monticulipora and Stromatopora and the worm Gitonia sipho. These compact, stony, massive structures covered with thousands of arms reaching out for new supplies of nourishment, seem to have especially invited the settlement of straight tubed worms which, for convenience, are designated as Gitonia sipho.

A very striking example is that illustrated in plate 1, figure 4, where the coral has overgrown the face and eyes of a moulted head shield of the trilobite Dalmanites and a series of worms has started growing obliquely upward from the very beginning of the coral (Monticulipora) growth. This specimen is from the Onondaga limestone.

A very similar combination is shown in figure 3, plate 1, which represents a colony of Favosites sphericus (Helderbergian) with worms of like character. Figures 1, 2 are of a Stromatopora from the Cobleskill (Uppermost Siluric) limestone, one showing the worm apertures on the weathered surface, the other being a polished face of the same specimen with many cross-sections of oblique tubes.

The tabulate coral Pleurodictyum; the worm Hicetes innexus; a sponge, and the gastropod Loxonema (sometimes **Pleurotomaria**) **or the brachiopod Chonetes** [*see* plates 3, 4]. This is a very remarkable and most instructive combination and we have illustrated it quite fully on the accompanying plates. The combination of the coral and the worm has long been known and the sandstone casts of the base of Pleurodictyum with the "coiled central body" or "wormlike object" are common in the Lower Devonic (Coblentzian) of Germany and have frequently been illustrated.

Pleurodictyum is a compound coral growing in small lens shaped colonies with large cells and the genus is widely distributed in faunas of Lower and Middle Devonic time. We may mention P. lenticulare Hall of the Helderbergian of New York and its variety laurentinum of the Grande Grève limestone of Gaspé; P. convexum Hall, Onondaga limestone; P. problematicum Goldfuss of the Coblentzian; P. constantinopolitanum Archiac and Verneuil, from the lowest Devonic of the Bosphorus; P. amazonicum Katzer of a similar age in the Amazonas and P. styloporum Eaton from the Middle Devonic Hamilton shales of New York. The concurrence of the coral and its convoluted worm has been noted in several of the species here mentioned but the varying degree of its frequency is instructive. Thus in the earliest species, P. lenticulare, I have seen the worm tube very rarely, after the examination of a considerable number of examples; in the var. laurentinum not at all; never in the large species P. convexum Hall of the Onondaga limestone. The single illustrations of P. amazonicum and P. constantinopolitanum show its presence but enable one to form no conception of its prevalence. The combination is frequent enough in P. problematicum to have given rise to the specific name of the coral. The Middle Devonic P. styloporum has afforded the material for most of the illustrations here given. Of this very common species in the calcareous shales of the Hamilton I have been able to critically examine several hundred individuals and it is safe to say that the worm is present in the majority of examples. It is easy to determine its presence on inspection of the tentacular surface of the coral by the contrast between its round tubes and the angular coral cells. All the specimens here figured to show the convolutions of the worm have been drawn from actual preparations.

The history of the combination in P. styloporum is as follows: At the close of the free-swimming larval stage the coral, in fully eight cases out of ten, selected and attached itself to a dead or living shell of the gastropod Loxonema hamiltoniae. Directly upon fixation or even actually contemporaneous with it was the attachment of the larval worm upon the incipient coral or alongside it. In many cases, such as that illustrated in plate 4, figure 3, the worm tube is directly fixed to the gastropod; again it may be free of the gastropod, and separated from it by the thickened basal theca [*see* pl. 4, fig. 1, 2]. With the multiplication of cell growth and the upward trend of the coral, the worm began its convoluted growth, its tube growing as much at one end as at the other. Some of the existing serpulid worms have their eyes on the hinder end of the body at the tentacular surface; it is fair to presume that at this early period this advanced stage of degeneracy had not been reached and the tube was thus kept open at both ends. In view of the regularity of coiling shown in some of the commensal worm tubes it is interesting to notice that in this case the worm after making a start, gets its double coil into parallelism for a half to an entire turn and then each arm starts off into a direct course following the radial path of the coral cells. These branches often pass in and out between the cells, keeping their extremities always at the tentacular surface and very seldom is there evidence of the worm encroaching on the polypite cells. Still this may occur and the worm tube occasionally becomes encased by a young polypite and holds a position in the center of the cell [pl. 4, fig. 4].

There may be other worms encased in the thickened base of this coral as shown in figures 1, 2, plate 4, but it is not yet clear where their apertures lie as I have never seen but two annelid openings at the surface of the adult coral. It is quite possible that originally opening on the tentacular surface at an early stage of coral growth they have been buried in the later accumulations of stereom. There are long tubular passages between the corallites in early growth stages which have not been described in the structure of this coral genus and in sections these are confounded with worm tubes but in etched specimens such as have here principally served for illustration, their nature is clear.

In this interesting combination there is still another member—a small calcareous sponge. It has come to my notice several times. The one here figured was taken from the tube of the worm but whether that is its usual position or whether it may seat itself in one of the coral calyces or whether indeed it is a usual member of the consociation can not clearly be regarded as established.

I have given (pl. 4) some illustrations which show how readily the dead parts of these organisms become incrusted with serpulid worms. Figure 8 is the surface of a part of a dead Loxonema to which a Pleurodictyum had grown and figure 7 shows the inside of an old tube of the commensal worm H i c e t e s   i n n e x u s, itself incrusted with minute worm tubes.

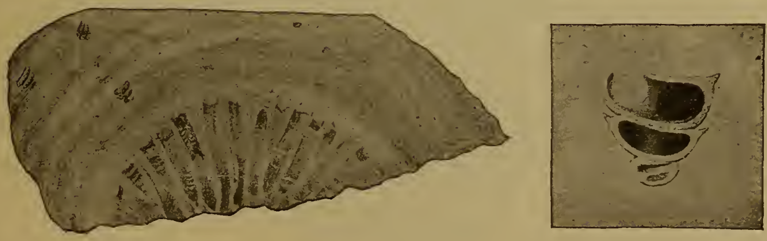
Interesting as is this instance of commensalism, its most extraordinary feature is the amazing evidence of selection by the larval coral of the body to serve as the base on which it is to grow. I have stated above that a very evident majority of the colonies of this coral Pleurodictyum as it occurs in the Hamilton shales are attached to an organic object and that this organic base in approximately 80 per cent of the cases is a shell of L o x o n e m a   h a m i l t o n i a e. Occasionally the shell may be a Pleurotomaria of one or another species. I have no record of its being any other than one of these gastropods. On the other hand the German P l e u r o d i c t y u m   p r o b l e m a t i c u m fixes itself by decided preference to the brachiopod C h o n e t e s   s a r c i n u l a t u s Schlotheim. I have examined a considerable number of specimens of this Coblentzian species but have seen no other shell used for attachment nor have I found record of any other. Though I can not use percentages with reference to the frequency of this occurrence, this palpable fact remains that as between these two closely allied if not identical corals, one selects a gastropod, the other a brachiopod as its base of attachment. Emphasis is to be put on the word "selects" for among the brilliant examples of selective adaptation none could be more striking than this. The floor of the New York ocean was covered with Chonetes and of the German ocean with gastropods during the life of this coral. Were either wanting in the other fauna, hundreds of other species of organisms lined the sea bottom. The coral was not deprived of its choice.

Taken as a whole this combination is very complicated commensalism from a date so ancient as the Devonic, more extreme than any other yet known from the Paleozoic rocks. But we find a somewhat parallel case in the present described by Bouvier as occurring in the Gulf of Aden — a coral and a worm growing together, and hidden in the coral substance a gastropod on which both settled down when the partnership began; furthermore there appears to be a small bivalve in association with the worm. Other somewhat similar cases might be cited.

The Devonic coral Acervularia and the spiral worm Streptindytes acervulariae; a Siluric Stromatopora with a somewhat similar spiral worm, Streptindytes concoenatus; a Devonic Stromatopora with the spiral worm, Streptindytes compactus. The first of these occurrences was described some years ago by Prof. Samuel Calvin [On a New Genus and Species of Tubicolar Annelida. Am. Geol. 1:24. 1888]. It is the case of a large annelid whose tube measures $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter growing upward in numbers among the cells of the compound coral Acervularia davidsoni Edw. & H. from the Middle Devonic rocks of Iowa. The species has not before been illustrated and I have to thank Dr Calvin for the privilege of introducing the accompanying cut of this interesting commensal [pl. 1, fig. 7].

Another example of these spiral commensal worms (Streptindytes concoenatus) is afforded by the Stromatopora reefs of the Cobleskill limestone (Upper Siluric). The illustration here given [pl. 1, fig. 5, 6], affords some idea of how a small mass of Stromatopora may be quite riddled with these minute corkscrews. This is taken from a single section across a small colony in which it is apparent that these worms have become sessile at different stages of growth in the coral mass as they start at different levels in the colony. It is also clear that the worm tube made at least one horizontal convolution before starting on its upward spiral growth and it is more than likely that its elongated spiral is due to the requirement of keeping its tentacular end up at the feeding surface of the growing coral. These tubicolous worms have very plastic tubes and readily adjust themselves to surroundings. In the worm of Pleurodictyum (Hicetes innexus) the early spiral form was soon lost, perhaps because the corallites are so large and close that such growth was effectually obstructed. I have given here some illustrations of a worm from the Hamilton group described by Hall as Spirorbis angulatus from closely attached examples showing but one or two entirely horizontal volutions. These silica etchings show how quickly in later growth the tube departs from the horizontal position and draws out into a loose spiral even when not confronted by the necessity of keeping its feeding end on a level with that of some companion organism [pl. 2, fig. 8-11].

The third of these combinations is illustrated by a specimen for which I am again indebted to Professor Calvin. A little colony of Favosites has had its tentacular surface entirely overgrown with a Stromatopora. Within the substance of the Stromatopora is a multitude of spiral worm tubes not stretched out into loose volutions as in the other instances mentioned, but keeping their two or three volutions in close contact and resembling an Autodetus without its external smoothly sloping surface. The edges of these tubes are apparently always angular. These little worms have started growth anywhere on the substance of the Stromatopora and instead of growing like a Spirorbis with whorls broadly attached for a turn or two, have coiled closely upward and ceased growth in every case very abruptly. This case is singularly instructive as showing that the worm failed to keep pace in growth with the coral and confessed its natural limitations of growth, while in the other cases cited the worm apparently has had the ability to adapt itself to this upward growth by stretching out its tube into loose curves and keeping its aperture always clear at the surface. The little Streptindytes compactus however was not equal to this struggle for existence except as it planted its successors in-



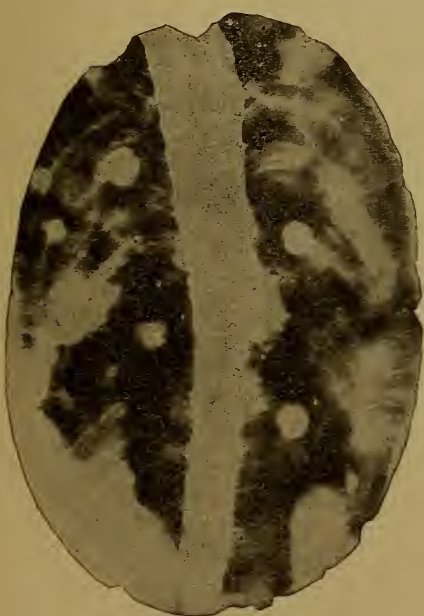
Stromatopora with embedded spiral annelid tubes. **Streptindytes compactus**, located at various stages of the growth of the coral. The character of the annelid tube is shown in the enlargement at the right (x 5). The Stromatopora has entirely overgrown a small Favosites colony. Middle Devonic. Iowa discriminately over the coral at its various levels of growth. How well it struggled to maintain itself is indicated by the presence of fully 30 individuals on a surface of this coral 2 inches square. The single specimen of this species observed is from the Middle Devonic Cedar Valley beds at Iowa City, Iowa.

Worms and Sponges

We find in more than a single instance among the fossil hexactinellid sponges of the family Dictyospongidae evidences of worm tubes attached to the inner wall or cloaca of the sponge and living in a condition of commensalism. Such worms have been observed in the species Hydnoceras tuberosum var. glossema and Prismodictya telum Hall & Clarke, from the sponge plantations of the Upper Devonic in western New York [pl. 5, fig. 1, 2]. In a considerable number of individuals of the latter species from the same locality nearly all showed the presence

of the annelid commensal and as the surface of the impression left in the sands by the worm tube is in all cases crossed by the reticulated skeleton of the sponge it is inferred that the position of the former was internal. These are silicious sponges allied to Euplectella and though we find no parallel expression of commensalism in the living glass sponges, yet Euplectella carries a parasite in the form of a crustacean which in youth enters its open cloacal cavity and remains there so that when the sponge has in adult growth built the terminal or sieveplate over its aperture the crustacean is wholly and permanently caged.

A very commanding illustration of the association between the sponges and spiral annelids is afforded by a series of specimens displayed in the British Museum. These I am able to reproduce here by the kindness of the trustees of that Museum from photographs made by permission of the Keeper of the Department of Geology, through the friendly agency of Dr F. A. Bather. In all these specimens it would appear that the worm, which has made a tube of large dimensions, began its commensal existence early in the life of the sponge and has coiled upward in a very loose spiral about and just within the cloacal wall. Of the figures given here two



These and the figure on the preceding page represent silicified sponges with spiral annelid tubes from the English Chalk. In the upper figure (locality unknown) and the lower right-hand figure (Beckhampton), the exposed worm tube is coiled about a vertical tube which appears to be the silicified wall of the cloaca. These spirals are obviously in reversed direction. The lower left-hand figure is a direct print from a thin section of another sponge in which the position of the worm tube, cloaca and concentric structure of the sponge are shown. Prepared by Dr. Bather. Figures about natural size. British Museum (Natural History) Department of Geology: A. 475; 55117 are of specimens so broken as to expose the interior. Solid flint has replaced the outer part of the sponge body, but in the disintegrated silica of the interior the tube of the cloaca stands vertical with hardened walls about which the worm tube seems to coil like a beanstalk on a pole. The transparent section which is reproduced from a direct print, shows with probably more accuracy the actual distance of the tube from the cloaca. It is extremely instructive to note that the direction of coiling is unlike in the two specimens exposing the spiral, while in the section it would be impossible to determine whether the course of the coiling is dextral or sinistral.

Barnacles and Corals

The barnacles of today express to us one of the extreme results of modification through adaptation to a parasitic condition. I have ventured to suggest on a previous occasion that the Siluric barnacles of the genus Lepidocoleus [pl. 5, fig. 3] are an expression of these creatures before such modifications set in. It is regularly segmented throughout its length, its biserial row of plates being open on one side only for the protrusion of the appendages. The forms known as Turrilepas, Plumulites and Strobilepis of the Devonic, are not of greatly different structure. We know however of fully modified acorn barnacles in the Devonic Protobalanus and Palaeocreusia. The latter is parasitic on a Favosite coral of the Onondaga limestone (Lower Devonic), in which it appears to be embedded by the overgrowth of the polypites rather than by burrowing its way into the colony as do sometimes the acorn barnacles of the present [pl. 5, fig. 4, 5].

Crinoids and Cystids with Gastropods

We are here presented with what appear to be instances of genuinely dependent parasitism—where an attached organism relies upon its host for its nutriment and existence. They constitute the earliest instances we can cite of a dependence between organisms that has become essential rather than merely convenient and it is of extraordinary interest because we find some clue here to the origin of the habit. The attachment of the limpetlike gastropod Platyceras to the calyx of the crinoid of the Paleozoic has already been referred to and many instances of it have been cited and illustrated.[1] This attachment is so effected that the mouth of the shell is seated directly over the anal aperture of the crinoid so that the former may catch the digestal waste of the latter. Upon this waste the Platyceras palpably sustains itself. So many instances of this conjunction have passed under examination that no question can arise as to the fact that such attachment is solely for feeding purposes. Suggestions which have been occasionally made that the attachment is rather accidental than otherwise, as attachment to some substantial object is the habit of the gastropod, are not borne out by the evidence afforded by multitudes of these cases. It is quite certain, however, that in the Devonic and Carbonic faunas where this habit became most prevalent, there was always a predominant percentage of the gastropods that did not lend themselves to it; nor have we reason yet to conclude that the habit once inaugurated necessarily continued during the remaining life of the individual. It did continue for a considerable period of the shell's existence as the very instructive figure 6 on plate 6 indicates, the concentric scars being the successive impressions of the lip of the shell as its growth enlarged, while its position relative to the after opening of the crinoid is unaltered.

The history of this form of dependence is extraordinary and illuminating. Throughout the Siluric the crinoids and cystids abounded but mollusks of the limpetlike construction of Platyceras were few. Moreover the crinoids were for the most part built with slender domes well hedged about by delicate arms, and on these domes the mollusk might have found difficulty in securing a footing.

The earliest intimation of the tendency on the part of a mollusk to seek its food from the rejectamenta of the crinoid is afforded by an example of a Lower Siluric Glyptocrinus which holds within its arms and in a feeding posture a shell of the holostomatous gastropod Cyclonema bilix. One might regard the occurrence accidental if it had not been observed more than once.

In the Upper Siluric, Platyceras had become somewhat more abundant but its numerical development did not reach that of the allied mollusk Diaphorostoma and in plate 6, figure 1, we have an illustration of a small shell of this latter genus attached over the after of the cystid Caryocrinus ornatus (Rochester shale). Thus far in time no examples have come to our observation of

[1] See particularly C. R. Keyes. Synopsis of American Carbonic Calyptraeidae. Acad. Nat. Sci. Phila. Proc. 1890. p. 150. The author here records a long list of these parasitic associations and especially indicates the effect of this condition in modifying the aperture of the gastropod.

attachment between Platyceras and the crinoids. With the opening of the Devonic the development of Platyceras became enormous, so much so that the calcareous phase of the earliest Devonic has been termed the Platyceras stage. The crinoids also were common at this time, but cases of any dependent conjunction of the two are extraordinarily rare; the only instance of this early date known to me is that cited by Drevermann from the Coblentzian. Little by little, however, the habit was assumed and becoming more frequent in the Middle Devonic it seems to have attained a culmination in the faunas of the earlier Carbonic. During all the ages which have intervened between the

Silicified specimens of Platyceras attached to the dome of Megistocrinus farnsworthi White, from the Middle Devonic of Iowa. The perfect adjustment of the shell to the crinoid is seen in the adaptation of its margin to every irregularity of the surface of the dome. Loaned by Prof. Samuel Calvin

Paleozoic and the present there is no record which has come to my notice to prove that this ancient habit has had an uninterrupted existence. The crinoids and the limpets have continued and certainly the detailed records of Mesozoic and Cenozoic faunas should have given some account of this habit had it perdured. We have remarked that the consociation was always an easy one to which even at its hight not all the members of the genus Platyceras were compelled. In the absence of demonstration, it may be fair to hold it possible that the descendants of these mollusks really abandoned this form of attachment and rebounded from the degenerative condition which it involved; this would be a fact of profound significance if it indicates that an organism once started on the downward path can take a new hold of life and regain its independence. Yet we are doubtless not justified in such a conclusion. In the present seas all gastropods of truly parasitic habit are parasites on the Echinoderma, the class to which the crinoids belong. Crinoids are few today and appear to be relatively free from these attachments, but their allies, the starfish and sea urchins, are still beset by the gastropods, often so reduced by the degeneration of their condition as to be scarcely recognizable. This far-reaching and general condition of depravity would seem a direct inheritance of the ancient conditions we have portrayed.[1]

Crinoids and Starfish

We have some very interesting instances of association between the crinoids and the ophiuran Onychaster flexilis Meek & Worthen. Three of these are here figured, one a copy from Wachsmuth and Springer's figure of Actinocrinus multiramosus W. & Sp., the others drawn from specimens in the possession of Mr Fred Braun. In the first the starfish has encircled with its arms the dome of the crinoid, mouth downward in such an attitude as to suggest though probably not to demonstrate that it was diligently attending to the waste of the crinoid. As the arms of the crinoid have been broken away the act of the starfish is exposed in all its nakedness. In the specimens of the Onychaster with Barycrinus hoveyi Hall, the arms of the two creatures have become completely entangled and fixation for feeding purposes at least is entirely effective. In respect to the end sought and attained this condition is one of parasitism but one still subject to the control of the individual. There seems no reason to assume that the starfish is here endeavoring to suck the life out of the crinoid itself and it would be going further than the facts justify to interpret this demonstration solely as an act of feeding like that of the common starfish of today in its attacks upon the oyster.

I quote here some remarks from Wachsmuth and Springer's *North American Crinoidea Camerata* [1897, p. 566], concerning the relations of Platyceras and Onychaster to the high domed crinoid Actinocrinus multiramosus.

Of this large and beautiful species we obtained at Indian Creek and Canton over forty specimens, most of them in excellent preservation, with the arms attached; and it is very remarkable that nearly one half of them have either a Platyceras attached to the

[1] The brothers Sarasin have described a very interesting case of the parasitic attachment of a limpetlike Platyceras to a living starfish, in which the former by an extension of its mouth into a snout which penetrates the test of the starfish, sucks out the nutritious fluids *Ergebniss einer Forschungsreise auf Ceylon, v. I*]. While the parasitic condition between the limpets and crinoids of the Paleozic was elastic, this is fixed and beyond repair. Other living snails parasitic on the allies of the crinoids are interestingly described in the *Naturwissenschaftliche Wochenschrift*, January 17, 1904.

tegmen, or a specimen of Onychaster between the arms and coiled around the anal tube. This, so far as we know, is the first instance in which a Platyceras has been found in contact with a Crinoid with a long anal tube; in all cases heretofore noticed the Crinoid had an anal opening directly through the tegmen, and the Gastropod was fastened invariably with the anterior portion of the shell over the opening. This led to the supposition, for which there seemed to be good reasons, that the Mollusk obtained its nourishment, in part at least, from the excrements of the Crinoid. This, however, was impossible in the case before us, where the anal tube, with the anus at the distal end, extends out far beyond the tips of the arms, and, so far as observed, bends abruptly to one side, so that neither the opening nor the refuse matter could have been in contact with the Mollusk.

In more frequent association with this Actinocrinus is the Onychaster, and it is worthy of note that this species of ophiuran is rarely found by itself. Nor has it been observed at Indian Creek on any of the other Crinoids, while at Canton it appears also on most of the specimens of Scytalocrinus robustus (Hall), a species with a large ventral tube, and the anus located far down at the anterior side; but with this exception we have not seen it on any other species. The fact that this Ophiurid is only found associated with certain species, and there always under similar conditions, and the frequency of this occurrence, would seem to indicate that the position between the arms of these crinoids was its favorite resting place, in which it either found protection, or some special facility for obtaining nourishment.

These specimens are from the Crawfordsville limeshale of the Lower Carbonic (Mississippian).

Crinoids and Myzostomum

All the known living species of the minute wormlike creature Myzostomum (60 to 70 in number) are parasitic on the crinoids whereon they form galls or swellings by the overgrowth of the test. Similar galls have been noted on both Mesozoic and Paleozoic species of crinoids by Bather, Shipley, Fraas and other writers, and they are generally ascribed to the Myzostoma.

Coral on a Coral

The case of Caunopora. It is now quite generally conceded that Caunopora which has commonly been regarded as a hydroid coral like Stromatopora, but with sharply defined, definitely walled tubes, is actually a laminate hydroid overgrowing a series of erect tubes like those of Syringopora or Aulopora, carrying oblique dissepiments within. Caunopora placenta Phillips is a Devonic species.

Fistulipora occidens presents a similar coalition of a hydroid coral and the primitive tubulate Aulopora. This species was described from the Upper Devonic Lime Creek shales of Rockford, Iowa, by Hall [N. Y. State Mus. 23d Rep't. 1873. p. 228, pl. 10, p. 9, 10] who recognized the fact that the large pores on the surface of the coral are projecting tubes of Aulopora. An interesting feature of this concurrence is that colonies of the Fistulipora are quite as frequently without the Aulopora as with it.

One may compare with these instances the interesting case mentioned by Whitfield of the recent coral Ctenophyllia, entirely inclosed by a hemispherical growth of Meandrina labyrinthica (described in Am. Mus. Nat. Hist. Bul. 1901. 14: 221).

In addition to the instances given above of actual commensal conditions, I am taking this occasion to append a brief account of certain ancient pseudoparasitic organisms of boring habit. These come frequently under the eye of the paleontologist but very little attention has been given to them, occasional incidental references being for the most part the sum of our knowledge of the Paleozoic expressions. The literature of the later formations contains random accounts of such organic relics but I should be going too far afield in this instance to make definite allusion to these.[1]

These boring bodies infesting the dead shells which form a large part of the material of the paleontologist are very likely to be either minute algae or fungi, or sponges of genera producing similar effects to the living Cliona or Vioa. The work of the former has had some notice [*see* Duncan Quar. Jour. Geol. Soc. 1876. p. 205; Kölliker. Zeitschr. Wiss. Zoolog. 1859, 10: 215; Loomis, N. Y. State Mus. Bul. 39. 1900. p. 223] and their tubules are recognizable by contrast by their microscopic size and the occasional presence of hyphal swellings. The total amount of deterioration and disintegration of skeletons caused by these minute organisms was doubtless great even in Paleozoic times.

The work of boring sponges, however, on ancient organisms has been a far more effective cause of destruction and waste of dead shells. There are certain conditions of preservation in which these borings enforce themselves on the attention, especially when the student has to deal with an arenaceous matrix from which all the calcareous matter of the shells has been dissolved leaving sharp

[1] Very instructive instances of these later expressions are cited in a recent paper by E. Schütze, Die bohrenden und schmarotzenden Fossilien der schwäbischen Meeresmolasse, Jahresb. d. Ver. f. vaterl. Naturk. in Württ. 63, 1907. p. 81-84; Bericht ueb. 29 Versamml. d. Oberrhein. geolog. Vereins zu Wörth, 1906; Zeitschr. f. Mineral. Geol. u. Palaeont. Jahrg. 1.

and clean casts of the borings; or when these natural conditions are reproduced artificially by removing the calcareous material from a lime shale.

Probably the first attempt to characterize with a definite name these undoubted sponge borings was that of McCoy [Brit. Paleoz. Foss. 1855. p. 260, pl. 1B, fig. 1, 1a] who illustrated under the name Vioa prisca a series of simple straight club-shaped casts of borings occurring in the shell substance of the pelecypod identified as Pterinea demissa Conrad of the Upper Siluric. It is probably safer not to designate these sponge relics by the name of any genus now living and I propose, in speaking of several distinct forms of them, to employ the term Clionolithes.

The straight clavate tubes of Clionolithes priscus (McCoy) usually originate at the edge of a dead shell and expand gently inward; probably the sponge nested at the club-shaped extremity of the hole, drawing the water currents in to itself. It is not always the case that the shell was dead before the work of these borers began. There are several illustrations given here to show that a brachiopod or pelecypod may have been attacked by these sponges at any growth stage and that after the attack had begun the growth of the shell continued. There is a curious simultaneousness in the attacks of these pseudoparasites—all started in at once and frequently one such attack is not followed by others [*see* pl. 8, fig. 2, 4]. This form, C. priscus, was quite common in the late Siluric and very abundant throughout the Devonic.

Clionolithes radicans designates a quite different expression of this boring habit. Here the tubes radiate and branch outward from a center, giving a decided rootlike expression to the resultant very complicated combination of tubes. These branching tubes often unite, fuse or anastomose producing a somewhat irregularly reticulated expression. This sponge particularly infested the living and dead shells of the brachiopods, finding entrance less often at the margin than through the pores on the surface of the shell. The complex of tubules is small in comparison with those of C. priscus and it is not unusual to find both of these forms infesting the same shell. This boring sponge, so far as my observation extends, is restricted to the Devonic.

Clionolithes reptans has threadlike vermiform tubes which wander loosely and at random through the shell substance of both brachiopods and pelecypods.

Clionolithes palmatus, a singular form assuming broad sparsely branched palmate hollow fronds and found only in the pelecypods and gastropods of the Portage group (Upper Devonic).

Among these boring bodies is another, which judging only from the form of its tubes must have been very unlike the rest. I have observed it only in the brachiopods of the Coblentzian sandstone and in order to express its notable difference from the other borings mentioned shall designate it as Caulostrepsis taeniola. In these the borers began at the edge of the shell and the casts of their borings are long, narrow tapelike tongues with an elevated edge all the way around. This corded edge is a continuous tube while the area between is a narrow flat space connecting the tubes of the loop. I hesitate to assign this curious form to the sponges; it has in miniature a resemblance to some of the worm casts found on the surface of old rocks, but the evident open connexion between the tubes of the loop makes it difficult to allot to this boring its probable maker.

Boring pelecypods were not unknown in the early Paleozoic. Instances are rare indeed but a very striking example is the small Modiomorphalike shell Corallidomus concentricus described by Whitfield from the Cincinnati shales of Ohio [*see* Geol. Ohio. 1893. 7: 493, pl. 13]. The figure given by this author shows a colony of the coral Labechia ohioensis Nicholson perforated by scores of burrows in some of which the shell itself is found. Such occurrences have been freely described in Mesozoic faunas and boring insects in the woods of the Tertiary.

EXPLANATION OF PLATES

PLATE 1

1 Part of the weathered surface of a Stromatopora from the Cobleskill limestone, Schoharie, N. Y., showing the openings of the worm tubes Gitonia sipho

2 A section of the same colony permeated with such tubes

3 A colony of Favosites sphericus Hall from the New Scotland beds (Helderbergian) with similar tubes

4 A head of the trilobite Dalmanites overgrown with a colony of Monticulipora in which is embedded a series of Gitonia sipho. Onondaga limestone, Becraft mountain, N. Y.

5 Sections of spiral tubes (Streptindytes concoenatus) in a colony of Stromatopora. The apparent difference in direction of volution in these is due entirely to the different depth and angle at which the tubes are cut. From the Cobleskill limestone (Upper Siluric) Schoharie. x 2

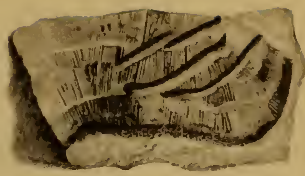
6 An enlarged restoration of the characters of these worm tubes. x 5

7 Streptindytes acervulariae Calvin: two tubes in a colony of Acervularia davidsoni E. and H. x 1.5. From the Middle Devonic of Roberts Ferry, Iowa

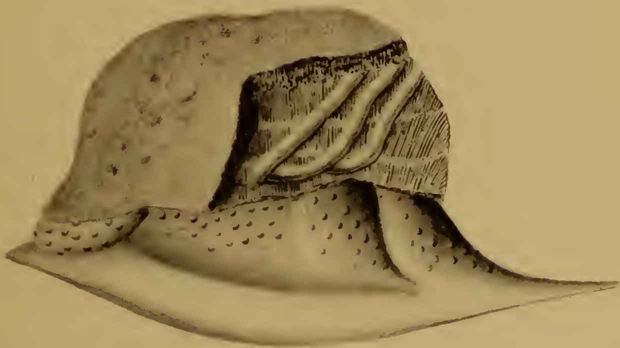
PLATE 1.

1

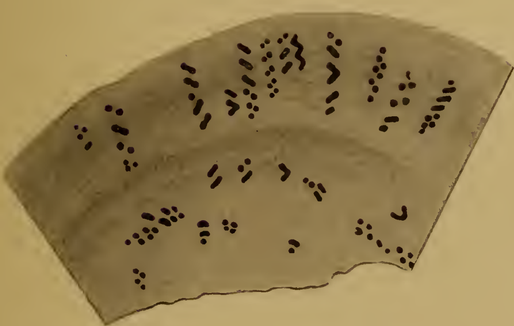
3



4

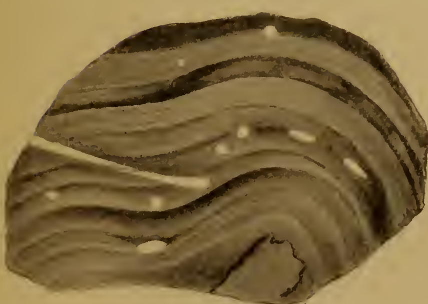


5



7

2



6

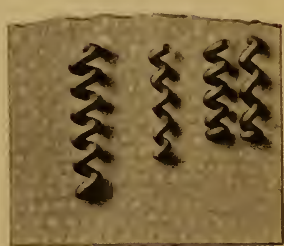


PLATE 2

1 A calyx of Zaphrentis with a number of tube openings of Gitonia corallophila

2 Tubes of the same character opening outward through the lateral walls of Zaphrentis; much enlarged

3 A Zaphrentis with tube openings at the base

4 A Cystiphyllum with short tubes opening outward through the thecal walls

5, 6 A Zaphrentis from two points of view to show the course of a tube of Gitonia corallophila with both ends opening outward in the calyx

All these specimens are from the Onondaga limestone (Lower Devonic).

7 Caunopora — a schematic section showing the Syringopora- or Auloporalike tubes overgrown by the Stromatopora substance; coral on coral

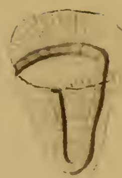
8-11 Enlarged figures of Spirorbis angulata Hall, a worm tube from the Hamilton group of New York. These specimens are silica replacements etched from limestone (Menteth limestone), and show the tendency of the tube to unwind in a lax spiral as soon as fixation is firmly established.

PLATE 2.

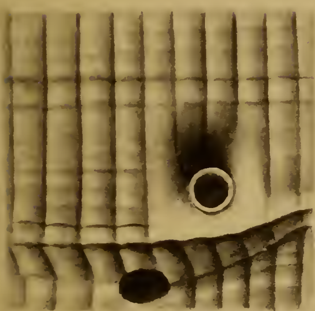
1

5

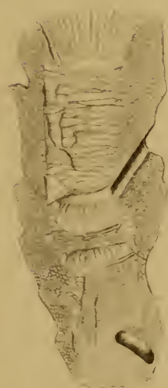
6



2



4



3

7

8

10

11

9

PLATE 3

A series of drawings to illustrate the commensalism of Pleurodictyum and the worm Hicetes innexus

1, 2 Top and side views of a corallum of Pleurodictyum styloporum Eaton from the Hamilton shales of New York. The worm tubes are clearly seen at x-x on the surface of the colony.

3 Vertical section of a corallum showing sections of the convoluted tube near its base

4 The under side of a corallum with impression of the gastropod Loxonema hamiltoniae to which it is attached

5 An etching which has removed the base of the coral and shows the initial convolutions of the worm tube

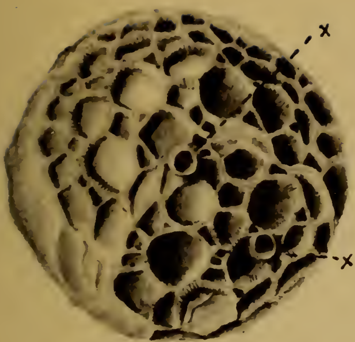
6 The form of the entire tube, drawn from an actual specimen

7 The basal surface of Pleurodictyum problematicum attached to the brachiopod Chonetes sarcinulatus Goldfuss. This specimen is from the Coblentzian at Stadtfeld.

8 An etching of the basal part of P. styloporum showing the chief worm and a wormlike extension which appears to arise from the base of a polypite and turn into an upward course between the cells

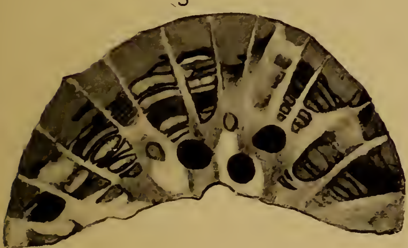
PLATE 3

1

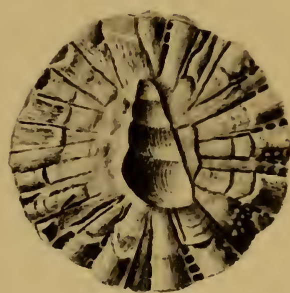


2

3



4



5

6

7

8

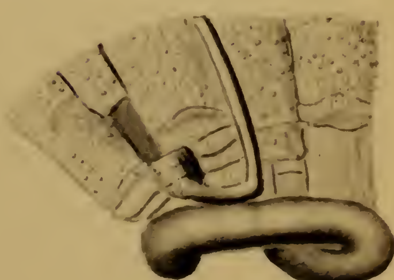


PLATE 4

Continuation of the illustration of Pleurodictyum and Hicetes, etc.

1, 2 Sections of P. styloporum showing not only the large worm but the smaller ones in the thickened base of the coral

3 An etching of P. styloporum showing actual attachment of the worm tube Hicetes to the surface of the gastropod Loxonema

4 The tube Hicetes penetrating one polyp cell and passing thence into another

5 The small sponge found in the tube of the large worm Hicetes

6 Chonetes sarcinulatus Goldfuss, the brachiopod to which P. problematicum usually is attached. (After F. Roemer)

7 The greatly enlarged interior surface of the worm tube Hicetes with slender serpulid worm tubes attached

8 The enlarged surface of part of a Loxonema, covered with small serpulids. This specimen of Loxonema had served as base of attachment for P. styloporum.

9 Loxonema hamiltoniae Hall

PLATE 4.

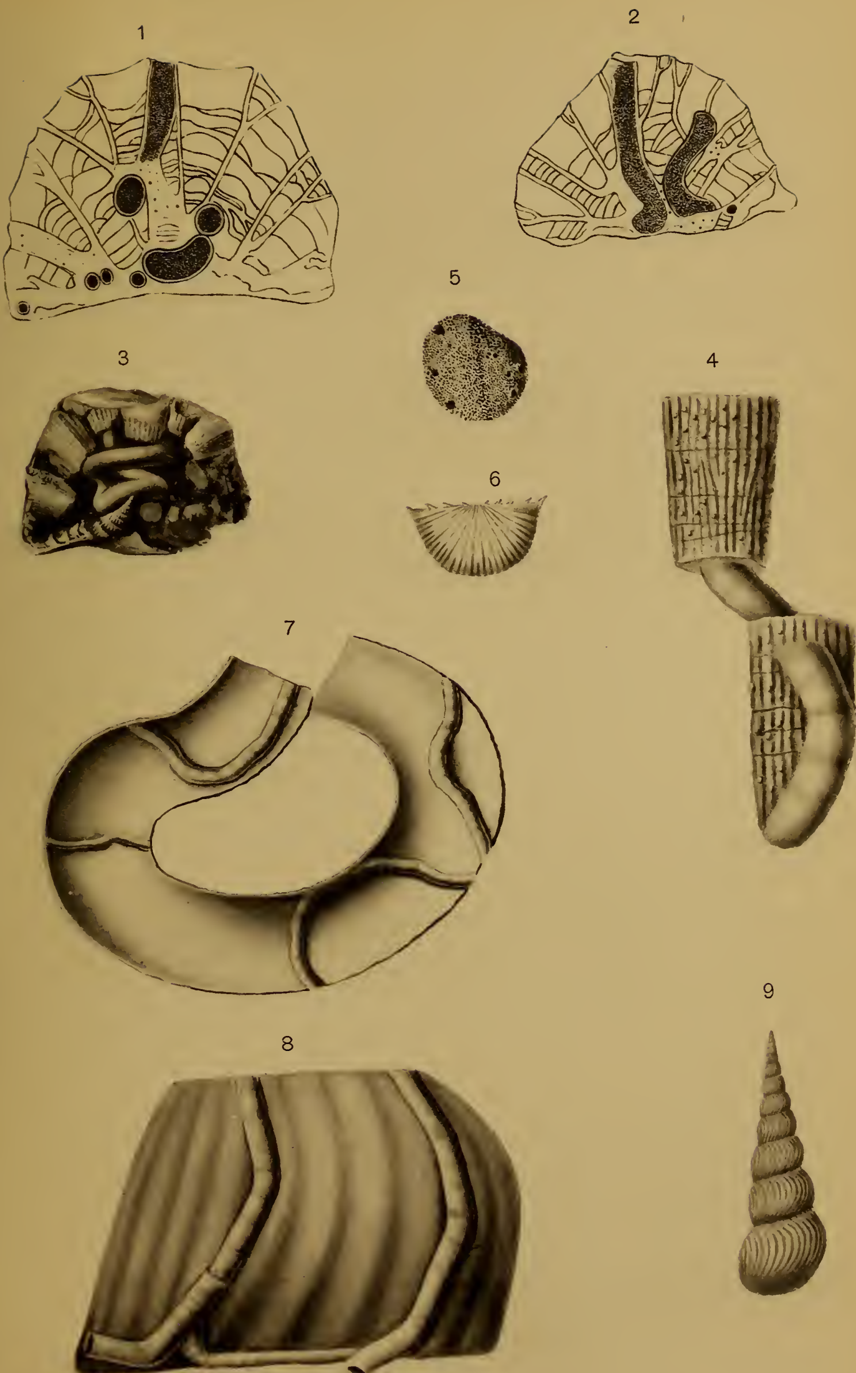


PLATE 5

1 Hydnoceras tuberosum Conrad var. glossema H. & C. A silicious hexactinellid sponge with markings of worm tubes on the inner side of the recticulum. From the Chemung group (Upper Devonic) of southwestern New York

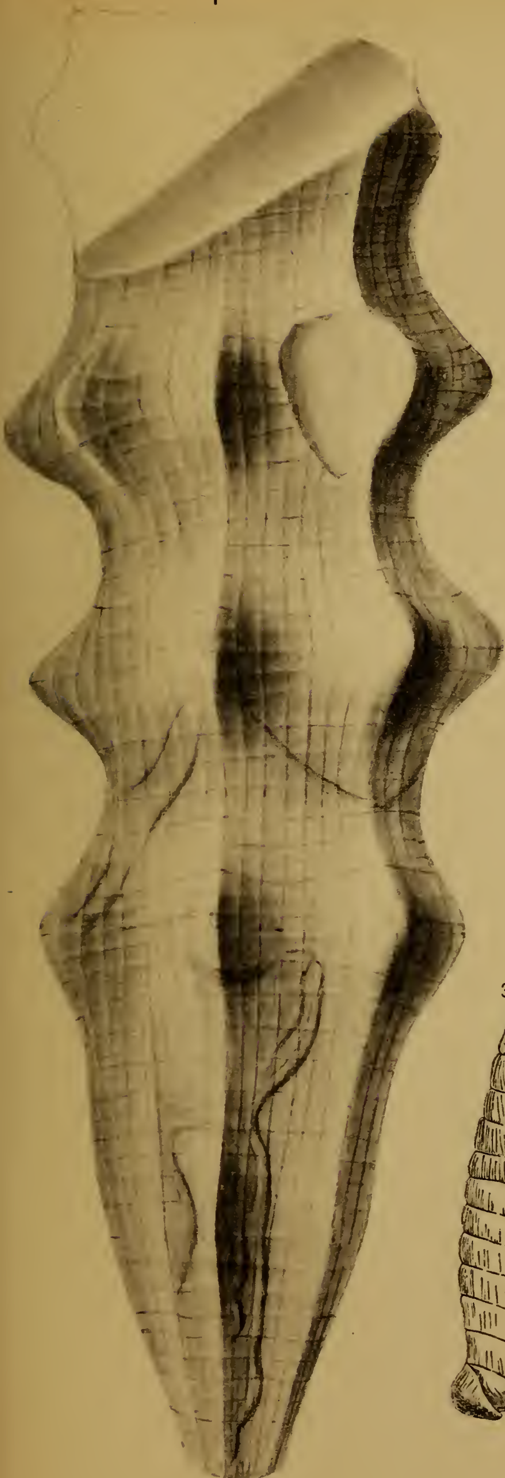
2 Another silicious sponge, Prismodictya telum H. & C. with similar worm tubes also from the Chemung group of New York

3 The barnacle Lepidocoleus jamesi of the Lower Siluric (Cincinnati group) showing the unatrophied condition of the animal whose segmentation may be regarded as represented by the paired valves which meet at the edge allowing room for the protrusion of the appendages

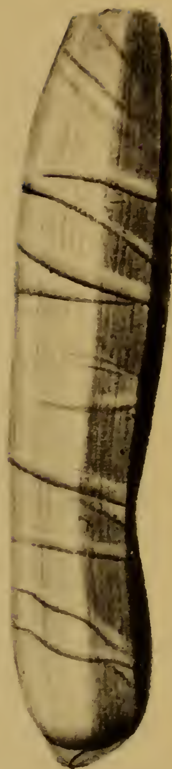
4, 5 Palaeocreusia devonica Clarke, a barnacle buried in a colony of Favosites hemisphericus partly by burrowing and partly by overgrowth of the coral. From the Onondaga limestone, Leroy, N. Y.

PLATE 5

1



2



3

4

5

PLATE 6

1 Caryocrinites ornatus Say, a cystid having a small gastropod (Strophostylus) attached and covering the apertures of the summit. From the Upper Siluric (Rochester) shale of western New York

2 Glyptocrinus (decadactylus Hall) with a holostomatous gastropod, Cyclonema bilix, inclosed within the arms in an attitude of feeding at or near the anal aperture of the crinoid. From the Cincinnati shale

3, 4 Cromyocrinus simplex with attached Platyceras of relatively large size, its anterior portion covering the anal aperture of the crinoid while the rest of the lip of the snail extends over the entire hight of the calyx. Carbonic limestone, Moscow, Russia

5 Platyceras enveloping the dome of Arthracantha punctobrachiata Williams [after Hinde, Ann &. Mag. Nat. Hist. 1885]. From the Hamilton group

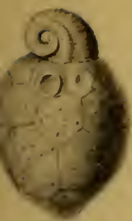
6 A part of the tegmen of Strotocrinus regalis Hall showing the successive growth marks made by an attached Platyceras, always keeping its anterior extremity over the anal aperture of the crinoid [after Keyes, Acad. Nat. Sci. Phila. Proc. 1890. pl. 2, fig. 7]. From the Carbonic (Mississippian) of Crawfordsville, Ind.

7 Platyceras infundibulum Meek & Worthen attached to the anal surface of Platycrinus hemisphericus M. & W. [after Keyes *ut. cit.* fig. 10]

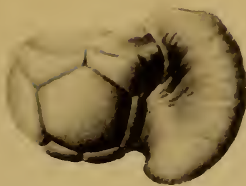
8 Actinocrinus multiramosus Wachsmuth & Springer. The calyx with a starfish (Onychaster) fastened to the anal tube [after Wachmuth & Springer *ut cit.* pl. 55, fig. 3]

PLATE 6

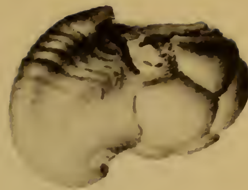
1



3

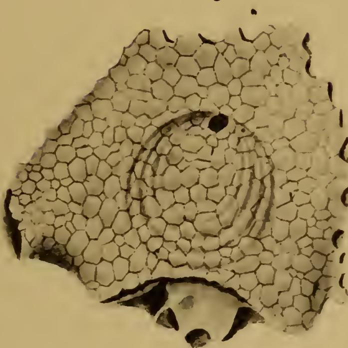


4



2

6



5

8

7

PLATE 7

1, 2 Two specimens of Barycrinus hoveyi Hall with the starfish Onychaster flexilis intertwined within the arms. (Mississippian) Carbonic. Crawfordsville, Ind. From the collection of F. Braun

PLATE 7

1

2

PLATE 8

..thes (Vioa) priscus McCoy, cast of
..s in a shell of Pterinea demissa (Conrad)
oy [after McCoy, Brit. Paleoz. Foss. pl. 1B, fig. 1, 1a]
.. same. A series of clavate tubes in the shell substance of Leptocoelia flabellites (Conrad) all starting from the margin of the valve at a definite period of growth in the shell. x 2. Oriskany sandstone, Highland Mills, N. Y.

3 The same in a valve of Spirifer from the Chemung group near Sideling hill, Maryland. x 3

4 The same. A valve of Aviculopecten from the Chemung group (Upper Devonic) of Allegany county, N. Y. with a series of borings all beginning at a definite growth stage of the shell beyond which shell growth has continued, indicating that the mollusk was alive when the borings were begun and continued to live while they were making

5 A valve of Spirifer granulosus from the Hamilton shales of New York, with several such borings

6 A tube cast in the valve of the brachiopod Leptostrophia perplana (Conrad). The sponge started to bore at the thickened cardinal process of the dorsal valve and on account of the thinness of the valve was compelled to make its tube broader than high. At the inner end the tube spreads out and shows a tendency to divide. x 3. From the Hamilton shales of New York

7 Another example of a flattened tube cast on a thin shelled pelecypod of the Hamilton group, N. Y.

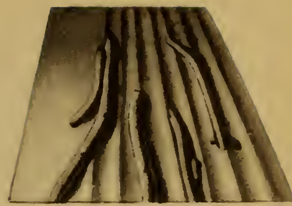
8 Clavate borings in a valve of Leptostrophia oriskania, Oriskany limestone, Becraft mountain, N. Y., x 3

PLATE 8.

1

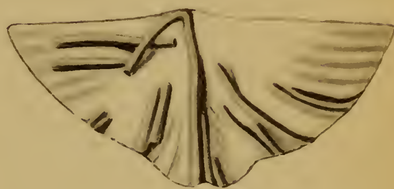
2

3

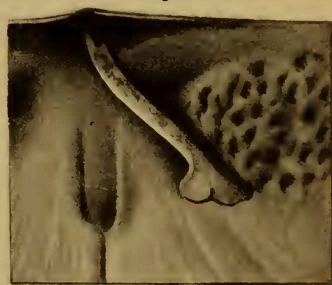


4

5



6



7

8

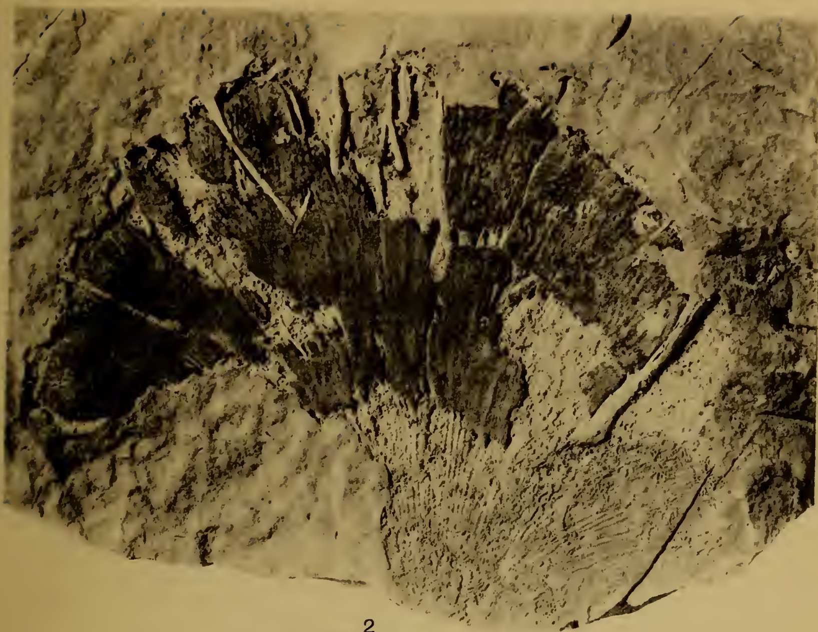
PLATE 9

1 Clionolithes priscus (McCoy). A specimen of Leptostrophia magnifica Hall, from the Grande Grève limestone (Lower Devonic) of Gaspé with several straight clavate tubes extending in from the margin of the shell. Where the shell substance has disappeared at the right of the specimen are seen numerous examples of the branched boring, Clionolithes radicans.

2 Clionolithes radicans. An etched specimen of an old shell of the brachiopod Dalmanella superstes H. & C. of the Chemung shales of New York with a multitude of irregularly branching borings riddling the shell and apparently starting inward from the shell margin. x 8

PLATE 9

1



2

PLATE 10

A greatly enlarged view of an etched specimen of the brachiopod Atrypa reticularis Linné, whose outer surface has been overgrown with a monticuliporoid coral and whose shell substance was perforated with branching clusters of the tubes of Clionolithes radicans. From the Onondaga limestone, Becraft mountain, N. Y.

PLATE 10

PLATE 11

1 Clionolithes radicans, a single cluster of tube casts, x 5 in the substance of the shell of Atrypa reticularis from the Chemung sandstone of Mansfield, Pa.

2 The same. A silicified replacement of a tube cluster within the shell substance of Leptostrophia magnifica Hall, standing in relief on the surface of the valve. From an enlarged photograph, which also shows the casts of the small tubules constituting a proper part of the structure of this shell and through one of which it is probable that the sponge entered. From the Grande Grève limestone (Lower Devonic) Gaspé

3 Clinolithes reptans; sparse, diffuse tubules in the substance of a shell of Leptostrophia oriskania, Oriskany limestone, Becraft mountain, N. Y. Greatly enlarged

PLATE 11.

3

1

2

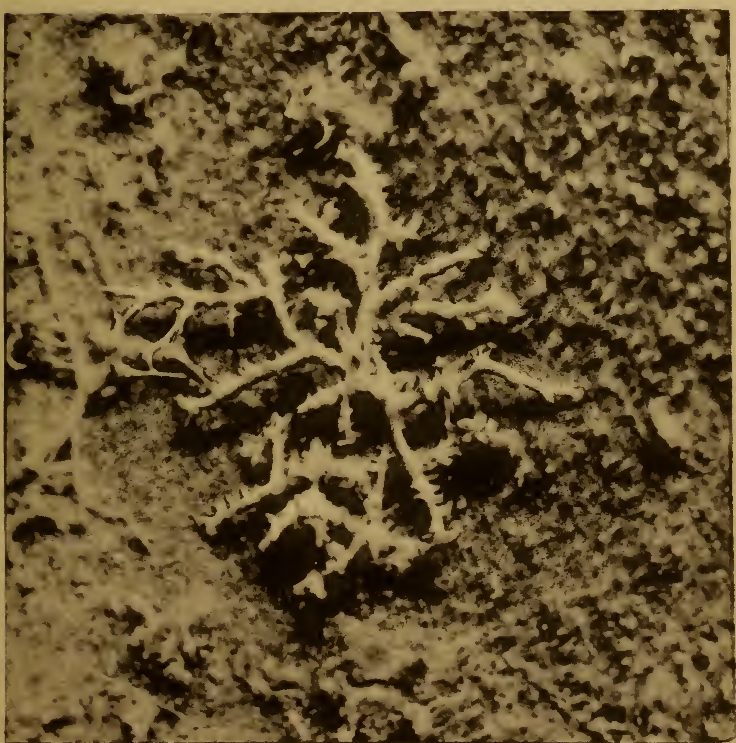


PLATE 12

1 Clionolithes palmatus. A valve of the pelecypod Loxopteria dispar Sandberger, from the Portage beds (Upper Devonic) of Correll's point, N. Y. in the substance of which this cluster of frond-shaped cavities lies. x 2

2 The same. A somewhat more diffuse cluster in the shell substance of Loxonema danai Clarke from the same formation and locality. x 5

3 Caulostrepsis taeniola. Stropheodonta cf. gigas McCoy from the Seigener schichten (Coblentzian) of Seifen. The margin of the brachiopod has been entered on all sides simultaneously by these borers forming loop-shaped tubes which are joined by a thin median cavity. Together with these are simple tube casts of Clionolithes priscus. I owe this specimen to the kindness of Prof. E. Kayser.

4 The same on Stropheodonta protaeniolata Maurer, same locality [after Maurer]

5, 6, 7 Large circular perforations in the valves of brachiopods, probably made by the radula of predatory gastropods. In figure 5 the brachiopod is Spirifer medialis Hall from the Hamilton shales of New York; figure 6, Meristella from the Oriskany limestone of Glenerie, N. Y.; and figure 7 a small Spirifer granulosus Conrad from the Hamilton rocks. In 5 and 7 the hole is on the dorsal valve and has precisely the same position with reference to the shell and the animal within which the gastropod was doubtless seeking. The hole, figure 6, has the same position on the ventral valve of Meristella. It is interesting to observe that the Spirifer in figure 5 and the Meristella in figure 6 succeeded in forestalling the purposes of the enemy by secreting a false floor beneath the hole after it had perforated the shell. Spirifer, figure 7 may have fallen a victim to the attack as the hole is not sealed. These are instructive illustrations of the early acquisition of this perforating mode of attack by the gastropods.

PLATE 12.

1

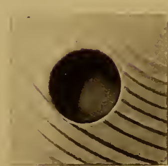
2

3

5

4

6



7

PLATE 13

A colony of the coral Favosites niagarensis Hall which has partially overgrown a small plantation of the cyathophylloid coral Amplexus, but not to such extent as to interfere with the calyces of the latter

From the Niagaran formation near Monticello, Iowa. The print has been kindly loaned by Dr Samuel Calvin.

INDEX

Appendix 1

Economic geology

Museum bulletins 119, 120, 123

119 Geology of the Adirondack Magnetic Iron Ores with a Report on the Mineville–Port Henry Mine Group

120 Mining and Quarry Industry 1907

123 Iron Ores of the Clinton Formation in New York State

Education Department Bulletin

Published monthly by the University of the State of New York

Entered at the postoffice at Albany, N. Y. as second-class matter

NO. 423 ALBANY, N. Y. APRIL 1908

New York State Museum

JOHN M. CLARKE, Director

Museum bulletin 119

GEOLOGY OF THE ADIRONDACK MAGNETIC IRON ORES

BY

DAVID H. NEWLAND

WITH A REPORT ON THE

MINEVILLE-PORT HENRY MINE GROUP

BY

JAMES F. KEMP

New York State Education Department
Science Division, December 7, 1907

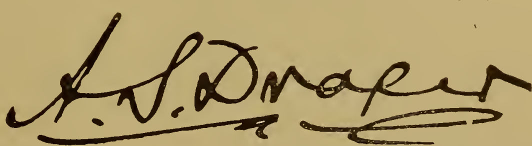
Hon. Andrew S. Draper LL.D.
Commissioner of Education

SIR: I communicate herewith, for publication as a bulletin of the State Museum, a timely treatise on the iron ores of the Adirondack mountains prepared by David H. Newland, Assistant State Geologist, to which is attached a special report on the deposits at Mineville, the result of many years of expert investigation by Prof. James F. Kemp.

Very respectfully
JOHN M. CLARKE
State Geologist

State of New York
Education Department
COMMISSIONER'S ROOM

Approved for publication this 7th day of December 1907



Commissioner of Education

Education Department Bulletin

Published monthly by the University of the State of New York
Entered at the postoffice at Albany, N. Y. as second-class matter

NO. 423 | ALBANY, N. Y. | APRIL 1908

New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 119

GEOLOGY OF THE ADIRONDACK MAGNETIC IRON ORES

BY

DAVID H. NEWLAND

WITH A REPORT ON THE

MINEVILLE-PORT HENRY MINE GROUP

BY

JAMES F. KEMP

INTRODUCTION

The description of the Adirondack magnetites has been prepared in partial fulfilment of a plan to give an account of the iron ore deposits throughout the State. Field work was started in the Adirondacks in 1905 and has been carried on, as opportunity offered, during each succeeding season. It is hoped to complete the investigation of the other ore-bearing regions in the near future.

In the present report Prof. James F. Kemp has contributed the part relating to the important Mineville deposits, a section which he has recently mapped in connection with the geological investigation that is being carried on in the region under direction of the State Geologist.

The Adirondack region of crystalline rocks affords a variety of iron ores differing in their character and geological surroundings. Those found in sufficient abundance to be exploitable commercially may be classified under the main groups — (1) nontitaniferous magnetites, (2) titaniferous magnetites, and (3) hematites. Of the three classes the nontitaniferous magnetites are the characteristic product of the region and have afforded by far the greater part of the output.

The occurrence of limonite deserves some notice, perhaps, though it can hardly be considered as an available resource at the present time. It is limited to surficial accumulations of impure bog ore doubtless derived from solution by ground water of the iron minerals that accompany the crystalline rocks. The ore is only occasionally found in deposits of any size and is then usually too lean to be marketable. It has been exploited on a small scale at times when conditions were specially favorable.

The two kinds of magnetites mentioned form the basis of the present report. They are quite distinct in respect to commercial considerations, as well as in the particulars of their geological associations and local distribution, wherefore it has been thought advisable for purposes of description to place them in separate divisions.

The hematite ores are practically confined to a single district on the west side of the Adirondacks. They have been mined for over 50 years and still supply a considerable output. They occur within metamorphosed Precambric sediments, mainly quartzose schists and limestones, where they have been formed by a process of chemical replacement. Their detailed description is reserved for a future paper. An isolated deposit of hematite, the only one that has been worked outside of the western district, is found near Fort Ticonderoga, on Lake Champlain, the particulars of which are given on a subsequent page of the present report.

The magnetite deposits of the Adirondacks have furnished altogether not less than 35,000,000 tons of commercial ore, an output that ranks them among the more important sources of this class of ores in the country. They have been exploited almost continuously for the past century, the earliest operations in the Champlain valley dating back to about 1800. Though some deposits have been practically exhausted by past operations, these are mostly the smaller ones, many of which would not repay working under existing circumstances. The larger mines now operated can continue along present lines for an indefinite period, so far as it is possible to judge their ore reserves.

A diminished ore supply, in fact, is of less concern for the future progress of mining, than the possible recurrence of a period of inactive demand for the ores such as has been felt at different times during the past. It is believed, however, that the industry is on a firmer basis than ever before, due to the improved methods of preparing the product for the market. By the addition of milling plants to the installations, the mines are now able to ship their output in the form of concentrates, which contain smaller amounts of phosphorus and sulfur and higher percentages of iron than the crude material formerly marketed. The concentrates are in wide demand for mixture with the leaner ores of other districts and command a price above the average.

While the local charcoal industry which had long been the support of many small workings was completely extinguished during the depression of the last decade, there are now two coke furnaces in operation locally on Adirondack ores. The furnace recently built at Standish, Clinton co., manufactures a superior grade of low-phosphorus iron from the Lyon Mountain concentrates. The Port Henry furnace is run mainly on foundry irons, using the Mineville ores. The surplus product of the mines from these operations is sold to furnaces elsewhere in the State and in Pennsylvania.

The titaniferous magnetites which hitherto have been neglected almost completely may add materially to the output of the region in the near future. Their development is already in prospect at Lake Sanford, where there are enormous bodies of the ores, exceptionally situated for convenient working. The ores possess important advantages in their low phosphorus and sulfur, though the titanium content has been generally regarded as presenting difficulties to their reduction in the blast furnace. Under the present management of the enterprise at Lake Sanford a thorough test of the question as to their adaptability may be expected.

Acknowledgments. The courtesies extended by the mining companies and others interested in the development of the Adirondacks have been of invaluable aid in the preparation of this report. Much of the information relating to ore analyses, mine maps and sections, magnetic surveys, drill records, etc. has been secured through their agency. Some of those who have contributed in this way and to whom special recognition is due are: Messrs S. Norton, superintendent, and S. Le Fevre, engineer, of Witherbee, Sherman & Co., Mineville; W. T. Foote, Port Henry; J. N. Stower, Plattsburg; H. H. Hindshaw, New York, at one time geologist for the Delaware & Hudson Co.; N. V. Hansell, New York, formerly engineer at Lyon Mountain; C. S. Hurd, New York; W. L. Cumings, geologist for the Bethlehem Steel Co., South Bethlehem, Pa.; M. H. Newman, Madison, Wis.; and the Oliver Iron Mining Co., Duluth, Minn.

Part I

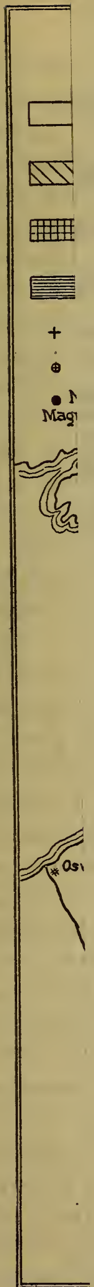
SKETCH OF THE GEOGRAPHY AND TOPOGRAPHY OF THE ADIRONDACKS

Under the Adirondack region is included the area of crystalline rocks of northern New York that is approximately bounded by the Mohawk valley on the south, the Black and St Lawrence rivers on the west, the St Lawrence plain on the north and the Hudson-Champlain valley on the east. Roughly rounded in outline it has an average diameter of 125 miles, and a surface of about 12,500 square miles. Within its limits lie nearly all of Essex, Warren, Hamilton and Herkimer counties and portions of Washington, Clinton, Franklin, St Lawrence, Jefferson, Lewis, Oneida, Fulton and Saratoga counties.

The region is a well defined physiographic unit. The Adirondacks and their foothills cover the whole area, forming an uninterrupted highland. They are composed mainly of long parallel ridges, separated by longitudinal valleys, and arranged in series or *en echelon*, with a prevailing northeasterly trend. Toward the borders the ridges gradually fall off and are succeeded by the bordering uplands which are constituted of outward sloping Paleozoic strata. On the east, however, they terminate more or less abruptly against the Lake Champlain trough, with but a narrow and interrupted fringe of sediments on that side.

The surface is diversified throughout, but not specially rugged except in the eastern central portion. Here the ridges are massed into mountain groups that stand out prominently by reason of their bold sculpture and elevation. Essex and southern Clinton counties contain most of the high elevations. The Mt Marcy group, the highest, has a few peaks rising 5000 feet or a little more, and there are many others with peaks above 4000 feet. The surface has a general, but not uniform, slope radially away from the central group, as will be observed from the directions taken by the streams. The drainage courses are influenced to some extent, however, by the general northeast-southwest alinement of the ridges.

The western part of the region, in St Lawrence county, shows a more subdued topography than other sections. It is a plateau broken by gentle ridges and open valleys, with occasional elevations rising a few hundred feet above their surroundings. The surface falls by gradual stages from the interior, which stands at about



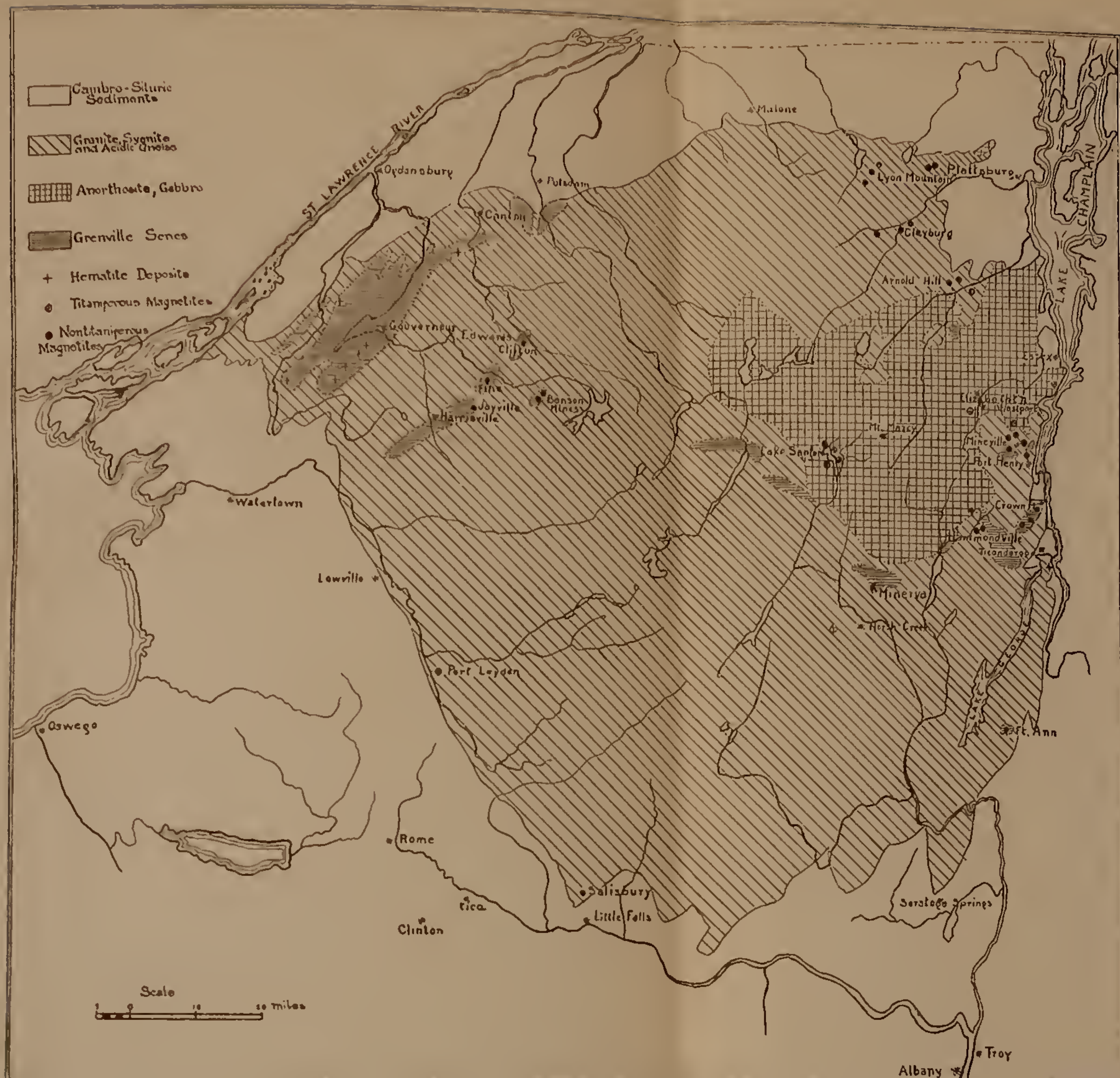


Fig. 1 The Adirondack region. Distribution of the principal geologic formations and occurrence of the iron ores

2000 feet, to the St Lawrence. The valley of the St Lawrence in this section has been worn down through the Paleozoic strata exposing the underlying crystallines in belts that extend to the river itself.

The history of the Adirondack topography is very involved. The mountains were upraised and folded long before Potsdam time, while they have been since subjected to long cycles of erosion and to renewed uplifts. The whole region appears to have been planed nearly level in the early Cambric period. It probably participated in the general Appalachian upheaval and has subsequently undergone more or less movement. Local faults have modified the erosional features, giving rise to abrupt rock scarps, serrated ridges which appear to be due to block tilting, and to wild passes and gorgelike valleys. The numerous belts of crystalline limestone that are interfolded with the other crystallines have also influenced the development of relief by their more rapid wear. The valleys floored by the limestone always have a rounded open character, in contrast with the usual narrow steep sided valleys found in the gneiss.

The Labrador ice sheet invaded the Adirondacks from the northeast and north, scoured the ridges to the summits and removed the products of rock weathering that must have accumulated in great thickness during the long period in which the region had been exposed to subaerial decay. Residual sands and clays from the decomposition of rocks in place are practically absent. In turn the ice spread over the region enormous quantities of transported materials—boulders, gravels, sands and clays. The preglacial valleys are often buried beneath hundreds of feet of such materials. It is to obstructions of this kind that many of the lakes, which afford one of the most attractive scenic features of the Adirondacks, owe their existence.

The mineral deposits constitute one of the main industrial resources of the region. They are perhaps second in importance only to the forests, as measured by value of the output. In addition to the iron ores, there are workable deposits of talc, graphite, garnet, feldspar and pyrite in different parts of the region. The quarry materials, of which there are inexhaustible supplies, include granite, syenite, anorthosite, trap, limestone and marble, suitable for building, construction or ornamental purposes.

GENERAL GEOLOGY

Principal publications. The geology of the Adirondacks was investigated in the early part of the last century by Prof. E. Emmons under commission of the Natural History Survey of New York State. The final report of Emmons, which was published in 1842, contains a vast collection of observations on the topography, rocks, stratigraphy and mineral resources of the region, constituting a valuable reference work to this day. The notes on the iron ores and the iron mining industry are commendable for their detail and accuracy. Professor Emmons considered the rocks to be mainly "primary" and divided them into the classes of unstratified, stratified and subordinate. Among the unstratified rocks he grouped granite, hypersthene rock (anorthosite), limestone, serpentine, and rensselaerite. The stratified class included gneiss, hornblende (hornblende gneiss and amphibolite), syenite and talc. The subordinate rocks were porphyry, trap, magnetite and specular iron ores. The stratigraphic sequence of the formations received little attention as, indeed, the question involved problems that could scarcely be met by the methods and opportunities which were at Professor Emmons's disposal.

A paper by C. E. Hall, published in the report of the New York State Museum for 1878, contains a description of some of the iron ore deposits of the eastern Adirondacks. The ores are stated to be associated with the following rock groups: Lower Laurentian magnetic iron ore series; Laurentian sulfur ore series; and the Upper Laurentian, or limestones and Labrador series, with titanic iron ores. In a note to the article the classification is amended by placing the limestones in a separate group with an unconformity at their base where they rest upon the Upper Laurentian.

In the last 15 years a geological investigation of the Adirondacks, wider in scope than any previously undertaken, has been in progress under the direction of the State Geologist. The field work has been carried out principally by Prof. J. F. Kemp, C. H. Smyth jr, and H. P. Cushing. Their efforts until recently have been directed toward a general reconnaissance as a preliminary to a detailed survey which was necessarily deferred until accurate base maps could be prepared. The results have appeared from time to time in the bulletins and reports of the New York State Museum. Much has been done to clear up the main problems connected with the lithologic and stratigraphic relations of the rocks, and it may be said that the principles for the interpretation of the geology of the region are now fairly well defined. Professor Kemp has worked in the eastern section including Essex, Warren, and Washington counties and adjacent territory. Professor Cushing has been mainly occupied with the northern region of Clinton, Franklin and Hamilton counties; while Professor Smyth has worked in St Lawrence, Jefferson and Lewis counties on the western side.

With the publication of topographic sheets for parts of the region by the United States Geological Survey in cooperation with the State Engineer it has been possible recently to undertake the preparation of detailed geologic maps. Thus far Professor Cushing has reported upon the geology of the Little Falls quadrangle in Herkimer county and the Long Lake quadrangle in Hamilton county and Dr I. H. Ogilvie has surveyed and described the Paradox Lake quadrangle in Essex county. Field work has been completed also upon one or more quadrangles in Essex, Hamilton and St Lawrence counties.

Outline of geology

The rocks comprising the Adirondack region are almost exclusively Precambric in age. The bordering Paleozoic strata are sometimes found well within the interior, but they occur in disconnected exposures which altogether comprise an inconsiderable portion of the total area. Their base, the Potsdam sandstone, rests unconformably upon the Precambric crystalline rocks. The unconformity marks a very long time gap. Before the deposition of the Potsdam the Precambric rocks had been modified by repeated dynamic action, had been uplifted, intruded, and finally exposed to erosive influences that removed great thicknesses from their surface.

The Precambric rocks, with the exception of small dikes that were of late Precambric intrusion, have all been subjected to powerful compression and in many cases have been greatly changed by metamorphism. Among them there are representatives which were undoubtedly original sediments, but these have almost wholly lost the characteristic features of such rocks so that their recognition is at times a matter of extreme difficulty, if indeed they can now be identified at all. The metamorphism took place while they were deeply buried, under conditions of pressure and heat that brought about a recrystallization of the fragmental components; and what were once sandstones, shales and calcareous sediments now have the characters of gneisses, schists and coarsely crystalline limestones.

The inference as to their origin is more readily apparent in the case of the limestones and schistose types than in reference to the more massive gneisses, for which the field evidence alone is seldom determinative.

Plutonic igneous masses invaded the region at different times during the Precambric period. They have broken up the sedimentary rocks into isolated areas, injected them with their materials and blended with them along the contacts. Subsequent compression has converted them into gneisses which are often hard to distinguish from those of the sedimentary class. A later manifestation of igneous activity led to the intrusion of dike rocks.

While a great part of the crystallines can be differentiated into the two classes of igneous and sedimentary derivatives, there are considerable areas of gneisses whose origin has not been fully established. Their relationships have been obscured by profound alteration, leaving little evidence as to their original nature. It is in connection with these rocks that the principal stratigraphical problems remain to be solved.

According to the classification generally employed for Precambric rocks, the sedimentary gneisses fall within the Grenville series. If any rocks exist in the region which antedate the oldest sediments of that group, they are probably to be found among the gneisses previously mentioned.

Sedimentary, or Grenville, series. So far as known, the sedimentary derivatives are the oldest rocks in the Adirondacks. They possess much similarity in their development and individual constitution to the Grenville series of Canada, with which they are now generally correlated as the nearest equivalent in age. They are believed to be ancient water deposits and if so must have been laid down upon some floor of still older rocks that have not yet been definitely recognized. Little is known as to the thickness of the series, though from the facts of their distribution it is concluded that they must have been originally very thick. The variation in composition, from original calcareous and magnesian deposits to shales and sandstones and probably coarse conglomerates, as well, is such that it can be explained only by wide-reaching changes in the processes of accumulation that require long lapses of time. Neither the base nor the top of the series has been identified.

Limestone. The limestones have the crystalline texture of marbles, they range from nearly pure lime carbonates to magnesian limestones and dolomites. They are always impregnated by foreign minerals that have been formed out of the carbonates and the included impurities by regional and contact metamorphism. Pyroxene, amphibole, mica, graphite, pyrite and scapolite are common associates. With an increase in the proportion of the silicate minerals, the limestones pass into micaceous, pyroxenic or amphibole schists. By secondary alteration of the pyroxene a serpentinous limestone or more rarely a massive serpentine may be developed.

The limestones and associated schists are found generally in long narrow belts bordered by the sedimentary gneisses. They are most widespread on the northwestern side of the Adirondacks in St Lawrence, Jefferson and Lewis counties. Four main belts, with a length of from 15 to 35 miles, and a great number of smaller ones have been mapped in this region. On the east side they occur most abundantly in Essex county, but they are here less extensive. In the interior and on the northern and southern borders, the limestones are encountered in disconnected patches, occasionally interfolded with the igneous rocks in which they were, no doubt, involved during the intrusion.

Gneiss. The sedimentary gneisses are an extremely varied class. Their many phases comprise light colored acid types made up purely of quartz and feldspar, gray or dark gneisses in which the ferromagnesian minerals are represented more or less abundantly, and black basic varieties with only subordinate feldspar or quartz. Wide differences in composition are often observable within the limits of a single outcrop, particularly in passing across the foliation. The transitions from one variety to another take place quickly and lend the appearance of a banded arrangement comparable to that of bedding among unaltered sediments. Still there are districts in which the gneisses show a fair degree of uniformity, and their relations are only to be established after careful investigation in the field and laboratory. The presence of graphite is common and suggestive. Garnet, sillimanite and pyrite are also characteristic minerals. Where pyrite occurs the beds weather rapidly, taking on a peculiar rusty appearance. The texture of the gneisses is always granular, as a rule finely so, due to the intense crushing they have undergone.

The distribution of the sedimentary gneisses corresponds in a general way to that of the limestones, being most widely developed on the borders of the region. They occur, however, over considerable areas where limestone may be relatively scarce. In the northern Adirondacks, Cushing has found them to be of small importance, as the main formations are igneous or of so questionable character that their relations can not be stated definitely. In St Lawrence county the sedimentary gneisses are widespread in the vicinity of the limestone belts above mentioned. They have also been traced by the writer to the east toward the interior as far as Cranberry lake. They are the country rock of the magnetite deposits in this section. Professor Kemp has described gneisses of sedimentary type in southern Essex, Warren and Washington counties. As to the southern border of the Adirondack region, little has been made known but it is probable that the sedimentary gneisses are well represented.

Amphibolite. Involved with the limestones and gneisses, and less frequently with the plutonic igneous rocks, are small masses of amphibolite, dark colored and consisting essentially of hornblende and feldspar. They often have a rusty appearance that betrays the presence of pyrite. Their occurrence in tabular bands, which may be persistent for considerable distances, is suggestive of dikes and it is quite likely that they are in part metamorphosed diabases or gabbros. This view is particularly applicable to examples that have a plagioclase as the principal feldspar constituent, but can hardly be accepted for occurrences in which the hornblende is associated with orthoclase, as is not infrequently the case. For these the derivation from a magnesian shale seems to be the more obvious explanation.

Quartzite. As a somewhat uncommon type of the Precambric sediments, may be mentioned the occurrence of quartzite which has been made known on both the eastern and western borders of the Adirondacks.

In Essex county, Professor Kemp has noted several localities where this undoubted fragmental rock occurs. It nearly always carries graphite, pyrite and sillimanite and sometimes feldspar and mica. At Hague on Lake George and at the village of Graphite, 5 miles west from Hague, a bed up to 15 feet thick is included between a garnetiferous sillimanite gneiss. At Rock pond between Graphite and Hammondville, there is another area; while in the town of Lewis, 3 miles south of Elizabethtown, exposures show a thickness of 100 feet of quartzite overlain by graphitic gneiss.

Professor Smyth has found the same rock in St Lawrence county. On Wells island in the St Lawrence river a white vitreous quartzite is exposed along a ridge for nearly 5 miles with an estimated thickness of 500 feet. It is associated with schist and both are cut out by granite gneiss which forms the southern part of the island. A second belt occurs between Redwood and Rossie, the quartzite being interbedded with limestone and hornblende, mica and pyroxene schists. The St Lawrence county quartzites contain feldspar and mica, but are not so graphitic as those of Essex county, where they have been exploited.

The quartzites are no doubt ancient sandstones that have been hardened by recrystallization of the quartz particles; they may be considered, therefore, to represent the extreme silicious phase of Precambric sedimentation.

Gneisses of undetermined relationship. The recent work in the Adirondack region has disclosed the existence of certain gneisses of obscure character. While more detailed investigation may resolve them into elements which can be classed with the igneous or sedimentary series, they have been found so far to have no well defined connection with either.

Saranac formation. The principal area of these gneisses seems to be on the northern borders in Clinton and Franklin counties. Professor Cushing has described a belt that extends along the Paleozoic contact for a distance of 70 miles. The rocks are mainly red acid gneisses, composed of alkali feldspar, which is usually microperthite, and quartz, with small amounts of hornblende and biotite. They are thus mineralogically related to the granites, but differ from the latter in their textures which are often finely granular or without the definite arrangement that characterizes igneous rocks in their original state of consolidation from a molten condition. Besides the acid gneisses a gray variety consisting of pyroxene and feldspar (orthoclase and plagioclase) and dark hornblende gneisses or amphibolites occur as bands or larger masses. Of the Grenville rocks there are very few exposures throughout the entire belt. The gneisses as a whole correspond in composition quite closely to a series of igneous rocks grading from granites through syenites and diorites to gabbros, though the comparison has not been substantiated fully by chemical analyses.

Professor Cushing is inclined to regard them as an older series than the recognized intrusives and has proposed to group them collectively as the Saranac formation, a name suggested by their occurrence along Saranac river. Concerning their possible position among the Precambric rocks of the Adirondacks, Professor Cushing points to the similarity which they show to the basal gneisses in other regions and more specially the so called Ottawa gneiss of Canada; while he seems to favor the view that they represent the original floor on which the Grenville rocks have been deposited, he does not regard the proofs for this explanation to be fully established.

Within the belt are comprised several large magnetite deposits, including those at Lyon Mountain and vicinity, the Arnold hill and Palmer hill bodies, and a number of smaller ones. Opportunity has been afforded the writer of studying the gneisses in the field as well as to compare them with the rocks of other mining districts. At many localities within the belt have been found undoubted representatives of the igneous rocks. The acid gneisses particularly contain cores which are coarsely textured, even porphyritic, and in other respects are analogous to the characteristic Adirondack granites; the coarse phases can be traced at times by gradation into fine grained gneissoid rocks which are evidently only crushed portions of the same mass. It seems probable that the granitic series will be found to abound throughout the belt, yet there are large areas of gneiss that can not be satisfactorily correlated on the basis of present knowledge.

Igneous intrusions. The plutonic igneous rocks of the Adirondacks can be divided into four great groups, viz: anorthosite, gabbro, syenite and granite. In their normal development the individual groups are well contrasted by their physical appearance, as well as by the peculiarities of their chemical and mineral composition. They are all connected, however, by a series of intermediate rock types, presenting a variation scarcely interrupted from the acid to the basic members. This close relation between the groups is generally recognized to be an original feature, due to a common derivation from a continuous magma in the interior. By repeated segmentation and intrusion the magma has given rise to the rock series now existing at the surface.

Anorthosite. The anorthosite is the earliest in point of time of the intrusions mentioned. Its occurrence in the Adirondacks was made known by Professor Emmons who described it under the name of hypersthene rock. That he recognized its igneous nature is clearly evidenced by the fact that in his report it is placed among the unstratified class of rocks, though the name he used has given way to the more appropriate one which emphasizes the feldspathic component. Hypersthene plays a very subordinate role in the composition of the Adirondack anorthosite. The rock forms the central massive of highest uplifts. It is exposed over an area that is roughly triangular in shape with its base on the north along the Essex-Clinton county border, extending west from Lake Champlain for over 50 miles, and its apex in southern Essex county near the Warren county line. The area probably exceeds 1200 square miles. There are some belts of gneisses and crystalline limestone within the area, probably entangled masses borne up on the surface of the intrusion, but in the main the anorthosite is unbroken by other rocks. Small outlying exposures of anorthosite have beeen found on the northern and southern borders, the most remote being the Rand hill intrusion near Dannemora, Clinton co., and the one near Bakers Mills, Warren co., both of which lie some 20 miles distant from the proximate portion of the principal area.

In its normal development the anorthosite consists of little else than feldspar which is generally a blue labradorite. This mineral occurs as a rule in large interlocking crystals, giving the rock a very coarse texture like that of porphyritic granites. The accessory minerals include augite, hypersthene, hornblende, ilmenite and magnetite. While usually constituting a small percentage of the rock, the ferromagnesian silicates may assume such importance as to mark a gradation toward or even a complete transition into the gabbros. With the increase in the proportion of these minerals, there is also a change in the texture, which becomes finer by diminishing the size of the feldspar and shows the characteristic mottled aspect of gabbroic rocks. There are innumerable places within the area where this variation is to be found. The gabbro type, however, falls far short of the wide distribution of the feldspathic phase, being limited to patches and dikelike bands in the latter. By compression the anorthosite has become laminated, specially in the bordering zones where it often shows a thoroughly gneissoid appearance. The feldspar crushes down to a white mass of granules, in which remnants of the original blue feldspar may usually be seen. The granulation is accompanied by the development of garnet in the form of pink crystals surrounding the dark silicates.

Gabbro. This rock stands in close relation to the anorthosite. It is abundant only within the area occupied by the latter or in close proximity thereto. The gabbro is a black, very dense aggregate of labradorite, augite, hypersthene and ilmenite or magnetite, with olivine as a somewhat uncommon constituent. It seems to have been a later differentiation of the magma which has given rise to the anorthosite as it sometimes cuts the latter intrusively. The gabbro inclusions which grade into the anorthosite are, however, contemporaneous segregations.

The limited masses of gabbro have sometimes been so thoroughly metamorphosed as to assume the character of amphibolites. The presence of unchanged pyroxene and basic plagioclase feldspar furnishes a clew to the derivation of such amphibolites, in distinction from those which are of sedimentary origin.

Syenite. The Adirondack syenite constitutes an abnormal variety of that rock, and was not recognized as such until recently. Mineralogically it occupies a middle place between the gabbroic rocks and the granites. A green augite is nearly always the chief dark constituent, but hornblende and hypersthene may be present. The feldspar is commonly microperthite. Orthoclase, oligoclase, quartz and magnetite are the more important of the other minerals. The rock nearly always has a greenish color, varying from light to dark shades. When there is a considerable proportion of the dark constituents, it resembles the gabbro so much as to be hardly distinguished in the field, a resemblance which is even closer in comparing gneissoid varieties of the two rocks. With the increase of those minerals there is apt to be a change also in the feldspars shown by the preponderance of the oligoclase over the alkali feldspars. It is not apparent, however, that the syenite ever merges completely into the gabbro, the evidence tending to show that the two are separate and distinct intrusions. On the other hand the acid types of the syenite pass into typical granite, as was first demonstrated by Professor Smyth.

The syenite occurs in local intrusions all through the Adirondacks outside of the anorthosite area. It is developed in great force in the northern section, specially in Franklin county, and is common in the eastern part though the different areas here have not yet been delimited. On the south side the Precambric outlier near Little Falls consists of syenite. The Diana-Pitcairn area on the northwest, described by Professor Smyth, deserves mention as affording the first evidence of the intrusive character of the rock and its lithologic relations.

Granite. The granites, with the derived gneisses, are the most frequent of all the intrusives. They are closely involved with the Grenville series and over large districts are the only igneous formation present. It has already been pointed out that they constitute an important factor in the belt of Saranac gneisses.

The granites are prevailingly light colored, gray or reddish rocks. Feldspar and quartz always predominate and may be practically the only minerals present. Hornblende granite seems to be more common than the mica varieties, while augite granite occurs as a variation of the syenite. It is only rarely that the intrusions have preserved their original massive character, a granulated cataclastic and gneissoid texture being the rule. In regions where compression and crushing have been carried to an extreme, the resultant gneisses present most difficult problems to the geologist since they are often inextricably involved with the sedimentary gneisses.

The age of the granite intrusions relative to that of the other igneous rocks has been demonstrated in only a few cases. There is little question that some granites are later than the anorthosite and according to Professor Cushing even later than the syenite. Not improbably they may represent more than one period of intrusion.

Dike rocks. The dike rocks in the Adirondack region are mostly diabases. These are common in Clinton county, where they have been uncovered in large numbers in the mines, and to a lesser extent in Essex county. In the interior and on the southern and western sides they occur only rarely. The dikes seldom attain a thickness of more than 20 or 30 feet, the majority perhaps being less than 10 feet. A few dikes of syenite porphyry have been found in Essex and Clinton counties. The dikes cut all the formations previously described, but have not been found anywhere to intersect the Paleozoic strata. They belong thus to the Precambric. That they must have been intruded very late in Precambric time is indicated by the fact that they have undergone no appreciable metamorphism or compression in which the other crystalline rocks have participated.

Paleozoic sediments. The Paleozoic sedimentary strata, which are found on the edges and to a lesser extent in the interior of the Adirondacks, rest in nearly horizontal position upon the eroded surface of the crystallines. During the period of their deposition the region underwent a gradual subsidence that brought a continually increasing area, with the progress of time, below the level of the sea. The formations have at their base the Potsdam sandstone, while the highest member is the Utica slate.

The Potsdam is mostly an indurated sandstone or quartzite, coarse and conglomeratic near the bottom. It lies along the entire northern border but thins out nearly to disappearance to the south. The Beekmantown, or Calciferous, formation following the Potsdam consists of calcareous sandstone and limestone and is found on all sides except the western. In the Champlain region it attains its extreme thickness. The Chazy limestone, which is next in order, is confined to the Champlain valley. The Lowville, Black River and Trenton formations are made up of gray and black limestones, with shaly partings in the Trenton marking a transition into the Utica shale, the last of the series. They are mainly developed on the south.

Small areas of the sediments occur in the interior as far as 40 miles from the borders. In some instances they lie 1500 feet above sea level. They represent mere remnants of once continuous deposits which extended over most if not all of the Adirondacks. There is strong evidence that the submergence of the region was practically complete during Utica time. Since the close of that epoch the region has been above sea level, exposed to weathering and erosion, and has received no deposits except the sands, gravels and clays left by the glacial invasion and the more recent river detritus.

Structural features. The structures of the Precambric rocks as revealed by their present attitudes in the field have not been worked out for the Adirondack region, and even over the limited areas that have been studied and mapped with care the structural details in most cases have proved too confusing to be deciphered. There is abundant proof, however, that the rocks have undergone great compression and have been folded and faulted on an extensive scale.

One of the principal difficulties encountered in the study of the structural features is the extreme variability as to the evidences afforded by the rocks of their disturbance. The presence of foliated and gneissoid textures is a common characteristic but they are not always so apparent as to be a serviceable guide in the field.

Foliation is best developed in the dark sedimentary gneisses and schists. These rocks contain a considerable proportion of the ferromagnesian silicates — biotite, hornblende and pyroxene — which owing to their crystal habit would orient themselves most readily under compression. When the foliation is parallel to the original bedding planes, as seems to be the general case with these rocks, the records of dips and strikes afford unquestionable evidence for establishing the structure. The limestones have flowed and recrystallized so that they rarely show either foliation or traces of their former bedded structure.

In areas underlain by a complex of igneous and sedimentary formations it is seldom that any connected series of dip and strike observations can be made. There is some possibility that in the districts composed mainly of the Grenville series, such as on the west and south, a close study of the field relations may yield positive results.

The strikes and dips in any part of the region seldom remain uniform over more than a small area. The strike generally follows more or less closely the prevailing trend of the ridges, that is in a direction east of north, but it is subject to local variations of several degrees. The swings are gradual as would be expected in folded rocks. The principal thrust has been evidently from the southeast or northwest. From the fact that the eastern section has undergone the greatest disturbance from its influence, the direction would appear to be from the southeast rather than from the opposite point.

The iron ore deposits afford many interesting examples of flexure. Originally they were probably straight tabular bodies formed previous to the dynamism that has affected the inclosing rocks. In some districts they have been very little disturbed, either along the strike or on the dip. In others as instanced by the deposits of Essex county, they have been flexed, twisted and made to assume the most intricate shapes, around which the walls have been closely molded.

The existence of faults can be demonstrated in many cases where the conditions are favorable for their detection, that is in areas made up of contrasted formations, and their presence is indicated elsewhere by topographic considerations. The probable close connection between the present surface conformation and faulting has been brought out more specially by Professor Kemp in his work in Essex county.

The main series of faults has a northerly trend, varying from nearly due north to northeast. It approximately parallels the longer axes of the ridges and tends to produce steep faces on the northwest and southeast sides. This faulting may have been responsible to some extent for the markedly uniform trend of the ridges and valleys. In some cases the latter appear to occupy a depressed strip between two parallel faults of this character.

A second series of faults, which has probably resulted from the movements initiated by the main series, trends away at variable angles, so that the ridges are divided into irregular blocks. Examples of such block faulting in which the displaced portions are more or less tilted form a characteristic feature of the interior Adirondacks.

The eastern and southern margins of the region have been extensively faulted. In Clinton county Cushing has found the Paleozoic strata to be frequently displaced by meridional faults, of which one in Chazy township along Tracy brook has a throw of at least 2000 feet, and cuts out the entire Beekmantown formation. Most of the faults in this section downthrow to the east. It would appear that the New York shore of the lower part of Lake Champlain is limited by a series of meridional breaks forming a basin tilted to the west. North of the Mohawk valley there are a number of displacements trending northeast across the dip of the Paleozoic strata into the crystallines. As described by Darton they are normal faults with a downthrow to the east, amounting to 800 feet in the Little Falls fault and to 1600 feet in that at Hoffman. The faults cut the latest of the stratified rocks represented, the Utica shale.

An earlier period of faulting occurred in Precambric time, though the displacements can be distinguished from those of later age in but few cases. The ore bodies on Arnold hill have been broken by a system of cross faults, and along some of these diabase dikes have been intruded. The dikes are, as already stated, of late Precambric age. As they show no effects themselves of any disturbance, it would appear that the displacements occurred before their intrusion.

Part II

NONTITANIFEROUS MAGNETITES

General relations and distribution

The class of so called nontitaniferous magnetites includes the ores that are relatively free from titanium. The term nontitaniferous, it may be noted, is hardly an accurate one to apply to any of the Adirondack magnetites, since the presence of titanium has been shown to be almost universal in these ores. For practical purposes, however, the low-titanium magnetites may well come under such designation, since they carry an inconsiderable proportion of the element — usually but a fraction of one per cent — too small to have any notable influence on their metallurgical behavior. The titanium is traceable usually to the mineral titanite which is a common constituent of the wall rocks and is often intergrown with the magnetite. Its proportion is generally higher in crude ore than in concentrates, the titanite being removed to a greater or less extent by mill treatment.

The nontitaniferous magnetites are the most widespread of the Adirondack iron ores. They have been worked at a great number of localities distributed over different sections.

With some exceptions the deposits may be grouped, however, into two geographical regions. The first and more important is that lying on the eastern border of the Adirondacks within the Lake Champlain drainage basin. To this region belong the deposits of Washington county, the Hammondville and Mineville districts and the smaller mines of Essex county, and all of the mines of Clinton county aside from the Lyon Mountain group. The last named is the only one on the north side of the Adirondacks that has been exploited to any extent, though there are a few small bodies in Franklin county. The second region lies on the west side in St Lawrence county and includes the Benson, Jayville, Fine and Clifton deposits all lying in the same vicinity. The rest of the western border extending through Jefferson, Lewis and Oneida counties contains, so far as known, no deposits of size. On the south side the Salisbury mine of Herkimer county is the single representative.

Attention has been called by Smock and other writers to the fact that nearly all of the mines occur in the bordering zone and that comparatively few have been opened in the interior of the

Adirondacks. This is attributed to the more thorough exploration of the outer areas owing to the advantages they afford in regard to accessibility for prospecting and transport of the ore to the market. No doubt the explanation is a reasonable one and entitled to serious consideration. But it would seem not improbable that there is an underlying geological basis for the general distribution of the occurrences that may be brought out clearly when the region is mapped in detail. The present study has not been extended beyond the limits of the ore-bearing districts. The interior of the Adirondacks is occupied in part by the great anorthosite mass, within which the ores are all titaniferous. Of the extensive region to the west and south of this area to near the Adirondack borders little is known as yet concerning its geology.

By far the greater number of mines that have been worked, including all the important ores, are restricted to a few districts of comparatively limited area. The total surface embraced within these districts constitutes but a very small portion of the whole region. It is probable that future exploration when extended into the outlying areas will result in the addition of new deposits to the list; but it can hardly be expected that the discoveries will compare in importance with those already made. The favorable ground for development was sought out by the early prospectors who seem to have penetrated into the most remote parts in their search and to have made good use of the dip needle and compass, by which the location of highly magnetic bodies like these is a comparatively easy matter.

Character of the ores

The ores show great variation in their mineral and chemical composition. They range from impure lean varieties consisting of magnetite intermixed with the constituents of the wall rocks, such as quartz, feldspar, pyroxene, hornblende etc., to those made up of practically pure magnetite. The richest average from 60 to 70 per cent iron. They have been obtained principally from the Mineville district, where some large bodies have averaged 60 to 65 per cent iron and have afforded considerable quantities assaying above 65 per cent and even approaching closely the theoretical limit for magnetite which is 72.4 per cent. The Hammondville, Arnold hill and many other mines have yielded ores with 50 to 60 per cent iron. The magnetites that carry less than about 50 per cent iron are generally considered too refractory for direct smelting; their utilization depends upon concentration, to which they are as a rule very adaptable. There are large bodies of such ores in the Lyon Mountain, Arnold hill and St Lawrence county districts. The lowest grade of milling ore that is worked carries about 35 per cent iron.

According to the percentage of phosphorus present, the magnetites may be subdivided into low-phosphorus, Bessemer and non-Bessemer grades. There is no well defined connection between the distribution of phosphorus and the nature of the ore occurrence. In some districts, as instanced by Mineville, both Bessemer and high-phosphorus ores have been produced from contiguous deposits, though generally the ores from any one district show a fair degree of uniformity in respect to the phosphorus. The leaner magnetites are apt to be lower in phosphorus than those having a high percentage of iron. The bulk of the low-phosphorus ores has been produced at Lyon Mountain; the present concentrates from this locality carry less than .01 per cent of that element with 65 per cent iron. The non-Bessemer ores range up to about .2 per cent phosphorus, corresponding to 10 per cent of apatite, which is the containing mineral. The Old Bed group of mines at Mineville has furnished most of this grade of ore.

The magnetites carry a variable proportion of sulfur, due to admixture with pyrite and more rarely pyrrhotite. The part played by these minerals in the composition depends upon the geological associates of the ore bodies, and a sharp line can be drawn generally between the class which carries any considerable proportion of them and the low-sulfur deposits. The presence of sulfur above a fraction of one per cent is confined mainly to the deposits that occur in the banded gneisses and schists of the Grenville series, which are themselves impregnated with pyrite. When the wall rock is an acid variety, corresponding to granite or syenite in mineral composition, sulfur exists only in minute quantity. Among the deposits belonging to the former class it is possible to find gradations from ores with fairly low sulfur to those in which the magnetite is replaced largely or almost completely by pyritic minerals.

Local variations in the ores frequently arise from the association of pegmatite which may carry magnetite in quantity to make it valuable. It has additional interest as affording a number of the rare minerals and many that attain unusual crystallographic development. Mineville and Lyon Mountain have yielded the greatest variety of species. Professor Kemp[1] has listed the minerals from the former locality, with mention of their more important characters. The Lyon Mountain locality has been described recently in a detailed manner by H. P. Whitlock.[2]

As a rule the magnetites show little alteration or effects of weathering, and are quite fresh at the surface. The only chemical change at all common is oxidation with the formation of hematite. The latter is usually pseudomorphic showing the characteristic granular structure and octahedral parting of the magnetite—the form known as martite. It occurs sparingly in several deposits, but in quantity only on Arnold hill where the so called "blue" veins are practically solid hematite. The oxidation of magnetite to hematite is accomplished very slowly under ordinary atmospheric conditions, and it seems to have been induced in these deposits by some special agency connected probably with underground water circulations. There are bodies of unaltered magnetite in the same vicinity.

Shape of the deposits

The Adirondack deposits occur in a variety of forms such as are common to the magnetites found in gneisses and schists elsewhere. They have been designated by different writers as beds, veins, pods, shoots, lenses etc., depending upon their particular development in the locality investigated.

In general the bodies have a much greater extent along the strike and dip than at right angles thereto, and show a more or less lenticular form in horizontal section, wider at the middle and tapering toward either end. In some cases they are so prolonged in the direction of strike that they are better described as tabular bodies, their regularity of width being like that found in a bed or stratum, a resemblance that has been emphasized by some geologists as evidence of a sedimentary derivation. The tabular and elongated lenticular bodies are more abundant in the northern and western Adirondacks. The Lyon Mountain, Arnold hill and St Lawrence county districts afford examples. The greatest irregularity of form prevails in the eastern districts, particularly those of Essex county, where the deposits often exhibit a puzzling complexity of pinches, swells and sharply compressed folds not observable in other sections.

---

[1] Geology of the Magnetites near Port Henry. Amer. Inst. Min. Eng. Trans. v. 27. 1897.

[2] Minerals from Lyon Mountain. N.Y. State Mus. Bul. 107. 1907.

There can be no doubt that the form assumed by the ore bodies is conditioned by the structures of the inclosing rocks. When the latter are foliated to an extent that permits observations of dip and strike, the contours follow the changes closely, even the subordinate ones. This feature is least apparent in the gneisses of the igneous series, the structures of which are often only faintly indicated, and most evident in the banded gneisses and schists of the Grenville. The ores consequently must have been deposited before the great regional disturbances took place, or at least before the rocks received their present structural arrangement. They have passed through all the vicissitudes of squeezing, folding and other deformations that have been impressed upon their walls.

In their original condition the ore bodies were probably tabular masses, like those now existing in the regions of least disturbance. From such masses, a complete sequence may be traced into lenses, shoots and the more complicated structures that have been developed by operation of mechanical processes.

Associated rocks

There is no constant type or formation that is characteristic for the nontitaniferous ores as a whole. The wall rocks include gneisses of granitic, syenitic and dioritic composition, acid pyritic, garnetiferous gneisses, hornblende and biotite schists, amphibolites and occasionally crystalline limestones.

From considerations of their probable origin, they may be divided into (1) igneous derivatives and those closely allied to the characteristic intrusive masses of the Adirondacks; (2) members of the sedimentary or Grenville group. Nearly all of the magnetite-bearing rocks may be referred with a degree of certainty to the one or the other of the two classes. For a few occurrences, however, the evidences of relationships that have been found thus far are too obscure to admit any definite conclusions, though it is probable that the rocks are uniform with the others, rather than characteristic of a distinct class.

1 **Igneous group.** The more acid members of the igneous series constitute the country of the Clinton county mines, all of which occur within the belt of alkali-feldspar gneisses known as the Saranac formation. At Lyon Mountain, the country consists of a massive reddish variety composed of microperthite, oligoclase, green augite, hornblende and magnetite with a small amount of quartz. Mineralogically it lies on the border between the syenite and granite rock

groups, with local variations ranging through both. Its intrusive nature is evidenced by the penetration and absorption of an older formation, a hornblende schist which occupies limited belts in the vicinity, as well as by its pegmatitic and thoroughly massive phases.

The numerous deposits centering around Arnold hill and Palmer hill, in southern Clinton county, are inclosed by the same Saranac series. The Palmer hill ore body is particularly interesting, in that it consists of a magnetite band in a massive augite-biotite granite that carries fluorspar. This mineral forms an integral part of the ground mass, where it is associated with quartz and feldspar (microcline and orthoclase) reaching at times large proportions. Its presence can hardly be explained except by pneumatolytic action during the consolidation of the rock from a molten state. Fluorspar is a quite common mineral in the magnetites elsewhere, but usually in small quantities and limited, so far as observed, to pegmatite or vein material.

Syenite of the characteristic Adirondack type is represented in force in the Mineville group of mines. It has been shown by recent drilling to underlie the ore bodies in what seems to be a continuous mass. The rock is of greenish cast and is normally composed of microperthite, green augite, hornblende and magnetite, but through the addition of quartz and shrinkage of the ferromagnesian constituents, passes into a lighter reddish rock that is much like the varieties above described. This rock called the "21" gneiss in the earlier report of Professor Kemp, forms the hanging wall of the Old Bed group. Its relations to the underlying syenite, as well as the apparent differentiation of the latter into a dioritic phase, are brought out in the article by Professor Kemp included herewith.

A basic variety of augite-syenite constitutes the wall rock at the mine near Salisbury, Herkimer co., being a part of the intrusives in that region which reach southward from the Adirondacks into the Mohawk valley. The dark minerals (augite, hornblende and magnetite) constitute about 75 per cent of the rock in immediate contact with the ore, but away from the latter there is a gradual change into the normal syenite.

While the rocks from the different mine localities have not been chemically analyzed, the following tabulation of analyses taken from a recent report by H. P. Cushing[1] may be useful in showing the general range of the igneous series. The description of the

[1] Geology of the Long Lake Quadrangle. N. Y. State Mus. Bul. 115. 1907. p. 520.

specimens taken for analysis indicate close resemblances in many cases to the ore-bearing rocks. Professor Cushing has worked out the corresponding mineralogic composition and it will be of interest to note the relative quantities of magnetite present.

	1	2	3	4	5	6	7
SiO_2	54.10	59.70	61.01	62.85	63.45	66.72	68.50
Al_2O_3	17.45	19.52	15.36	16.80	18.38	16.15	14.69
Fe_2O_3	4.52	1.89	2.98	2.96	1.09	1.23	1.34
FeO	6.47	4.92	7.77	2.89	2.69	2.19	3.25
MgO	2.33	.78	.78	1.48	.35	.73	.26
CaO	6.17	3.36	4.05	3.24	3.06	2.30	2.20
Na_2O	3.81	5.31	3.68	4.09	5.06	4.36	3.50
K_2O	3.06	4.14	3.90	5.49	5.15	5.66	5.90
H_2O	.57	.52	.49	.37	.30	.77	.40
TiO_2	.19	......	......	.09	.07	......	......
P_2O_5	.88	......	......	.13	......	......	.03
Cl	......	......	......	......	......	......	......
F	.05	......	......	.01	......	......	......
S	.14	......	......	.02	......	......	......
MnO	.35	.09	.08	.21	tr.	.07	.10
BaO	.10	......	......	.06	.13	......	.05
	100.19	100.23	100.10	100.69	99.73	100.18	100.22
Magnetite	6.57	2.73	4.32	4.29	1.58	1.85	1.86

1 Basic syenite from near Raquette falls. E. W. Morley, analyst.

2 Augite syenite, road from Tupper Lake to Wawbeek. E. W. Morley, analyst.

3 Augite syenite, 3½ miles north of Tupper Lake Junction. E. W. Morley, analyst.

4 Red, quartz, hornblende syenite from north boundary of Litchfield park. E. W. Morley, analyst.

5 Augite syenite, Loon Lake, Franklin county. E. W. Morley, analyst.

6 Augite syenite, Little Falls, Herkimer co. E. W. Morley, analyst.

7 Quartz, augite syenite, 2½ miles south of Willis pond, Franklin county. E. W. Morley, analyst.

With the exception of No. 6 (syenite from Little Falls) the rocks represented are from the interior of the Adirondacks, away from the mine localities.

2 **Sedimentary group.** The association of magnetites with distinctly Grenville types of gneisses and schists is characteristic for the St Lawrence county occurrences, as well as for some in southern

Essex county, notably around Crown Point. Compared with the preceding group the most striking peculiarity of these magnetites is the constant association of pyrite which brings the sulfur content up to very considerable amounts, a feature that has been a serious handicap to their development in the past. The pyrite may possibly be traceable to original organic matter in the sandstones, limestones and shales from which the present rocks have probably been derived. The widespread occurrence of graphite in the same rocks is noticeable.

At Benson Mines, St Lawrence county, the ore body consists of an impregnated zone in a quartzose banded gneiss. The gneiss contains sillimanite and scapolite in addition to the feldspar, while the dark minerals include hornblende, biotite and augite. Garnet and pyrite are prominent. The walls in places are cut by a later hornblende granite.

The Clifton mines, north of Benson, and those on Vrooman ridge, near Fine, are found within a black hornblende schist with interbedded layers of impure crystalline limestone. The latter occurs next to the ore in one of the openings at Clifton.

At Jayville the same sedimentary series is in evidence, though here the ore bodies and walls (hornblende-biotite schist) have been invaded by a great granite mass which has broken up what was apparently a continuous bed into numerous lenses and shoots that seem to give out in depth after passing the limits of the schist. Curiously enough, the ore contains little pyrite. There is evidence of recrystallization of the magnetite, and contact action has caused the formation of great masses of hornblende and abundant titanite.

The several mines near Crown Point have opened on bands of pyritous magnetite which are inclosed by a black hornblende gneiss that has been correlated with the Grenville of this section. The gneiss has been intruded by granite and in some places the latter lies close to the ore. The ore bodies are parallel in all respects to the St Lawrence county deposits.

Origin of the magnetites

The origin of these ore bodies has been variously interpreted by geologists. The problem is an obscure one, involving as it does accumulations of ores in rocks which are among the most ancient known on the earth's surface and which in many cases have undergone great vicissitudes from compression and metamorphism. So long as the nature of the rocks themselves remained doubtful, the problem might be viewed obviously from several standpoints.

The sedimentary theory of origin has been held in most favor perhaps by geologists. The condition precedent to its application is that the inclosing formations are themselves of sedimentary derivation. Different modifications of the general theory are possible: the deposits may be considered to have been laid down in the form of magnetite, in which case they represent original surface concentrations such as the magnetite sands that are found along the shores of lakes and streams; they may have been originally limonite or carbonate ores deposited from solution and subsequently changed under the influence of the metamorphism that has affected the wall rocks. The apparent conformity between the deposits and the foliation of the gneisses, their lineal development and persistence for long distances on the strike are supporting arguments for the sedimentary theory.

In a previous paper on the Mineville deposits,[1] Professor Kemp gave the first detailed account of the geological surroundings of the magnetites. As a result of his investigations, he was led to question the applicability of the sedimentary theory to the ores of that district. The existence of igneous masses in the vicinity and the evidences of their agency in the formation of many of the accompanying minerals were remarked and adduced in support of the view that the ores have been introduced by processes connected with the intrusion of those rocks, more particularly the gabbro of Barton hill. In the present contribution it has been possible to clear up some doubtful points relating to the geology of the district, with the result that a more immediate source of the iron minerals in the augite syenite is indicated.

For the occurrences in the midst of intrusive rocks, which have been found to be the prevailing type in the eastern Adirondacks, there would seem to be no escape from the conclusion that the ores have formed by igneous action. They are related to the wall rocks just as the titaniferous ores are related to the gabbros and anorthosites.

The processes which led to the accumulation of these deposits may have varied in some degree in the different localities. Magmatic differentiation has been, no doubt, a prominent factor in the early stages of their formation and perhaps is competent to explain the whole course of their development. Yet there is reason for believing that other agencies were active in producing the final

[1] Geology of the Magnetites near Port Henry, N. Y. Am. Inst. Min. Eng. Trans. v. 27. 1898.

results. Of these the influence of highly heated vapors and waters arising from the igneous mass has been most important. The occurrence of fluorite, apatite, hornblende etc., intercrystallized with the magnetite, is suggestive in that line, as well as the frequent accompaniments of pegmatite and vein quartz. This agency would be specially active in the final stages of cooling and consolidation of the wall rocks. In some cases it may have been the determinative factor in bringing the iron minerals into their present position. The ore bodies thus formed would be comparable in a way to pegmatite dikes.

Some authorities are inclined to doubt the efficacy of magmatic differentiation as applied to the formation of ore bodies in rocks of acid composition. There seems to be no valid reason for thus limiting it to the gabbros and anorthosites of the Adirondacks. The relative acidity of the rocks appears to the writer not so important as the relation between the iron and lime-magnesia percentages. With a large excess of iron over the amounts required for combination with the latter to form augite, hornblende and biotite, the segregation of iron minerals might well be expected. This is exactly the condition presented by the wall rocks of the ores. From the analyses that have been given on a preceding page, it will be seen that even the more acid of the intrusives carry relatively high percentages of free iron. The amounts of magnetite calculated for the rocks, all of which are from localities outside of the mine districts, run from 1.58 to 6.57 per cent. Higher percentages would be found, undoubtedly, in specimens taken from the actual wall rocks. With 5 or 6 per cent of magnetite a concentration of 10 to 1 would produce the leaner ores that are mined in this region.

The granites and syenites of the Adirondack iron ore districts constitute a group that has some elements of relationship with the gabbros and anorthosites. This is manifested by a similarity in important features of chemical composition and by the existence of transition types. The ores they inclose differ mainly in the titanium content. In the silicious rocks, the titanium has combined with lime and silica to form titanite which has been held mainly in the body of the rock mass. With the basic magmas, the silica has been entirely taken up by the feldspathic and ferromagnesian constituents and the titanium consequently united with the iron and has been concentrated with it in the ore bodies. The ores in the acid rocks commonly contain a fraction of one per cent or so of titanium in the form of titanite.

The pyritic ores that are found in the Grenville gneisses constitute of course a distinct class. They may be ascribed possibly to some process of sedimentation as outlined above, but it would appear to the writer more reasonable to regard them as introductions subsequent to the formation of the wall rocks. They apparently antedate the period of deformation during which the surrounding rocks were subjected to their final compression and folding.

As a rule the deposits are more irregular than would be expected in stratified bodies. They have no well defined bounds, but shade off into the country rock. It is seldom that the character of the hanging and foot shows any marked change that can be taken for original variations in the sedimentation. The thickness of some of the deposits is excessive when compared with known examples of bedded iron ores; the Benson body, for example, measures over 200 feet across the strike and the country rock is mineralized over much greater width.

Though it is believed that the ores are of epigenetic or secondary derivation, there is little basis of facts to support a more precise explanation of their origin. The view that they were formed before the surrounding rocks had undergone final rearrangement appears reasonable, because they have laminated textures and follow closely the general field structures. Their introduction may thus have taken place before the rocks were metamorphosed, in which case it might have been accomplished by ordinary ground-water circulations, with limonite or carbonate replacing the shales and limestones as the first step. The presence of organic matter in the beds, indicated by their content of graphite, would exercise a reducing action favorable to the formation of magnetite rather than hematite under the ensuing metamorphic conditions.

Mining and milling in the Adirondacks

Both underground and open-cut methods are used in the Adirondack mines, the latter, however, being restricted to a few large ore bodies or those so situated as to present a considerable surface development. In general the high inclination of the bodies and their narrowness across the strike render a system of underground working the most suitable from the start. Inclined shafts or slopes following the dip of the ore have been generally adopted in preference to vertical shafts which in some instances at least would seem to offer important advantages as regards economy of operation. The deepest shafts are at Lyon Mountain, about 1500 feet measured on the incline. Horizontal drifts are extended on either side of the shaft at more or less regular intervals and the ore stoped out between them, leaving occasional pillars of ore for roof support. In the Old Bed workings at Mineville, the ore is removed in large chambers which are extended downward with the progress of operations, as the main mass of ore lies nearly vertical. The chambers are of great size, measuring 200 feet or more from roof to floor. Timbering or other artificial support is not required in the Adirondack mines, and little trouble has been experienced from caving. The workings are relatively dry, as the wall rocks are nearly impervious to water.

Concentration of the magnetites has been practised since the early days of mining in the region. As early as 1836, according to local records, a plant was in operation at Palmer hill for treating the ore by a magnetic process. The details of this installation, an interesting precursor of the modern plants, have unfortunately been lost, though it is hardly probable that the venture could have been successful. A wet gravity system of concentration was commonly used up to about 15 years ago when the magnetic process was perfected to an extent that made its introduction feasible. This process is now generally recognized to be well adapted to the Adirondack magnetites.

At present there are six concentrating plants in the region; two are installed at Mineville, two at Lyon Mountain and one each at Arnold hill and Benson Mines. Another plant is in course of erection at the Cheever mine near Port Henry. In 1906 the mills at Mineville, Lyon Mountain and Arnold hill, which were the only ones operated, crushed 729,091 long tons of ore, making 479,644 long tons of concentrates.

The system of magnetic concentration employed is practically the same at all the mines. It involves dry crushing, sizing and treatment of the product by magnetic separators of which the Ball-Norton drum type is the one commonly used.[1] The crushing is regulated as to fineness by the granularity of the ores which varies at the different mines. As a rule it is not carried to the point where the greatest saving of the magnetite would be effected, since the production of fine concentrates is not desirable from a metallurgical standpoint.

The difficulty in handling the finer grades of concentrates in the blast furnace has been something of a drawback to the success of magnetic concentration as applied to ores in which the magnetite is intimately intergrown with the gangue minerals, an association that is not uncommon in the Adirondacks. Briquetting has not

1 For further details of the apparatus and methods used, consult the issues of the *Engineering and Mining Journal*, for June 9, and November 17, 1906, wherein are described the mills at Mineville and Lyon Mountain.

been attempted on a commercial scale, though it has been used successfully elsewhere for similar materials.

The concentrates from the Adirondack mills carry on the average 60 to 65 per cent iron. Besides raising the iron content, magnetic concentration affords a partial elimination of the phosphorus and sulfur, important advantages for some ores. In fact the treatment of the Old Bed ores at Mineville is designed particularly to reduce the phosphorus, and the concentration is rather incidental to that purpose.

The costs of mining and milling differ of course according to local conditions. With a modern plant 75 cents per ton is probably a fair average for underground mining under favorable circumstances. Quarry work has been conducted for less than half that amount at Benson Mines. Magnetic concentration costs from 25 to 40 cents per ton of material treated. For a period of ten months during 1900, the total cost of producing concentrates at Benson Mines, including mining, milling and general expense, is said to have been $2 per ton, which is equivalent to about 80 cents per ton of the crude material handled.

Statistics of ore production

The production of magnetite in the Adirondacks has amounted in all to something over 35,000,000 long tons. The total can not be stated accurately, though there is little doubt that the figure given represents a minimum. The actual production may be larger by two or three million tons. The following table gives the nearest possible approximation of the output distributed among the leading districts; it is based upon the statistics included in the reports by Smock and Putnam and in other publications and upon records of mining companies that have been obtainable. The statistics are carried down to the end of 1906. They are based on the marketable product as shipped to the furnace.

DISTRICT	LONG TONS
Mineville	25 000 000
Lyon Mountain	3 500 000
Arnold and Palmer hills	2 000 000
Hammondville	2 000 000
Saranac valley	500 000
Fort Ann	350 000
St Lawrence county	300 000
Other mines	2 000 000
Total	35 650 000

It is only within the last 25 years that statistics of the annual production have been recorded. The table below embraces all data that could be collected from published sources. The figures for the years previous to 1904 have been taken principally from the annual reviews by John Birkinbine, contained in the *Mineral Resources*, while those for 1904 and subsequent years have been compiled at the State Museum.

YEAR	LONG TONS
1879	420 341
1880	531 000
1881	637 000
1882	675 000
1883	500 004
1884	504 894
1885	379 077
1886	583 752
1887	768 852
1888	789 419
1889	779 900
1890	821 994
1901	329 467
1902	451 570
1903	451 481
1904	559 575
1905	739 736
1906	713 692

The period of maximum development in the Adirondack mines may be said to have extended from about 1860 to 1890. In the 10 years following the latter date for which no figures are available the output was comparatively small due to the depressed state of the iron markets and the expansion of the Lake Superior districts which were able to sell ore at a lower figure than was possible with the Adirondack mines. Since 1900 there has been a noticeable improvement in the conditions; the output for the past two years has been nearly as large as at any time previous and it will probably show an increase for the next few years, provided there is no marked falling off in the demand for iron ores.

MINES NEAR FORT ANN

The Potter, Podunk and Mt Hope mines are situated on the west side of Putnam mountain in Fort Ann township, Washington co. They are reached most conveniently from Fort Ann village which by the indirect wagon road is 9 miles southeast. The elevation of their outcrop according to the topographic map is about 900 feet. The total production of the three mines is reported to have been about 350,000 tons.

Potter and Podunk mines. The ore bodies outcrop near the foot of Podunk pond and but slightly above its level. They are included in a belt of schists which belong probably to the Grenville series, though no limestone was found in the vicinity. The schists, as exposed in the hanging wall at both shafts, consist of quartzose bands alternating with thinly laminated hornblendic and micaceous layers. They carry considerable amounts of pyrite. Their dip is 45° northeast. The rock on the foot-wall side is concealed for some

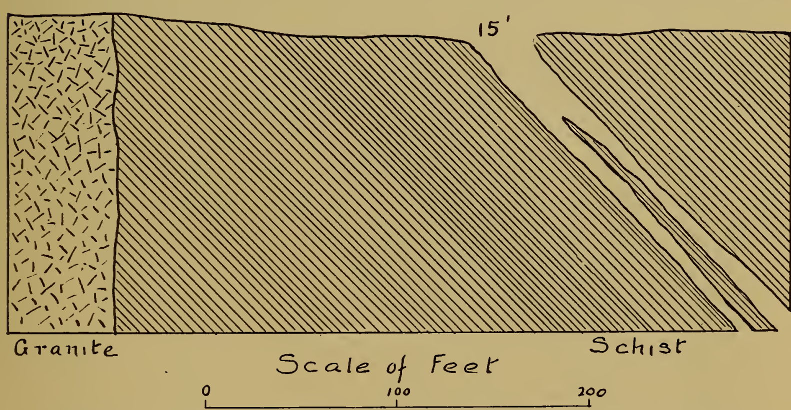


Fig. 2 Cross-section of the Potter mine, showing wall rock (Grenville schist) cut off on the south by granite

distance, but at one point midway between the two mines and 100 feet south there is an exposure of reddish gneissoid granite. This rock is found to the west in frequent outcrops and in such relation with the schists that its intrusive character is plainly indicated. It is a microcline, quartz, hornblende granite quite like the Hammondville type except that the texture is usually more finely granulated.

The Potter mine is 250 feet northwest of the Podunk. It was opened in 1879. A slope 100 feet long runs down the footwall at an average inclination of 32°. At the time of Putnam's report the ore had been stoped out for a distance of 175 feet southeast of the slope. His report contains a sketch of the workings from which the section included herewith has been prepared. A notable feature shown in the section is the horse of rock which splits the ore body into two seams. The horse thickens to the northwest, reducing the ore breast proportionately, so that the limit of profitable working was soon reached in that direction. On the southeast only the hanging seam 10 to 15 feet thick has been exploited.

The Podunk mine on a parallel ore body is bottomed at 300 feet. There are several hundred feet of drifts extending horizontally from the slope. The ore breast is said to have averaged 8 feet. A third opening called the Baker has been made on a deposit west of the Potter mine. It has produced only a few hundred tons. The dumps at the Potter mine contain possibly 2000 tons of waste ore that evidently carried too much pyrite to be shipped to the furnace. The sulfur has been oxidized to a great extent and washed out by long weathering so that the material might now be valuable. This ore came from a zone specially rich in pyrite; most of the output was sufficiently free from this mineral to be merchantable. Chemical analyses indicate a phosphorus content that meets the Bessemer requirement. Of the following, which have been communicated by Mr S. R. Potter, No. 1 relates to a sample from the Potter mine and No. 2 to a sample from the Baker opening.

Fe_2O_3	49.00	41.30
FeO	21.98	18.47
SiO_2	23.10	35.22
TiO_2	nil	......
S	.22	......
P_2O_5	.014	.05
Al_2O_3	3.70	1.61
MnO	.09	.42
CaO	1.39	.45
MgO	......	3.14
	99.494	100.66
Iron	51.46	43.30
Phosphorus	.006	.02
Manganese	.070	.32

Mt Hope mine. The ore belt continues in the direction of the strike northwest from the Potter mine and after an interval of a little more than half a mile outcrops along the ridge known as Mt Hope. According to published accounts ore was mined here 50 years ago. The last period of activity was from 1879 to 1881, when 15,000 tons or more were taken out and mostly stacked at the mine.

The workings are situated on the east, south and west sides of a north and south spur of Mt Hope. A drift has been excavated entirely through the hill on the strike of the ore, showing a thickness of 10 feet at the western entrance. It opens into a chamber 200 feet long, extended down the dip to the water level, and averaging 6 or 8 feet in hight. In another drift to the north two seams of ore 24 and 80 inches thick occur. The dip ranges from 10° to 30°. On the east side of the hill there are three open cuts which are on the same or parallel veins.

The deposit shows a tendency to form shoots and the walls are irregularly spaced with evidences in places of slight breaks. The reddish granite which has been mentioned as occuring on the foot-wall of the Potter and Podunk mines appears in force, sometimes in contact with the ore and again giving way to the schists. Bunches of black garnet are found in the latter, possibly as a result of contact action.

The ore averages leaner than the product from the Potter and Podunk mines on the eastern end of the belt. It is mixed with pegmatite, hornblende, mica and other minerals, but contains little pyrite. Most of the material in the stock pile is low grade and probably would not assay over 30 per cent iron as an average. The following analyses give the composition of the ore. In No. 1 which has been communicated to the writer by Mr S. R. Potter the iron is reported wholly as monoxid. The analysis was made by Messrs Booth, Garrett & Blair of Philadelphia. No. 2 is quoted from Maynard, the analysts being Maynard and Wendell.

	1	2
Fe_2O_3	......	42.09
FeO	85.481	19.10
SiO_2	7.180	20.04
TiO_2	.370	......
S	.077	.32
P_2O_5	.038	.21
Al_2O_3	3.533	7.90
MnO	tr.	.32
CaO	2.380	7.87
MgO	1.280	2.46
	100.339	100.31
Iron	61.900	44.31
Phosphorus	.017	.092
Titanium	.272	......

A sample stated by Putnam to have been taken from the stock pile near the western entrance to the drift gave:

Iron	36.99
Phosphorus	.055
Titanium	nil

MINES NEAR CROWN POINT

In the vicinity of Crown Point on Lake Champlain and west of there toward Hammondville are a few scattered ore bodies that have received attention in the past, principally as sources of supply for the Crown Point furnace. Among them are the Vineyard, Butler, Kent, Breed and Hammond mines, besides one or two prospects. The Mt Defiance hematite mine, south of Fort Ticonderoga, may also be included among the number. The Crown Point furnace has not been operated for the last 15 years and is now dismantled.

Geologically, the magnetites of this area show striking differences from the Hammondville group which lies immediately west of Crown Point. They are associated with banded gneisses and schists that can be classed without reserve in the sedimentary or Grenville series. They have a simple tabular or lenticular form, swelling and narrowing to some extent along the strike and dip, but otherwise are little disturbed. They lie conformable to the foliation of the walls, which is plainly marked. In their mineral composition they differ from the Hammondville ores in having a high sulfur content, due to disseminated pyrite and, in most cases, a higher percentage of phosphorus as well. Their admixture with pyrite was a serious drawback to their utilization, since there were no mills for concentrating the ores in this section.

The Grenville rocks which occur near the ores are mostly hornblende and biotite quartzose gneisses with occasional intercalations of thin bedded schists. They are conspicuously foliated and variable in their composition from layer to layer. Their color is generally gray, from light to dark shades, sometimes almost black. Pyrite is a common ingredient, while graphite is not wanting. Crystalline limestone has a very limited distribution, apparently, in this area, though abundant farther west. The only occurrence observed near the mines is at the old eupyrchroite locality on the north side of Breeds hill, just south of Crown Point village, and here it is confined to a thin bed of coarsely crystalline graphitic material associated with a dense quartzite.

The Grenville has been broken up into patches and larger irregular areas by granite which has invaded the series from below. The granite is more or less gneissoid, but yet has a quite massive appearance in contrast with the sedimentary gneisses. It consists mainly of microcline and quartz, with biotite and magnetite as the principal dark minerals. It is of pinkish color. The granite frequently cuts across the stratification of the sediments and sends off dikes and stringers which penetrate the latter in all directions. It is very likely a part of the same mass described as being intrusive in the Grenville around Hammondville to which it is very similar in its characters.

Vineyard and Butler mines. These mines are located on the same deposit. They lie in the narrow valley between Buck mountain and the next ridge to the west known as Dibble mountain, just over the border of Crown Point in Ticonderoga township. Their outcrop is 2 miles distant from and 500 feet above Lake Champlain.

The Vineyard mine was last worked by the Lake Champlain Ore & Transportation Co., during the years 1887 and 1888, but it had been under operation 40 years before. Some of the ore was used at the Crown Point furnace. The deposit can be traced along the outcrop for 100 rods or more following the highway that leads to Crown Point Center. It is inclosed by a laminated black hornblendic gneiss. The strike for most of the distance is a little west of north, but on the south end it bends around and becomes east of north. The main workings are on the southern portion and consist of open cuts and shallow pits sunk on the dip which is westerly at an angle of 40° or more as measured near the surface. The principal pit has recently been pumped out. It is less than 100 feet deep and shows 5 feet of ore at the surface which widens to nearly 15 feet at the bottom.

The ore is a fairly rich, coarse magnetite. It contains pyrite in variable amount, more abundant toward the walls than in the central part. The following analysis by J. B. Britton is quoted from Maynard who states that it was made from a sample after rejecting the most sulfury portion.

Iron	51.34
Silica	21.07
Sulfur	1.17
Phosphorus	.36
Water	.24

The Butler mine is located on the northern continuation of the Vineyard. It consists of surface workings of only a few feet depth. The body seems too narrow in this direction.

Kent mine. Thin bands of magnetite appear in the gneiss on the southern slope of Dibble mountain. Three places were found where ore has been taken out in small quantity. The deposits are thin and have been worked only superficially. The production could not have been more than a few hundred tons.

Breed and Hammond mines. These are situated on top of Breeds hill, 1½ miles south of Crown Point. Together with a third opening lying on the east shoulder of the hill they form an interrupted band of ore that extends across the hill in a northeasterly direction. There is a slight offset in the lines of outcrop of the ore bodies which is suggestive of faulting. The walls in both mines consist of dark, hornblende-biotite gneiss carrying pyrite, but the granite appears in close proximity and seems to have cut it off on all sides, limiting the former to a narrow belt.

The Breed mine is opened by an inclined shaft sunk at an angle of 45°. There is a drift 20 feet long at the bottom. The deposit is said to have afforded a breast 8 feet thick. The ore contains biotite and hornblende in considerable quantity, but portions are quite rich. It is highly sulfurous.

The Hammond mine which lies up the hill and to the east of the Breed is opened by a vertical shaft of no great depth. The outcrop shows about 5 feet of ore, similar to that just described.

Howe mine. A little exploration has been done on a deposit situated 6 miles northwest of Crown Point. The pit is 5 feet wide and has been excavated on a band of ore which runs northwest up the face of a prominent ridge. A line of magnetic attraction is traceable to the south of the pit, while higher up on the ridge a 2 foot band of rich magnetite outcrops with the same strike. The inclosing rock is hornblende gneiss. Pyrite is present in the ore.

Blye mine. This is a prospect 2 miles north of Crown Point Center on the southern face of Coot hill. The test pit shows a fairly rich magnetite, but the development work is insufficient to afford an estimate as to the size of the deposit. An area of magnetic attraction is reported on the top of the ridge, toward which the ore trends.

Mt Defiance mine. An interesting occurrence of hematite ore is found just south of Fort Ticonderoga station and west of the Delaware & Hudson Railroad tracks. Mt Defiance is the termination northward of the high ridge separating Lake George and Lake Champlain. It is made up of a greenish slightly gneissoid rock which has been described as containing microperthite, augite, hypersthene, hornblende and quartz, a composition that plainly establishes relationship with the augite syenites.[1] The mountain thus represents without doubt an igneous knob that has been intruded in the surrounding gneisses which are mainly sedimentary. The ore body occurs near the base of the mountain occupying a vertical fissure with a strike n. 70° w. The walls on either side are brecciated, and there has probably been more or less displacement though of uncertain extent. Close to the fissure the rock is mashed, altered to a greenish material which seems to be mainly chlorite, and impregnated with hematite. There is every reason for believing that the ore has been introduced by circulation of underground waters subsequent to the formation of the fissure. It is plainly not an altered magnetite band. The hematite is principally a soft amorphous variety, with occasionally some masses of specular; it is mixed with calcite and milky quartz. The deposit as seen from the surface ranges up to 5 feet wide. It has been worked through a drift which enters the hill a short distance above the base. Smock states that a pit was also sunk, but as the workings are full of water this can not now be seen. He further states that 8 feet of ore were encountered. Apparently the vein has been developed quite extensively for it is referred to by Watson[2] who says that 1500 tons had been taken out in the early operations. It was again mined in 1888 and ore shipped to Port Henry. Preparations were under way in 1905 for again reopening it, but after starting an adit at the base of the hill the work was abandoned.

HAMMONDVILLE MINE GROUP

The Hammondville mines are in the western part of Crown Point township, Essex co., 13 miles west of Crown Point village on Lake Champlain and 15 miles south of the Mineville district. They occupy a limited area that centers around the former settlement of Hammondville. Though mostly of small size they have furnished in the aggregate nearly 2,000,000 tons of ore (chiefly Bessemer) with an average of about 50 per cent iron.

---

[1] J. F. Kemp & D. H. Newland. Preliminary Report on the Geology of Washington, Warren and Parts of Essex and Hamilton Counties. N. Y. State Mus. Rep't 51. 1899. 2:512.

[2] History of Essex County, p. 385.

In the same vicinity are the Skiff, Long Pond and Schofield mines, situated on Skiff mountain, and the Harris mine near Paradox; they have subordinate rank as producers to the Hammondville group.

The exploitation of iron ores in the district dates back to 1824 in which year the Penfield mine was opened.[1] A forge was built in 1828 at Ironville, between Hammondville and Crown Point, for converting the ore into blooms and in 1845 a charcoal furnace was erected just north of Hammondville to smelt the product of the Hammond mine. The most active development, however, took place during the period from 1873 to 1890 under the Crown Point Iron Co. The mines were connected by a narrow gauge railroad with the lake at Crown Point, where a blast furnace was maintained in operation, while ore shipments were also made to the furnaces at Bethlehem and Scranton, Pa., and at Troy.

The mines were closed down in July 1893. In 1897, the property was purchased by the American Steel & Wire Co., and soon afterward the mining plant, buildings, railroad, etc., were dismantled. Recently the mines have been under exploration by the Oliver Iron Mining Co.

Geological sketch of the district

The country is broken by ridges and narrow stream valleys and has rugged contours. It is part of the foothill region of the Adirondacks, but lies close to the central uplift of anorthosites. As may be observed from the topographic map, which has been issued by the United States Geological Survey, the contours are very irregular and show little tendency to the usual alinement along a northeast-southwest axis so pronounced in most sections of the eastern Adirondack region. The ridges range from 1500 to 2000 feet reaching an extreme in Knob mountain slightly above the latter limit. Hammondville itself together with the mines is situated on the gently sloping surface of a ridge at about 1300 feet elevation.

The geology of the district, so far as concerns its broader features, has been mapped and described by Dr I. H. Ogilvie, in connection with the report on "Geology of the Paradox Lake Quadrangle, New York."[2] Since the publication of this report a more detailed investigation of the region surrounding the mines was

---

[1] W. C. Watson. The Military and Civil History of the County of Essex, New York. Albany 1869.

[2] N. Y. State Mus. Bul. 96. 1905.

undertaken by the Oliver Iron Mining Co., for the purpose of establishing a basis for exploratory operations with the diamond drill. The field work was carried on during the summer of 1906 under charge of Mr M. H. Newman, who has afforded the writer every opportunity to keep in touch with its progress and likewise to make use of the results. The district is extremely complex geologically by reason of the great variety of rock formations represented, which involve practically the whole series of Adirondack crystallines, and the intricate structural relations resulting from plication, faulting and the intrusion of igneous masses.

The formations may be divided in a general way into the Hammondville or ore-bearing gneiss, which is a quartz-plagioclase gneiss of doubtful relationships; a group of metamorphosed sediments including crystalline limestone and hornblendic and micaceous gneisses and schists, and an igneous series composed of anorthosite, gabbro, diabase, syenite and granite. This is essentially the classification proposed by Dr Ogilvie except that the Hammondville type of gneiss is considered by her to be eruptive and is mapped with the granites.

Hammondville gneiss. The rock inclosing the deposits is distinguished by a finely granular cataclastic texture and almost entire absence of dark minerals except magnetite. It has a homogeneous character for the most part, in contrast with the recognizable members of the sedimentary gneisses which vary greatly from place to place. Of the igneous rocks exposed in the district, it most closely resembles the granite, but differs in some particulars of mineral composition and in the more intense crushing effects which it exhibits.

Mineralogically it consists almost wholly of plagioclase feldspar and quartz. The ferromagnesian constituents are limited to occasional shreds of biotite and a little green hornblende, forming an inconsiderable proportion of the mass. Magnetite is fairly abundant, in many specimens richly so. Apatite, titanite and zircon are the remaining components.

The rock has uniformly a grayish color on unweathered surfaces, changing to brown in exposures, with sometimes a reddish stain from a little included pyrite. In the finely crushed phases it looks much like a feldspathic quartzite. In the percentage of silica present it corresponds to an acid granite with an indicated content of 70 per cent or more, but it differs from usual granites in the predominance of the soda feldspar, the potash varieties being practically absent. The magnesia and iron are below the average for granitic rocks. The texture gives no clue to its original nature, being completely granulated in most specimens. The quartz particles seem to be an earlier crystallization than the feldspar, contrary to the usual order of igneous rocks.

Sedimentary crystallines. The principal members of the sedimentary or Grenville series are limestone, hornblende gneiss and mica schist. Dr Ogilvie has recorded the presence of quartzite and sillimanite gneiss in the upper part of the series, but they have no representation within the limits of the district. The sedimentary derivatives are closely associated in their field relations.

The limestone forms bands and larger belts that are followed by the stream courses. It is thoroughly crystalline and frequently contains such minerals as graphite, pyroxene, amphibole and phlogopite and other silicates that have originated from the alteration of the limestone and its impurities by metamorphic agencies.

The hornblendic and micaceous gneisses and schists though completely changed from their original condition show indubitable evidences of their sedimentary derivation. They are as a rule very quartzose, with a proportionately small amount of feldspar and varying quantities of hornblende and mica. They are conspicuously banded; beds of light and dark varieties alternate across the strike, their junctions being sharp like the planes separating different sedimentary beds. Garnet, pyrite and occasionally graphite occur as accessory minerals.

Intrusive rocks. Of the recognizable intrusives found in the Hammondville district, the anorthosite and gabbro are uniform in their geology and mineral character with the general types which constitute the central Adirondacks. They grade into each other by imperceptible stages and have no doubt originated from a common magma. The syenite may also belong to the same intrusive series, representing a more acidic development. It is made up of microperthite, hornblende and a green augite, but in some phases contains labradorite feldspar as well and shows a gradation toward the gabbro. These rocks are all later than the sedimentary formations which are invaded by them, though the relations can be determined infrequently by contact effects owing to the regional metamorphism that has taken place subsequent to their intrusion.

The granite found on Knob mountain and in small areas within the gneisses is a coarse reddish variety. It contains microcline as the principal feldspar, with some orthoclase and quartz, hornblende, biotite, apatite and magnetite. It has a more or less gneissoid appearance, and the feldspar which originally existed in porphyritic crystals has been considerably crushed, but the textural relations are those of a plutonic igneous rock. It is regularly jointed and weathers out into massive blocks. In the Knob mountain area there are included fragments of the sedimentary hornblende gneiss which it has invaded. The Hammondville gneiss to the west is penetrated by dikes and irregular masses of granitic material which are probably offshoots from the larger intrusions.

Pegmatite may be mentioned as of frequent occurrence in the ore-bearing gneiss. In almost all of the pits this rock seems to have been encountered during the mining operations. It forms masses of varying size and shape that blend with the country rock, and is quite often associated with the ore.

Distribution and stratigraphy of formations. The Hammondville gneiss occupies a compact area about 2½ miles long from northeast, near Dudley pond and its outlet, to southwest where it extends to within a short distance of Burnt Mill brook. Its width is about 1½ miles. On the north it is cut off by the intrusion of anorthosite and gabbro that stretches over many square miles in an unbroken mass. On the other sides it is in contact with the sedimentary series which occupies the valleys of Paradox creek on the west, Burnt Mill brook on the south and most of the broad ridge between Knob mountain and Penfield pond in a connected belt. The Skiff mountain gneiss which is of the same type lies across the valley of Burnt Mill brook and is thus completely separated from the Hammondville area. The contact between the sedimentary and ore-bearing gneisses on the north side of Skiff mountain appears to be well up on the slopes.

The main granite area in the district is found on the ridge east of Hammondville. It takes in the rounded prominences known as Knob and Little Knob mountains, forming an irregular mass or boss intruded in the sedimentary series. Whether it is in contact with the Hammondville gneiss to the west could not be definitely determined, but from field observations a belt of sedimentary gneisses would appear to intervene for most if not the entire distance on that side. Both Knob and Little Knob present almost vertical cliffs as seen from the west, suggesting a north-south fault scarp, a feature that was noted by Professor Kemp. There is no direct proof of the existence of faulting at this point, though in a rock cut of the abandoned mine railroad 2 miles north of

Knob mountain a brecciated zone occurs bearing nearly in line with the cliffs.

The syenite is exposed in force northeast of Hammondville in the vicinity of Overshot and Round ponds. It has the anorthosite on the west, the line of contact following just west of the road toward Dudley pond. A tongue of syenite extends southward from this area into the sedimentary gneisses for a distance of a mile or more.

The stratigraphic order of succession for the sedimentary rocks is stated by Dr Ogilvie to be hornblende gneiss at the base and limestone above, with the mica schist interbedded in both. The field relations do not indicate any unconformity between the different members. Concerning the relative age of the eruptives, Dr Ogilvie states that the anorthosite is probably the oldest while the granite and syenite are nearly of the same period. The gabbro was the last to be intruded. The most probable order is anorthosite, syenite, granite and gabbro.

The stratigraphic relations of the Hammondville gneiss present perhaps the most difficult problem in the geology of the district and one that is of special interest owing to its bearing upon the magnetite deposits. The question naturally involves the origin of the gneiss, whether this is to be considered a member of the sedimentary series and like the other members has received its crystalline character by metamorphism, or whether it represents an intrusive of which the original igneous features have been obscured through crushing and possibly a partial recrystallization. The evidence obtained from a study of thin sections of the gneiss is inconclusive. As has been previously stated the mineralogy differs in some respects from that of typical igneous rocks of analogous composition, though the differences are not so great that they can be regarded as decisive. Compared with the class of igneous rocks most closely allied in composition, that is the diorites, the chief points of contrast are in the proportions of quartz and ferromagnesian minerals, the former being much larger and the latter smaller than obtain usually in diorites. To substantiate these inferences chemical analyses of the gneiss are needed.

The field observations of Mr Newman and the writer lend some support to the view that the gneiss does not belong to the intrusive series, or at least is not contemporary with the other members of it. The granulation and intense crushing which the rock has undergone is not common in the same degree to the igneous types which at most show these effects in limited areas or zones where faulting and shearing movements have occurred. The Knob mountain granite, the syenite and the gabbro are frequently gneissoid, it is true, but they preserve recognizable textural characters that leave no doubt as to their relationships. It seems likely, therefore, that the gneiss has suffered greater vicissitudes from compression and other dynamic influences than the igneous rocks due to an earlier period of formation. No apophyses or masses of the gneiss approaching dike form have been found in the adjacent sedimentary series and contact effects are wanting. On the other hand the gneiss is involved with the hornblende gneiss in a way that is difficult to explain on the theory that the former has been intruded into the latter. Alternating bands of the two rocks occur along the borders of the areas. This feature is particularly well developed south of Hammondville in Burnt Mill valley, where the bands of hornblende gneiss may be observed more frequently as the contact is approached. The regularity in width of the bands, their perfect conformity to the strike and their persistency suggest interbedding rather than inclusions caught up by an invading igneous magma. If the view that the gneiss is not an intrusive be accepted, then the rock probably belongs in the sedimentary series. The alternative that it may represent a part of the basal complex on which the latter have been laid down has little claim to attention since on this theory the same difficulties would arise in explaining the contact relations with the sediments that are met by the intrusive theory. The existence of a fundamental system of rocks underlying the limestones anyway has not been established beyond peradventure in the Adirondack region.

The structural relations of the gneiss are very obscure. Satisfactory readings of dips and strikes are not obtainable over much of the area, owing to absence of those minerals which produce foliation. That the rock has been subjected to intense plication is evidenced by the included pegmatite bands, which are folded and twisted in the most intricate manner, as well as by the structure of the ore bodies hereafter described. The observations of dips and strikes where made point to a concordant arrangement of the ore-bearing gneiss and the sedimentary rocks. The latter as a rule show strikes that follow more or less closely the outline of the area, suggesting that they wrap around and overlie the gneiss, though their inclination seems to be quite irregular. The attitude of the whole series may be the result of a compressed anticlinal fold.

If originally a sediment the ore-bearing gneiss has probably been derived from a feldspathic sandstone or arkose. The hornblende gneiss and mica schist on the other hand, are doubtless to be referred to an argillaceous deposit, and the crystalline limestone to a calcareous one. The order of succession presented by the series is thus a normal one, such as is found in sedimentary strata which have been deposited on a gradually sinking shore line.

Description of the mines

Hammondville mines. The accompanying plan, reproduced from the original recently prepared by the Oliver Iron Mining Co., indicates the distribution of the principal deposits and to some extent their underground continuations. The mine maps of the Crown Point Iron Co. have unfortunately been destroyed and complete details regarding the workings can no longer be had. The present plan has been compiled from such records as are still available and from the results of diamond drilling; it can be relied upon no doubt as reproducing the more important features [fig. 3].

The deposits in all cases are surrounded by the plagioclase gneiss which has been called the ore-bearing formation. They show no relation to the latter in the way of gradation, but have well defined boundaries. The only noticeable change in the gneiss as the ore bodies are approached consists in an increased proportion of magnetite, which gives it a somewhat darker appearance, and the development at times of a hematite stain resulting from the oxidation of this mineral. The magnetite seldom amounts to more than 5 per cent of the whole.

In their arrangement and form the deposits are characterized by great irregularity. Over 30 different openings have been made on as many ore bodies. Whether or not they occupy a definite horizon in the gneiss scarcely admits of determination, because the foliation of the latter is so obscure that little can be learned as to the stratigraphic structure. Putnam has expressed the view that they do occur in such a relation. With due allowance, however, for folding and faulting, the existence of which has been established in the ore bodies themselves, it would be difficult to bring them all into alinement, and it is more likely that there were originally two or three parallel series of deposits, probably tabular in shape; by compression and displacement these have been folded and broken up into the large number of lenses, shoots, pockets and bands now distributed with little apparent order. The strike perhaps in the majority of cases is northeasterly, but it is sometimes nearly east and west and occasionally northwest. The dip is more

Fig. 3 H

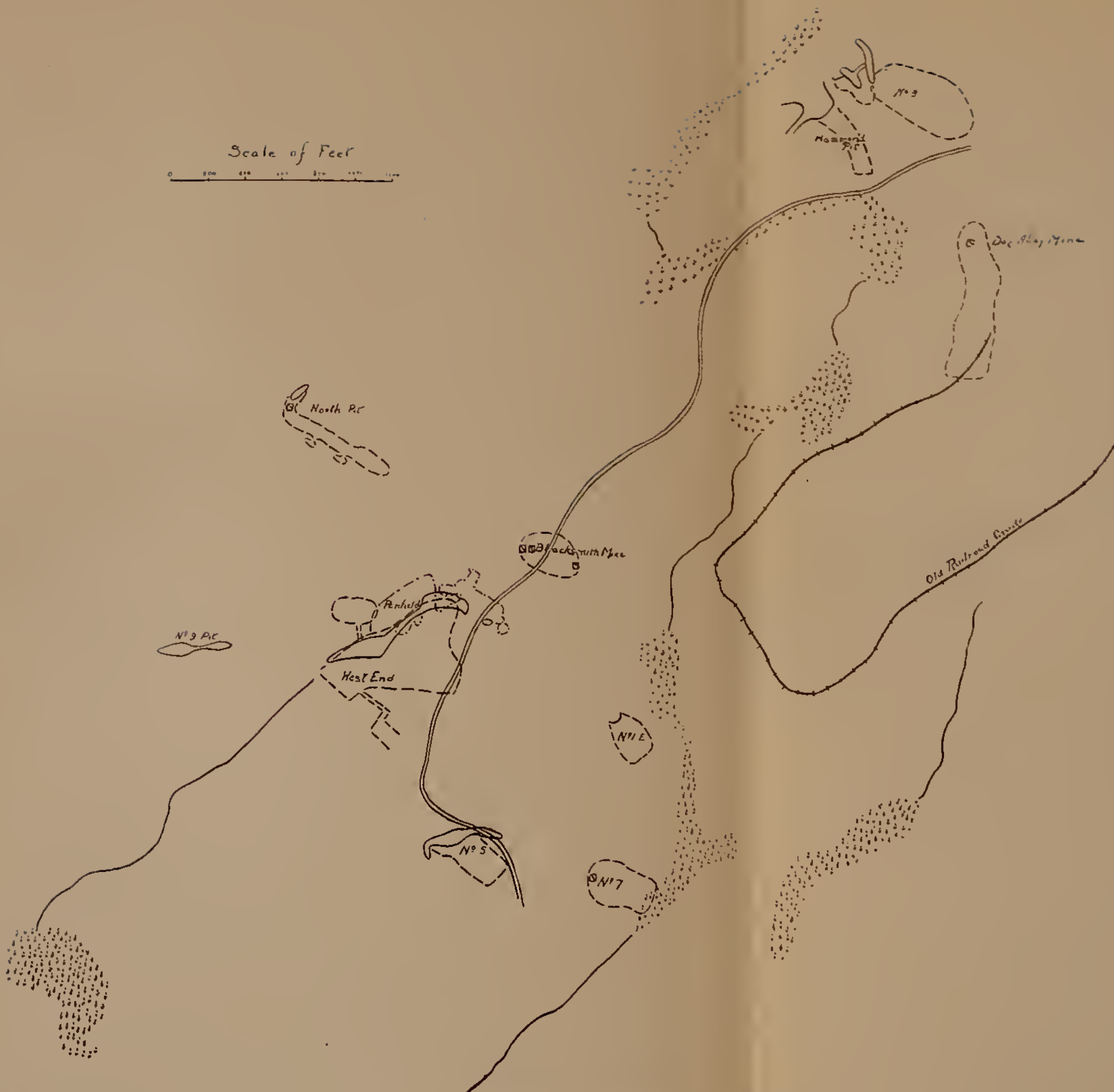


Fig. 3 Hammondville. Sketch of the principal workings. From a map compiled by the Oliver Iron Mining Company

often toward the south compass points than toward the north points.

Most of the deposits proved to be small and were quickly exhausted. The few notable ones which have yielded the greater part of the output for the district include the Penfield, the adjoining West End, the Hammond, Dog Alley, North and No. 7 mines.

The Penfield mine, with the West End, in the central part of the ore belt may be ranked among the largest in the Adirondacks. It is based on a deposit whose outcrop can be traced for 1000 feet. The line of outcrop forms nearly a right angle. The body is thus divided into a somewhat longer western portion which strikes northeast and an eastern portion with a northwest strike. The latter consists of a simple tabular bed swelling and thinning to some extent and dipping 15° or more to the northeast. The Ayers pit is on the extreme eastern end, across the Hammondville

Fig. 4 Section across the Penfield pit, western portion. Pegmatite developed along axis of the fold

road. The central and western portions are more complex in form; their outcrop lies evidently on the apex of an anticlinal from which the ore runs off to the southeast and northwest. The main workings are on the northwest wing of the fold following a dip of 45°, while the ore to the southwest pinches out rapidly on the dip. The foot-wall exposed in the open cut along the axis of the fold consists of coarse pegmatite. The accompanying section [fig. 4] shows the relations in the western portion of the deposit.

The relations of the West End and Penfield ore bodies are not certain from the little information that can now be obtained regarding the workings. The former seems to be an underlying body likewise developed as an anticlinal. Smock describes it in the following words: "The West End is on the normal (southeast) dip of the Penfield ore body, and is remarkable for its irregular walls and the slips which traverse it. The slope is about 900 feet long and vertically, 300 feet deep." Further particulars have been given by Professor Kemp. "The dip is very irregular, beginning in the west end with 45° it soon flattens to about 5° and then rolls abruptly over to 60°. The bed also drops away to right and left, as one descends, having thus a very curious roll, or dome-shaped outline. Swells of ore run into the foot, and smaller veins offset in the same direction. These small offsets are shot ore and very low in phosphorus." In the foregoing accounts no mention is made of the ore which lies to the north of the anticlinal axis as shown on the plan and have a northwesterly dip; it was exploited in connection with the southern workings. The West End deposit is more extensive than the Penfield, but it is not so thick on the average, though it is said to have given a breast 30 feet across in places.

The Hammond and No. 8 pits are to the northeast of the Penfield and higher up the ridge. They are located on the outcrop of a lens which strikes northeasterly and dips 30° southeast. The two pits are nearly connected at the surface but in depth gradually separate following the thicker portions of the lens. The latter shows a breast up to 20 feet thick in the exposure. Toward the edges it rapidly thins out and may be seen to branch off into small stringers of magnetite which gradually disappear in the gneiss. The axis of the lens when continued falls nearly in line with that of the Dog Alley mine, the shaft of which is about 600 feet from the nearest workings of the Hammond. A transverse fault is said to intervene between the two mines though they were considered to be on the same deposit.

As shown by the accompanying plan the Dog Alley is a long narrow body or shoot. It was tapped at the north by a vertical shaft which encountered the ore at 250 feet. It was one of the last to be worked. It yielded a large quantity of high-grade ore.

Mine No. 7 lies southeast of Hammondville on the edge of the belt where it falls away sharply to Burnt Mill valley. There are two slopes following a lens that dips 35° southeast. The main slope runs along the foot-wall and is stated by Smock to be nearly 1000 feet long. The ore is reported to have been 20 feet thick in places. Three diabase dikes intersect the ore body which is also faulted twice, with a displacement of 10 feet in one instance and of 11 to 22 feet in the other. Much of the waste rock on the dump shows the results of shearing with chloritization of the feldspar. The ore has been changed in part to martite and is veined by calcite, jasper and fluorite. The deposit gave out abruptly at the

Plate 1

Hammondville. Penfield pit; looking northeast

bottom on encountering a brecciated zone which probably marks an extensive fault. A drill hole was put down to a depth of over 1000 feet but failed to find the continuation of the ore beyond the fault line.

The North pit is on the ridge above the Penfield. It is partly an open cut, with a chamber running off to the southeast on the course of the shoot. A curious feature is the pods of ore along the southern edge which were worked through short inclines driven from the main chamber. Apparently they are squeezed portions of the larger body.

The Blacksmith mine is based on a comparatively small deposit which lies north of the eastern wing of the Penfield. The ore at the outcrop is from three to five feet thick and dips 30° northeast.

Exploration. The ore-bearing ground has been tested by the diamond drill, principally with a view to locating the extensions of the larger ore bodies. The drill holes have been mostly limited to depths not exceeding 500 or 600 feet. In the area between the West End and No. 5 workings, ore has been shown to exist in what seems to be a flat sheet at a depth of from 460 to 500 feet, and with a thickness of from 3 to 15 feet or slightly more. Its relation to the contiguous deposits can only be conjectured, but not improbably it represents an extension of the West End.

So far as has been observed the drills have not encountered any limit of the ore-bearing gneiss in depth. The cores show the rock to be quite uniform in character, the only marked variation being in the grain which at times becomes coarse owing to pegmatitization. The occurrence of red spots and streaks on the otherwise white core is considered a favorable indication of the proximity of an ore body; they are due to hematite stain.

Character of the ore. The Hammondville ore is compact, granular, or more rarely, a platy magnetite. The richest variety in which there is little admixture of foreign minerals is the so called shot ore made up of loosely cemented grains. In average material the iron content is about 50 per cent, the magnetite being associated with quartz, feldspar and hornblende. White vein quartz occurs quite abundantly in segregated masses and stringers. The percentages of phosphorus and sulfur are low. Of the following analyses, Nos. 1 and 2 have been taken from a paper on "The American Iron Trade" by James M. Swank, published in *Mineral Resources* for 1886. Nos. 3, 4 and 5 are from Maynard's paper "The Iron Ores of Lake Champlain." No. 3 is the result from an average sample from the Hammond mine; No. 4 from an average sample from the Penfield, and No. 5 from a selected sample from the same mine. The analysts for Nos. 3 and 4 are Maynard and Wendell and for No. 5, T. M. Drown.

	1	2	3	4	5
Fe_2O_3	47.38	49.72	50.13	55.60	64.98
FeO	21.32	20.62	23.29	25.24	30.18
SiO_2	27.48	24.52	20.02	17.44	1.44
S	.02	.02	......	tr.	......
P_2O_5	.08	.06	......	.05	......
Al_2O_3	1.97	2.62	4.22	1.09	2.46
MnO	......	......	.38	.31	.17
CaO	.36	.68	1.28	.53	1.07
MgO	.10	.21	.85	.12	......
	98.71	98.45	100.17	100.38	100.30
Iron	49.74	50.84	53.16	58.53	68.96
Phosphorus	.035	.026	......	.022	......

The incomplete analyses below are from Putnam's report. No. 1 relates to a sample of a pile of 7000 tons from No. 8 pit, No. 2 to a sample from a pile of 3000 tons representing the general shipping products from the mines exclusive of No. 8 pit, and No. 3 is based on a sample of the concentrates made at Ironville which were used in the forges at that place.

	1	2	3
Iron	50.73	49.09	63.30
Phosphorus	.090	.029	.030
Titanium	Present	Present	Present

The production of the Hammondville group is partly a matter of estimate, since there are no records relating to the early period of activity. In the paper by Swank, quoted above, is included a table showing the approximate output of Lake Champlain mines from the beginning down to the year 1885, in which Hammondville is credited with a total of 1,500,000 tons. This does not seem excessive as Smock reports the production for the period of 13 years previous to 1889 as 1,041,015 tons, evidently based on actual records. From the figures quoted in the volumes of *Mineral Resources*, it is gathered that the production subsequent to 1885 amounted to over 400,000 tons so that the entire product may be stated in round numbers at 2,000,000 tons.

Skiff mine. This mine, opened by the Horicon Iron Co. and later worked by the Lake Champlain Ore & Transportation Co., is near the east end of Skiff mountain 2½ miles southeast of Hammondville. It is about 500 feet above the valley of Burnt Mill brook. The deposit at the surface ranges from 3 to 6 feet wide thinning at either end. The strike is n. 70° e. and the dip is 80° south. Most of the ore has evidently been taken from the open pit, which is about 300 feet long; on the west side a shaft has been sunk, but its depth is not known. The ore averages fairly rich, probably about 50 per cent iron. Quartz is the most common ingredient of the magnetite. The wall rock resembles that surrounding the Hammondville deposits, but is more silicious and rather coarser in texture.

The analysis below is quoted from Maynard's paper. (Maynard and Wendell, analysts)

Fe_2O_3	47.59
FeO	21.41
SiO_2	20.65
S	.86
P_2O_5	.18
Al_2O_3	4.09
MnO	.27
CaO	4.06
MgO	1.08
	100.19
Iron	49.96
Phosphorus	.079
Manganese	.21

Long Pond mine. This is nearly opposite the Skiff mine on a parallel deposit which outcrops along the southern slopes of the ridge. It is entered from the surface by a short adit driven at a point 100 feet below the outcrop. The ore is gathered into parallel seams separated by the wall rock and dipping together at an angle of 60° south. The two principal seams are each about 18 inches thick. A second adit was run below the first to tap the deposit at greater depth. A partial analysis by J. B. Britton is given in Maynard's paper.

Iron	64.76
Sulfur	.06
Phosphorus	.16

Schofield mine. Ore was mined here between the years 1828 and 1845 and used in the forges at Schroon. The openings extend for several hundred feet along Skiff mountain near the base, trending about northwest and southeast. Apparently the excavations do not reach much over 100 feet in depth. The ore is rich, but does not average above 3 feet in thickness. A large quantity of waste rock has been taken out in working the deposit. The following analysis by J. B. Britton is reported by Maynard:

Iron	62.36
Insoluble silicious matter	7.23
Sulfur	nil
Phosphorus	.02

PARTS OF PORT HENRY AND ELIZABETHTOWN QUADRANGLES

MAP OF PORT HENRY AND VICINITY

The location of the mines is indicated by numbers which are referred to in the text

THE MINEVILLE-PORT HENRY MINE GROUP

BY

JAMES F. KEMP

Location and distribution of the ore bodies. The largest and most productive mines in New York at present are situated at Mineville, 6 miles northwest of Port Henry on Lake Champlain. Port Henry, the shipping point and the location of a blast furnace, is the town most widely associated with the industry in the minds of people in general, but the most important ore bodies really are at the above mentioned distance from it. In former years a very productive deposit was the basis of extensive operations at the Cheever mine, 2 miles north of Port Henry and near the shore of the lake. It is now being reopened with a view to magnetic concentration, but none the less the great center of ore production is at Mineville. There are two companies actively engaged at the latter place, Witherbee, Sherman & Co. Incorporated; and the Port Henry Iron Ore Co. The total output of the former is estimated at 15,000,000 tons, and, if to this is added the total shipments of the latter, the entire yield of the ore bodies up to date can not be less than 25,000,000 tons. There is no sign of exhaustion, and thus the amount of iron originally present in these deposits makes them rank well up among the great ore bodies of the world.

Besides the Cheever and the Mineville mines, there are several other smaller openings in the same general area. Almost within the limits of Port Henry itself is the Lee mine, a bed of somewhat sulfurous ore, now long idle. On the west side of the ridge separating Mineville from Lake Champlain and just at its foot is a series of openings locally called the Pilfershire pits, also long idle. Again just north of Port Henry, along the lake shore, according to the report of E. Emmons on the Second District [p. 236, 1842] there is a body of ore opened in his time as the Crag Harbor bed. Three or four miles southwest from Port Henry is another pit, now abandoned but opened up first by Butler and Gillette and continued under the name of the Essex Mining Co.

All these localities are marked upon the accompanying map [pl. 2], which is taken from the Port Henry and Elizabethtown topographic sheets, issued by the United States Geological Survey, the scale being 1 mile to the inch. Under the general name of the Mineville group are included a number of openings which stretch along from Mineville for nearly 2 miles to the north, even crossing the line of the town of Moriah into Elizabethtown.

History. The first of the ore bodies to be discovered was the one which is now called the Cheever, but which when Professor Emmons was preparing his report, 1836–42, was known as the Walton or Old Crown Point vein [*see* Emmons's Report on the Second District, p. 237]. Nevertheless the name Cheever appears in Professor Beck's report on the Mineralogy of New York [p. 15]. The Cheever had been worked for 50 years when Professor Emmons visited it, and this would place its opening at 1785–90. The ore beds at Mineville were known in 1835–40, but the largest of them, as now revealed in the "21" mine (so named from the number of the old land lot) was first opened in 1846.[1] It is evident that the early mining industry was prompted by the call for ore for the small blast furnaces which still remain in states of indifferent preservation. Plate 3 is from a photograph of the old Colburn furnace which was built in 1848, and which still stands about a mile west of Moriah Center. Another one is represented by a pile of collapsed masonry, at Fletcherville, also called "Seventy five" a mile and a half north of Mineville. At Port Henry there was a furnace at Cedar Point, even in Professor Emmons's time, and this is the site of the large plant now in full blast. Twenty years ago there were two other blast furnaces called the Bay State, and situated just west of the steamboat dock. The abundant slag along the shore at this point came from them, but they have since been torn down.

The old bloomeries or forges were located where there was a water power sufficient to run the blast and the trip hammer. But for 25 years or so they have been extinct. In their day they consumed an appreciable fraction of the output of those mines which were low in phosphorus and sulfur. The ore was hauled many miles to them. By 1890, except perhaps at Standish, in Clinton county they had practically gone to the scrap pile.

Topography. Lake Champlain stands at an altitude of almost exactly 100 feet above tide. Over extended areas its bottom is well below sea level, and in its deepest parts is more than 250 feet lower than the surface of the ocean. Its western or New York shore is marked by a series of spurs of the Adirondacks which come down to the lake with a northeast trend, and either ending abruptly at the water's edge or projecting into the lake itself,

[1] *See* Eng. & Min. Jour. May 26, 1906.

Plate 3

Colburn furnace, a charcoal stack built in 1848, about 1 mile west of Moriah Center, near Mineville

contain between them reentrant bays or valleys of much gentler upward gradient. At the mouth of one of these valleys, yet at the summit of a somewhat steep terrace, is the village of Port Henry on the 200 foot contour. To the westward beyond the terrace the surface rises again quite steeply to the 500 foot contour and higher. The gentlest gradient is south of the village along the valley of McKenzie brook, a line utilized by the Lake Champlain & Moriah Railroad, which brings the ore to the docks. The general valley is abruptly closed on the south by Bulwagga mountain, a steep fault block which fronts Lake Champlain at an altitude of 1100 feet; while on the north, Bald Peak at 2055 and its southern spurs with declining hights for 3 miles, stand between the hinterland and the lake. In a general way behind this ridge and forming a broad and upward sloping valley lies the heavily drift-covered district containing Mineville, which with its mines is situated at the foot of the inclosing hills at the north. While a few ledges project above the general mantle of sand and boulders within the broad valley, yet there are 2 or 3 square miles without exposures of any kind, and the largest ore bodies themselves must have been at the outset covered by at least 15 or 20 feet of drift.

If from the summit of some neighboring mountain the observer endeavors to eliminate in his imagination the cover of drift and restore the old bed-rock topography, the valley becomes one of presumably gentle outlines, broken at the foot of many of the elevations by steep and somewhat precipitous ledges. The latter have been in part, no doubt, freshened up by the erosion of the great ice sheet, but they are believed to have been primarily caused by faulting. The broad and open character of the valley is due to the relatively easy erosion of the rock formations lying beneath, since enough exposures can be identified to lead to the conclusion that they were once and probably still are in large part Precambric or Grenville limestones and their associated sediments, whereas the hills are in most though not all cases the harder gneisses which are believed to belong to intrusive masses of rock.

These general topographic relations are brought out upon the accompanying map [pl. 2]. From it we see that Mineville is on the 1200–1360 contours, while the largest mines open on the 1300. This makes it necessary for the railway to climb 1200 feet in its 6 miles of track, and since, in the nature of the case, this rise is not evenly distributed, the engineering problem presented is one of some difficulty. Heavy engines adapted to mountain railways are necessary, but as the heaviest traffic is downward, the grades chiefly militate against the return of empty cars and the haulage of supplies for the mines.

Geology. As affecting the ore bodies, two geological series are of chief importance, but there are at least two others of eruptive rocks which also concern them. Later than all and having little to do with the ores, but mentioned so as to complete the local geology, there are the Paleozoic sediments. The accompanying columnar statement presents all the formations from the latest above, to the oldest beneath.

Champlain clays
Glacial drift
Paleozoics { *Utica slate*, *Trenton limestone*, *Chazy limestone*, *Beekmantown limestone*, *Potsdam sandstone* }
Diabase dikes
Gabbros, dark, basic and more or less gneissoid. In the mining localities of uncertain relation to the syenites
Augite syenites and related types more or less gneissoid
Anorthosites more or less gneissoid
The Grenville series of metamorphosed sediments, limestones, quartzites, hornblende schists and rusty schistose gneisses

Champlain clays. The clays appear along the lake shore and are practically limited to a zone a hundred feet more or less above it. They have no bearing upon the iron industry.

Glacial drift. Under this term is embraced the morainal materials, sands and gravels, which beginning higher up from the lake than the Champlain clays mantle all the surfaces. Even the highest peaks are not free from boulders and the rounded cobbles of the hard resistant Potsdam quartzite are everywhere throughout the area. Sometimes the drift is water sorted but in the cases which especially affect the mines in the vicinity of Mineville it consists of heavy boulders and sand. In sinking the Harmony shafts quite 200 feet of this overlying burden were penetrated and in a neighboring bore hole, 248 feet, before bed rock was reached. These depths were encountered on the side of the present valley and above the stream bottom. Under these circumstances ore bodies can only be located by means of a magnetic survey, and this method is carried out by the companies with magnetometers of Swedish type. Explorations with the diamond drill then follow.

From Mineville southward through Moriah Center, Moriah (locally called "The Corners") and still farther, the mantle of drift extends with comparatively few exposures of the bed rock. Just east of Moriah Center, Mill brook has cut into it fully 100 feet without reaching the rock bottom. Presumably the expiring glacial activity filled the valley and the movement was probably from the northeast since such scratches as remain in the general region run n. 50°–60° e. The boulders seldom attain the gigantic size sometimes shown farther within the mountains but individuals up to 6 or 8 feet are not uncommon.

Paleozoic sediments. These strata are practically limited to the lake shore in the region under consideration. The Potsdam projects up the valley of McKenzie brook for perhaps half a mile from the water, but ceases long before it is concerned with any mines. No further mention is therefore made of any of them.

Diabase dikes. These interesting narrow bodies of dark basaltic rock are widespread and of no small scientific interest. Throughout the Adirondacks they appear not uncommonly in the mines, and usually occupy a fault line by which the ore is thrown varying distances up to 30 or 40 feet. They strike in two principal directions, a northeast set, embracing about three quarters of the known instances and an east and west set, including almost all the rest. In only one or two instances have they been observed with a northwest strike. These directions correspond with the chief structural breaks, and undoubtedly in seeking a path to the upper world the dikes have merely followed the lines of least resistance.

At Mineville, one, with an east and west strike is known in the Joker working; two or three, with a northeast strike cut the Harmony bed; one appears in the Miller pit, which is probably continuous with one of those in the Harmony bed, and another was reported from the Old Bed workings in former years. The rocks are all badly decomposed and not in good condition for careful determination. It is necessary to exercise care lest the darkened and chloritized breccias along faults be mistaken for them.

In the Cheever mine a number of dikes were met in former years and have been figured by B. T. Putnam.[1] The strike is not recorded and may be judged only from the fact that the dikes

[1] Report on the Mining Industries of the United States, Tenth Census, v. XV.

cross the east and west section which he gives. During all the writer's experience the mine has been full of water.

Diamond drill cores on the surface near the Lee pit indicate another dike in its northern extension and observations on the surface show it to be a large one. It can be traced for a quarter of a mile to the northeast.

In this district the dikes have not shown more than 4 or 5 feet of section in the mines. They are likely to appear at almost any moment and they may be associated with small faults, but they need never cause anxiety beyond this possibility.

Dark basic gabbros. These rocks are widespread and yet in less areal extent than the others whose description follows. They seem to appear without any pronounced structural relationship, but to have welled up as the last large product of the great igneous activity. The diabase dikes are so much smaller that they are not considered to be of the same order of magnitude. The gabbros are dark green or black in color and have, when closely examined, a faint pinkish cast from the quite invariable and richly disseminated small garnets, which are general throughout the mass in the form of rims around the dark silicates and iron ores. The chief component minerals are a dark green plagioclase, in rudely tabular crystals, so thickly charged with dust of pyroxene and spinel as to be at the best translucent in the slides; augite, which is black in the hand specimen and green in the slide; hypersthene of variable though sometimes large amount; brown hornblende in the same relations; and very abundant and sometimes relatively large bits of titaniferous magnetite. The feldspars on the one hand and the dark silicates and ores on the other almost never come into actual contact, but are separated by the rims of garnet referred to above, which course through the rock in faint pink bands.

The gabbros almost always show some gneissoid foliation. In extreme cases they pass into hornblende schists or amphibolites. In large part the change is probably due to dynamic shearing and dragging, but the banded alinement of the minerals may be in part attributable to original flow structures. The gabbros assume the form of intrusive sheets and irregular masses, whose outlines can seldom be worked out sharply because of lack of exposures. The railway cuts along Lake Champlain show that the intrusive mass may tongue out into the Grenville limestone with all manner of apophyses. Elsewhere single dikes are known, although they are not sharply defined anywhere within the area under discussion. In the maximum, the gabbros may cover as much as a square mile. They are of special interest because they contain bodies of low-grade titaniferous magnetite in numerous localities. These ore deposits have received some practical attention and will be mentioned in detail later.

The gabbros and their hornblendic derivatives may be very easily confounded with the basic phases of the syenites to be next described. The two rocks look extraordinarily alike. Yet under the microscope at least, the syenitic varieties display abundant orthoclase, the gabbros plagioclase. The garnets are more abundant in the gabbros, although they do not entirely fail the syenites. The granular fracture of magnetite is more in evidence in the gabbros, but when all is said, the field observer may often be in much doubt when confronted with the dark, basic gneisses, as to which rock he is dealing with. For the present we may consider them distinct.

Augite syenites and related types, more or less gneissoid. The syenites, now that they are well understood, are proving to be one of the most important members among the rocks of the eastern Adirondacks. They were first identified in the west and north by C. H. Smyth jr, and H. P. Cushing, respectively, for although gneissoid members with the corresponding mineralogy were found in the east, they were at the outset placed with the doubtful gneisses and were not recognized as distinct eruptives. The diamond drill cores at Mineville have done much to clear up their identity, and as they afford perfectly fresh rocks in definite relationships, they are in the highest degree illuminating. For several years they have been carefully saved and recorded by Witherbee, Sherman & Co., and have been of the greatest service in the preparation of this description.

The syenite is an extremely variable magma which must have been sharply differentiated into contrasted products, which then constituted different layers in the fluid mass at the time of intrusion into the older rocks. At Mineville, diamond drill cores have in one case been available showing a continuous section of nearly 1000 feet; in another of nearly 1400 feet, and in many others of less, so that the relationships of the several layers can be carefully studied.

The typical syenite consists of microperthitic orthoclase — that is of orthoclase filled with flattened spindles of albite — of emerald green augite, which looks black in the hand specimen; of brown hornblende, and of less abundant hypersthene. Magnetite is of course present in subordinate amount, and titanite, apatite and tiny zircons do not fail. Quartz is not entirely lacking, but in typical specimens it is a minor component. The syenite was called in the writer's earlier paper, the "Barton gneiss." A number of analyses have been made for Professor Cushing from specimens gathered in the northern Adirondacks and they uniformly run below 65 per cent SiO_2, the percentage at which quartz begins to be an important mineral in the eruptive rocks.

In the cores as well as in the hand specimens the syenite is a blotchy, black and green rock, which always has a pronounced green cast when fresh. On ledges that have been long exposed to weathering it is often decidedly rusty, especially in the basic phases. While the percentage in iron is not so very high, yet this element must be combined in one or more of the minerals in some unstable form, such that it readily oxidizes. It is often necessary to break into good sized blocks before the reasonably fresh green rock appears at the core. It has also been our experience in the field to find the syenite sometimes developing on exposure a dead white crust that resembles the anorthosites and that is deceptive. In these varieties the iron must be in small amount or else limited to some stable compound that resists decay. In fact with the variations to be next outlined and the protean appearance on weathering, it is not surprising that the syenitic rocks have so long escaped identification as such.

As a departure from the normal proportions of feldspar and dark silicate, we sometimes find the latter developing in greatly increased amount. The feldspar is far less prominent and a dark basic rock ensues which on slight acquaintance one would consider a basic gabbro or diorite. But the characteristic feldspar, as well as the normal dark silicates of the syenite, are still present, and both in the drill cores, as well as in the field, we find a quick passage from the usual variety to the basic with no eruptive contact that would indicate a separate intrusive mass or an included sediment. For these dark bands we can adduce no other reasonable conception than that the original intrusive mass was in parts more basic than elsewhere, and that if its parent magma were homogeneous, it separated, as has been so often observed in later years in large eruptive masses, into portions of contrasted composition although of common parentage. This basic syenite was not recognized as such in the writer's previous paper, but was esteemed to be a gneissoid representative of the gabbro. While it resembles this rock in the closest way, yet the drill cores now available prove its affinity with the syenites.

As contrasted with the basic members acidic varieties are also to be found most significantly in the cores but also in the natural ledges. In the acidic varieties the dark silicates retreat, it may be even to the vanishing point, while quartz enters and the rock reaches well into the mineralogy of the granites. The feldspar is most commonly microperthite as before and when mingled with abundant quartz it yields the "21 gneiss" of the writer's earlier article. Dark silicates almost entirely fail, plagioclase is rare, but magnetite is invariably present in scattered grains, which in the cores, unless care is taken, might readily be taken for a dark silicate. This rock is one of great importance in the geology of the ores since it is the common hanging wall of the Old Bed group. Although in coarseness of crystallization it does not vary in texture from the typical syenite, yet both in mineralogy and in rare associated minerals it suggests the suspicion that it has affinities with pegmatites, or that some influence such as the presence of vapors or mineralizers aided in its development from the normal syenitic magma. From this highly acidic and light colored rock the transition is abrupt to the dark basic masses of iron ore.

Another light colored phase consists of oligoclase and quartz with a few magnetites and zircons. This was specifically found above the Barton Hill group, and was described in the writer's former paper as the "Orchard gneiss." It is after all a not very different rock from the "21 gneiss." Microperthitic orthoclase implies rich soda because of its albite spindles, whereas, if the potash of the orthoclase fails and a slight increase of lime takes its place, we have the necessary components of oligoclase.

A still further variation from the normal augite syenite, is one in which the feldspar and the dark silicates, augite and hornblende, are in the usual proportions of say two thirds feldspar and one third dark silicates, and yet oligoclase takes the place of the usual microperthite. A rather acidic diorite results, but yet so involved with the syenites as to prevent one drawing any distinctions between them, as being separate intrusive masses.

In the above condensed outline of the rocks, the characteristic names of igneous types, syenite, gabbro, diorite etc., have been employed, implying that the rocks themselves are igneous. This is opposed to the older idea which is generally still held by the engineers and others engaged in the mining industry. The latter view the ores and their inclosing rocks as sediments, which conform in a pronounced degree to the sedimentary structures shown by strata in parallel arrangement and in folds and faults. The writer does not wish to discuss at length the points for and against each of these views in this place, reserving it for the fuller space which will be afforded by a separate bulletin on the Port Henry and Elizabethtown quadrangles, now in preparation. If supporters of the sedimentary view will add to the rock names used above the word gneiss, or change the rock names into the form of adjectives, so as to have syenitic gneiss, gabbroic gneiss, dioritic gneiss, etc., thus using them as short cuts of expression for the mineralogy of the gneisses, they may still be regarded from the point of view of sediments. The full discussion requires chemical analyses, and more ample illustration. Whether we have, however, parallel metamorphosed sediments, or differentiated layers of eruptive rock, the structural features of folds and horizons are not changed and for practical purposes these are the really important considerations. The ores, which occur at Mineville as integral members of the syenitic series, are in the form of layers conformable to such banding or foliation as appears in the rocks. These layers bulge and pinch to a remarkable degree, and in the case of the Old Bed group (or Mineville group of the writer's earlier paper) extend in a practically unbroken stretch for half a mile exhibiting at the same time a very complex and puzzling fold; while in the Barton Hill group the extent is still longer but the structure is simpler. The so called Cheever bed with its extensions must be fully half a mile in length, but all the others are smaller. The bulges and pinches give a marked podlike or lenticular form so that at Mineville the ore bodies are a series of richer and thicker shoots whose long axes run in a parallel northeast and southwest direction.

The ores are granular masses of magnetite which in the Barton Hill group were prevailingly of Bessemer grade, but which in the Old Bed series are high in phosphorus from disseminated apatite. These are now run through a magnetic mill and freed of the apatite to such a degree that they are a better grade for the furnace and the apatite is salable for fertilizers. Occasionally where the apatite is relatively abundant and the ore occurs near a fault or line of crushing which has caused decomposition of the augite both in the ore and in the country rock, red hematite has been yielded and has filtered into all the little crevices and has given the ore a red color. This variety is the so called "red ore" of the cross-section. In the same way the country rock is also colored red.

In thin section the rich Old Bed ore reveals a noticeable amount of the green augite, characteristic of the syenitic wall rock. This mineral has certain optical properties that suggest a variety rich in soda, but the inference has not yet been corroborated by analysis. The augite is, however, a much more characteristic igneous than metamorphic mineral, and militates against original sediments as the sources of the rocks and ores. The lean ores are mixed with the usual minerals of the wall rocks and among these the basic syenite is chief. Hornblende and biotite appear and bring down the percentage of iron. The Old Bed group is pretty sharply marked off against the acidic "21" gneiss, the quartz-microperthite aggregate, but scattered grains of magnetite continue out through the latter for many feet.

Anorthosites. This great group of undoubted eruptive rocks is specially represented in the western and northern portion of the area. Its typical representatives consist almost entirely of labradorite which may be very coarsely crystalline, still there are always minor amounts of augite and titaniferous magnetite and often hypersthene associated with the feldspar. The dark silicates sometimes become relatively abundant and lead to much variation in the rocks. At least one distinctive eruptive mass is known, characterized by relatively large amounts of them and later than the main anorthosites. At the headwaters of the Hudson the anorthosites contain the large bodies of titaniferous magnetite, elsewhere described in this bulletin, but they are not known to carry ores anywhere in the vicinity of Port Henry. The known titaniferous masses of this region are all in the basic gabbros.

Grenville series. Under this name it has been agreed between Canadian and American geologists to describe the undoubted metamorphosed sediments. They constitute an important belt underneath Port Henry and for 3 miles or more north. They appear also west of Moriah Corners and well over to the foothills of the bounding mountains on the west. The most easily recognized of these rocks is a coarsely crystalline white limestone, with graphite and many bunches of included silicates. There is less often a serpentinous variety or ophicalcite and with these are rusty quartz schists, mica schists, hornblende schists and thinly foliated gneisses. While there has been in the past a disposition to class with these the more massive gneisses yet it has been a growing belief as set forth above that the latter really represent the syenitic series of eruptives. The limestones and their included bands of silicates are mashed and folded in many complex and involved curves, some of which are curiously and strikingly suggestive of snakes and other organic forms. The sedimentary metamorphic rocks may possibly contain some ore bodies. The Lee bed of sulfurous magnetite is at all events closely involved with them. Crystalline limestones occur abundantly in the 225 feet or so of rocks that overlie the Cheever ore body in the deepest part of its basin. The limestones and their associated strata appear on the surface, but the wall rock of the ore is a syenitic gneiss of the usual mineralogy. The Pilfershire ores occur in almost exactly the same relationship. The limestones are near and above but the ore is really in a syenitic gneiss. Between the Cheever and the Pilfershire there intervene nearly 2 miles of mountainous ridges of syenitic gneisses rising a thousand feet above the former, and while one may remark the similarity of position, it is rash to go further.

The Grenville series is thus closely associated with at least three of the ore bodies, but the latter are not actually in undoubted sediments.

Description of the mines

Following the map [pl. 2] the ore deposits will be briefly outlined in order from south to north.

No. 1. This pit now abandoned was opened by Butler and Gillette and continued under the name of the Essex Mining Co. The work was based upon a band of ore now represented by an excavation 40 feet long and 8 to 10 feet high, sloping at an angle of about 60° and striking approximately n. 12° w. magnetic. The dump alone reveals a rather lean ore with much hornblende and feldspar intermingled. The walls are reddish granitic gneiss. No analyses of the ore are available nor were any samples taken or notes recorded by B. T. Putnam for the Tenth Census.

No. 2. Lee mine. This opening is just in the outskirts of Port Henry and in a little hillock with abrupt north and east sides which rises from a valley covered with sand. The nearest rocks both to the east and west are the Grenville limestones and their associates, but faults quite certainly intervene between them and the mine. Its wall rock is a granitic gneiss, whose dark silicate is biotite. It is reddish in color and somewhat different both in minerals and appearance from the greenish syenitic wall rocks, elsewhere met with the ores. The ore strikes n. 20° w. and dips about 19° westward into the hill at the more northern slope, but swings around to the southeast and steepens to a 30° dip on the south. B. T. Putnam visited it in 1880, for the Tenth Census [XV: 115], and has left a plan and sections. The mine is cut off on the north by a trap dike with an east and west strike. The dike can be traced across the hills to the eastward.

The pit is now full of water and serves as a dumping ground for refuse from the neighborhood. Putnam saw the mine when active and states that 9 feet of pyritous ore was displayed in the face. In old pillars a cross-section can still be seen of lean, hornblendic ore. Putnam's analyses of samples from two lots, one of 2500 tons from the north slope, and one of 1500 from the south yielded the following. The sulfur, however, was for some reason not determined although it is the chief point of importance after the iron.

Iron	45.01	44.38
Phosphorus	.047	.04

The ore is of low grade but the phosphorus is also low.

No. 3. Crag Harbor ore body. This is described by E. Emmons in the report on the Second District, page 236, as occurring in a cliff, 50 feet above the lake and half a mile below (north of) Port Henry and as being the most conveniently located of all the ore bodies in the region. It was 12 feet wide, in hornblende, and dipped 35° west. The vein extended half a mile along the lake but the ore was pyritous, tough and difficult to crush for the forge. An analysis from Dr L. C. Beck's report on the *Mineralogy of the State*, pages 15 and 37, is as follows:

FeO	24.50
Fe_2O_3	64.80
SiO_2. Al_2O_3, etc	8.70
	100.00
Iron	65.23

This old deposit is no longer worked and has almost been forgotten. It occurs where the gabbros are a marked feature in the Delaware & Hudson Railroad cuts and it may be titaniferous. Since both Dr Beck and Professor Emmons speak of its difficulty of treatment the titanium may be the reason. Little was known of titanium in their time.

No. 4. Cheever mine. This, the oldest opening in the region, is situated about 2 miles or less north of Port Henry, and at its eastern edge, outcrops rather more than a quarter of a mile from the lake shore and about 300 feet above it. The chief workings are just north of a small east and west depression, through which a little brook passes into Lake Champlain, falling over a fine ledge of Grenville limestone, one of the best exposures in the region.

There is certainly a great fault between the limestone and the eastern edge of the ore, since north along the railway the limestone gives way to greatly brecciated gneisses. Farther north again gabbro appears, but in irregular exposures mingled with hornblendic gneisses and quite difficult to understand. The ore itself, however, outcrops as a marked band or bed in green syenitic gneisses, and runs to the north for nearly a mile, with occasional pits. The Cheever at the southern end is, however, the chief one. These workings, now being revived after years of idleness, dip down steeply, at 50° or 60°, then flatten at somewhat over 200 feet vertically from the surface and run westward until cut off by a fault. Their relations are shown on the accompanying section [fig. 5] reproduced and reduced from the bulletin of the New York State Museum 14, page 346. The only point of revision lies in the fact that our recent fuller knowledge of the basic syenite gneisses, makes the occurrence of unbroken gabbro on the east doubtful. Field observations the past summer led to the con-

Fig. 5 Cross-section of the Cheever mine

clusion that much of the black hornblendic gneiss, formerly taken for gabbro, is basic syenite gneiss, but massive gabbro does occur mingled with it. The ore is a band in the syenitic gneiss, here quite quartzose, and about 150 feet from the undoubted Grenville. Below the ore 50 feet of similar gneiss appears before the basic rocks take its place. As the ore bed is followed north the dip appears to flatten and in an old working about half a mile from the Cheever slopes, the strike is north and south and the dip 20° w. The same wall rocks, however, appear.

Another outcrop of ore appears along the present highway a quarter of a mile north of the old Cheever engine house. It strikes northeast and dips southeast. It has limestone not over 15 feet above it and while thus apparently stratigraphically higher or nearer the limestone than the position of the western end of the Cheever, if we consider it the same bed, it suggests a synclinal basin for the ore, with a pitch of the fold to the south. There can be no doubt that a north and south fault on the west beneath a meadow cuts off both the ore and the Grenville series in this direction.

The Cheever ore resembles very closely the Old Bed variety at Mineville. It is not quite so rich in phosphorus, but is still rather high in this element. Mr Putnam for the Tenth Census [XV: 114] took six samples, four underground and two from stock piles on the surface, which showed the following percentages:

Iron	65.33	63.5	63.86	64.42	64.77	63.08
Phosphorus.	0.643	0.603	0.689	0.452	0.673	0.573

Titanic acid was found in five of the six, but its amount is very small. The ore is rich and as shown by the analyses, it is of quite remarkable uniformity. Recently [1907] a small magnetic mill has been built and concentration of the leaner unused ore is to be attempted, accompanied by a reduction of the phosphorus.

Nos. 5 and 6. These two pits are called the Pilfershire. They lie at the western foot of the ridge which intervenes between Moriah Center and the lake. Not far above them is the Grenville with its limestones, and the relations are extraordinarily like those at Cheever. Even the gabbro appears not far to the eastward as detected by F. L. Nason, who has called the writer's attention to it.

The southern pit is a small one and of no particular importance. The northern pits consist of three larger and two smaller openings. They strike nearly north and south and dip 60° west, passing below the highway 50 feet lower down. The wall rock is the familiar green gneiss which in thin section shows plagioclase and pyroxene. The mines are now abandoned and full of water.

The close parallelism between the geölogical relations here displayed and those at the Cheever is worthy of emphasis. In both the ore belt strikes nearly north and south and dips at about 60° west. It is in the characteristic green gneiss of almost identical mineralogy. Just above are the Grenville limestones. Just below but after an interval of gneiss is the gabbro. Between the two stands a ridge of old syenitic gneisses, with no Grenville involved and extending 2 miles without a break. Undoubtedly faulted upward, they make a mountain summit, 500 feet above the Pilfershire and 1000 feet above the Cheever.

Nos. 7 through 11. Mineville group.[1] A general outline of the

[1] In the preparation of these notes, every possible kindness has been extended to the writer by Mr S. Norton, general manager of Witherbee, Sherman & Co., Mr S. LeFevre, chief engineer, and Mr Rogers Hunt, assistant engineer. Mr Guy C. Stoltz, engineer for the Port Henry Co., has been equally courteous and helpful in affording data and advice regarding the adjacent properties.

relations of the ore bodies at and near Mineville, may first be given. There is one group of mines based on a large faulted and folded ore body in the village of Mineville itself. It outcrops at about the 1200 and 1300 foot contours and is the basis of several distinct mines, some of which are no longer worked. A half mile to the northwest, Barton hill rises to an altitude of 1880 feet and on its eastern slope, and ranging from its 1300 contour to the 1750 is a long diagonal outcrop with many pits. The group, collectively taken, is here called the Barton hill. It is possible that this bed swings around to the east under the drift and is the basis of the two Harmony shafts, south of the Mineville groups [*see* map: fig. 6]. Yet there is still much uncertainty about this connection.

At the north end of the Barton hill group a gap of concealed and drift-covered fields intervenes with no demonstrated ores. After half a mile, ore again appears in two bands one over the other, at the openings called the Fisher hill and Burt lot, both on the 1600–1640 contours and now for 10 years or so idle.

A half mile east of Fisher hill and on the 1450 contour of another hill, is the recently revived Smith mine, whose ore body is tapped still lower down by the O'Neill shaft. Another interval ensues to the north and then after half a mile two old-time but long abandoned mines are met, called the Hall and the Sherman. The former is one of the oldest in this locality and is mentioned by Professor Emmons. Drilling has recently been in progress in exploring them, but no mining has been done for many years. Still farther north no ores are known for several miles.

Mineville group. These great ore bodies are the chief source of the local production, and they present a mass of noble proportions. Thanks to the liberal spirit and courtesy of the two companies, and to the excellent and careful records of the engineers they can be so well illustrated that with the solitary exception of the Tilly Foster mine in Putnam county, they give us the best idea of the general shape and relations of a magnetite body, yet afforded in this country. At the latter the structural relations are simpler, and the amount of ore much less. The Mineville group presents a very violent case of folding, accompanied by stretching and pinching of the crest. The ores are in a pitching fold which makes depth rapidly to the southwest, so that we have to keep the relations constantly in mind in terms of solid or three-dimensional geometry. At the north end we have further to deal with a series of faults and a very puzzling relationship, which on the basis of one bed of ore is not easy to satisfactorily clear up. In the present description, the writer's

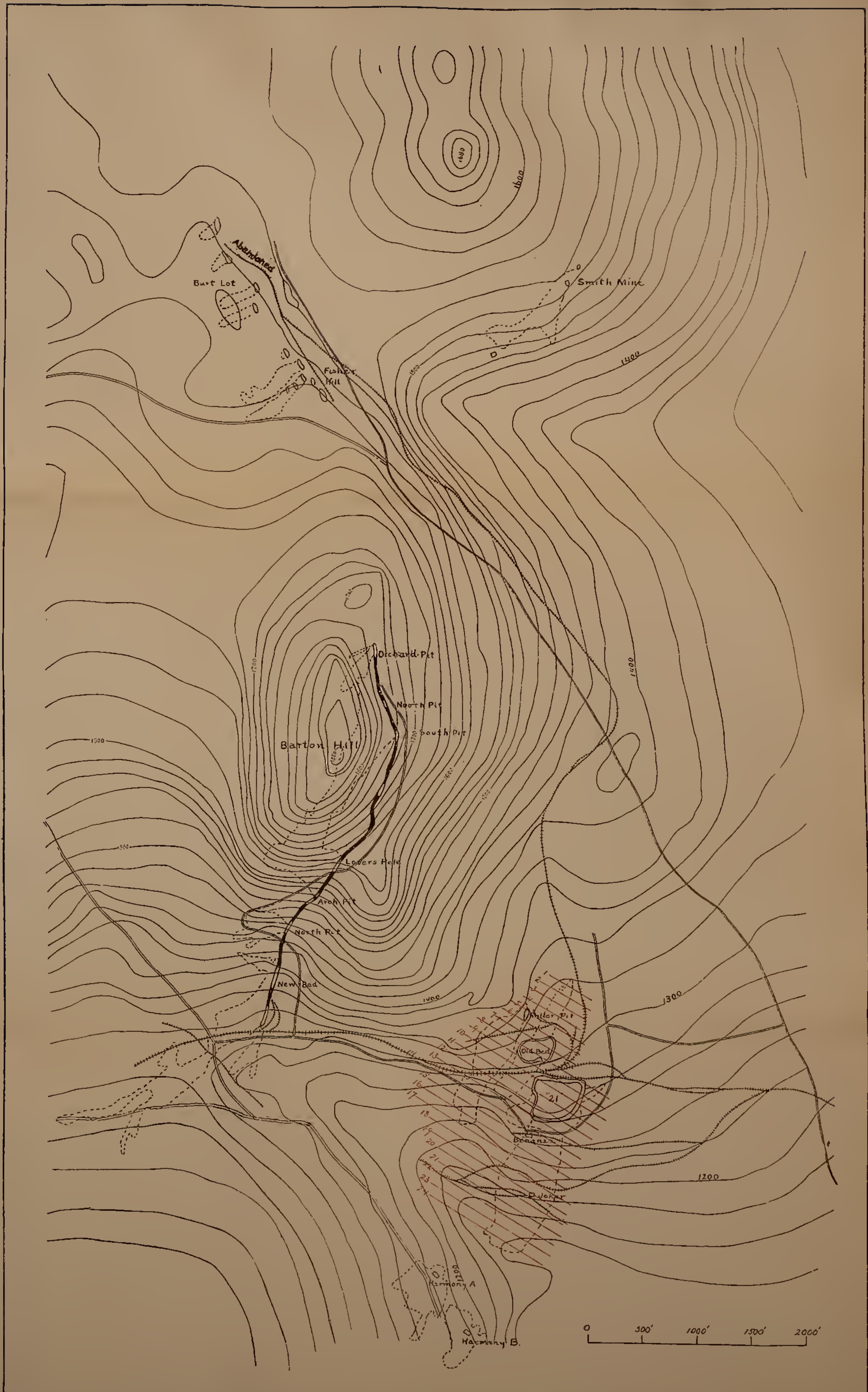


Fig. 6 Map of the vicinity of Mineville, to show the location and relations of the Old Bed, Barton Hill, Fisher Hill and Smith Mine groups. The red superimposed lines indicate the sections nos. 1-24 of figures 7-14

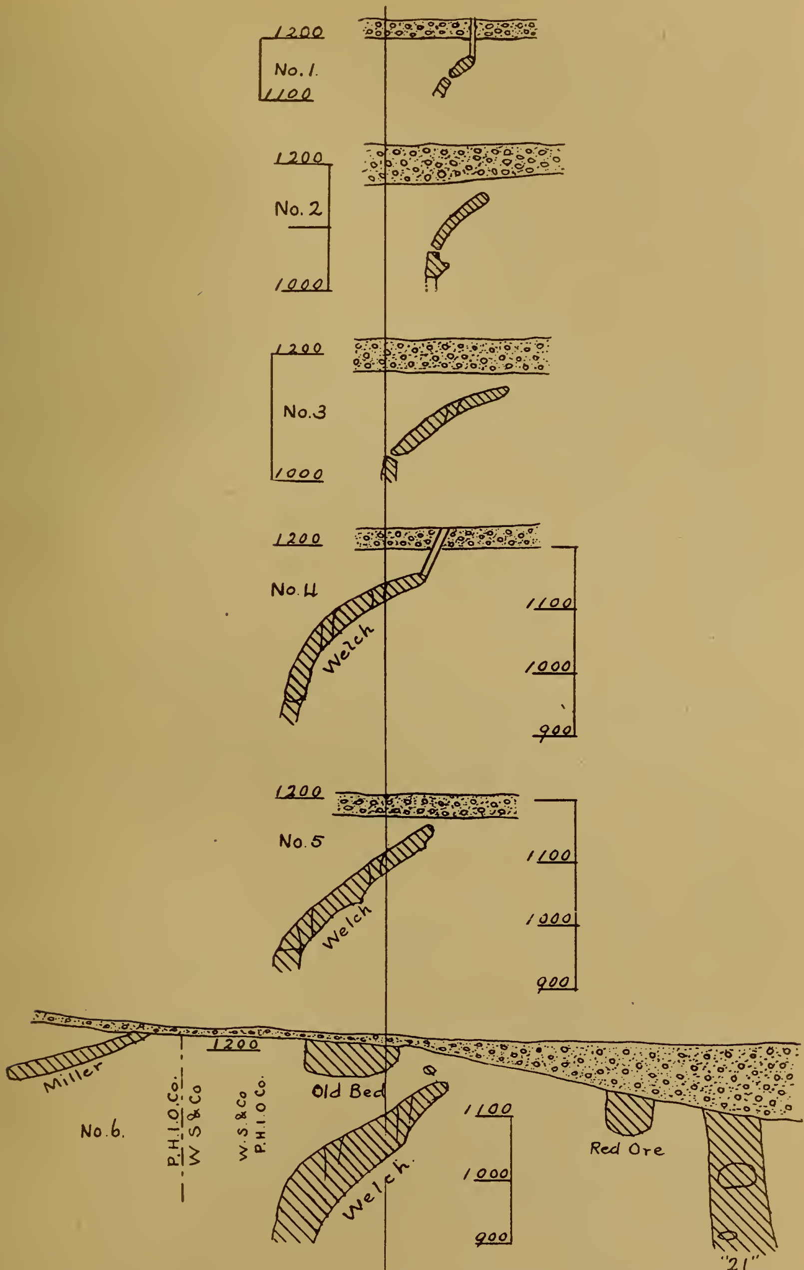


Fig. 7 Sections 1 to 6 of the Old Bed ore bodies Mineville. Sections are 100 feet apart and drawn with the same vertical and horizontal scales. *See* figure 6

paper and sections prepared in 1897 and published in the Transactions of the American Institute of Mining Engineers, volume XXVII, pages 146–204, are brought up to date and are made to include the results of 10 years of mining.

There are three principal and separate faulted parts of one great bed, viz: roughly from north to south, the Miller, the Old Bed or Mine 23 (the first discovered under the name of the Sanford pit) and the "21"-Bonanza-Joker continuous ore body, the chief source of the ore. There are several shafts for Old Bed and "21" (named from the lot) and there are large open pits as well. The axis of the fold strikes about n. 30° e., true, and, as stated pitches south. The full extent to the south has not yet been revealed. The sections here used are 24 in number, separated by intervals of 100 feet, so that they cover 2300 feet. The folded bed is broken by two main faults with strike a little more northerly than the axis of the fold, and apparently by one east and west fault under the skip way of mine "21." At least two trap dikes are known, running parallel with the main faults and probably themselves following additional small fault lines, while one other dike crosses the Joker at its southerly end in a nearly east and west direction. In the Harmony mines, the apparent prolongations of the north and south dikes are revealed. If now the reader follows the description with the diagrams beginning on the south with No. 24, the relationships can be most intelligibly stated [fig. 7–14].

Section 24 is largely inferential, but it is probably not far from the truth. The ore is a steep, vertical anticline, doubled over a fold of rock, and bulging at the lower part of the east limb. In No. 23, which is more fully based on mining experience, a great swell has developed in the eastern limb, and a tendency is shown toward a closed fold, the two limbs coming almost together in depth. In No. 22 the swell is more pronounced in the east limb, and a curious shoulder with an almost flat top has been revealed in mining. The interior core of rock shows a sympathetic development in the same way. A smaller swell or bulge is manifested in the west limb. In No. 21 the swell contracts a bit, but the bulge toward the upper left hand begins to assert itself, which is thereafter so marked a feature, and is apparently due to the stretching of a wellnigh viscous mass under irresistible compression, if indeed the rock was not still liquid from an original molten state. In No. 20 this upper left-hand bulge is much more pronounced, while the eastern shoulder is still very much in evidence. The intervening horse of rock has widened appreciably. In section 19 the upper western bulge has

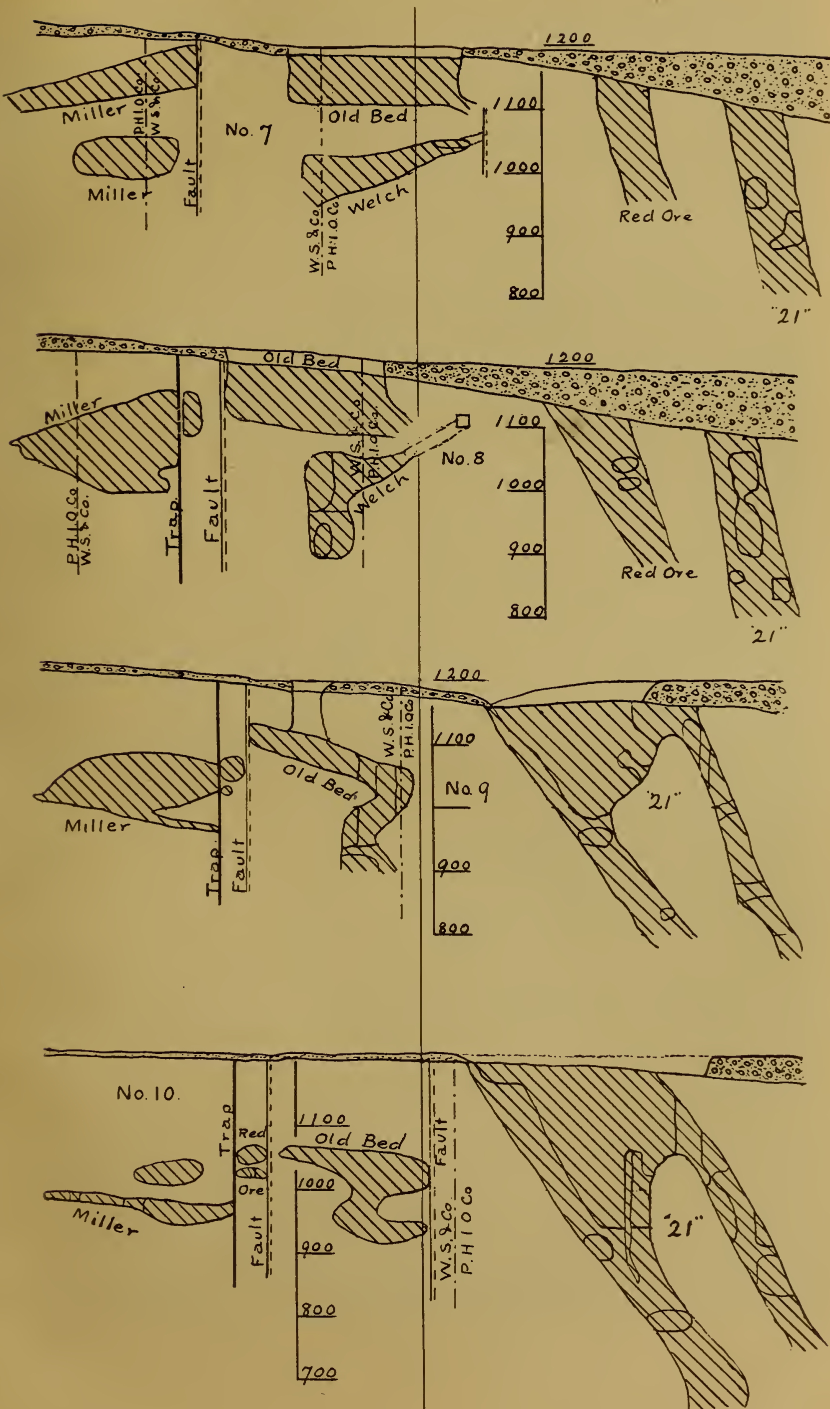


Fig. 8 Sections 7 to 10 of Old Bed ore bodies, Mineville. *See* figure 6

thinned somewhat, and has a very flat top, while the western shoulder has narrowed. It is very near the point where the Joker shaft first grounded in the ore. In No. 18 the upper western bulge has shrunk still more and the eastern lower shoulder has almost disappeared. Deeper mining has shown the true relations lower down on the limbs. We find them pinched together, so as to entirely circumscribe the horse of rock. In No. 18 also the sections first intersect the Miller pit as a small end of what soon becomes a large ore body. This can best be followed up by itself. In No. 17 the limbs have parted again, so far as yet indicated and the horse of rock has widened. The upper left-hand bulge has drawn in a little more. In No. 16 there is a bulge in the western limb, low down, but no very marked change in the other parts. In No. 18 we first encounter the property line and as developments have not been extensively made on the east side the data are not yet available. It is not an unreasonable expectation that the bulge in the lower right-hand limb of the earlier sections should manifest itself in depth to some extent in the as yet undeveloped portions to the north.

In No. 15 there is little change, but additional data as gained in the future will be of great interest. Between 15 and 14, a very remarkable change takes place. Apparently by a pinch and thrust from southeast to northwest a great bulge or wrinkle was rolled up on top of the anticline hitherto described, and just above its horse or core of rock. The old anticline soon pinches out but the new wrinkle bulges into a great second shoulder or roll, higher up than the one which we have hitherto followed. The latter gradually diminishes and in the end practically disappears between Nos. 12 and 11. Meantime the increasing bulge of the new wrinkle makes the noble ore body which was opened up originally in the Tefft shaft and in the great open cut of the "21" pit. The central horse of rock itself turns up to the vertical and, in the No. 13, even rolls over beyond it. All these features appear in sections 14 through 11. The upward trend or pitch of the axis of the fold now asserts itself strongly, and in Nos. 10 and 9 we see it almost reach the surface. Between 9 and 8 it emerges and thereafter the ore is in two separate limbs which run through No. 6. Beyond this point they have not been much mined in recent years, but, leaving faults out of consideration, we should expect the ore to be terminated only by the upward rise of the original outer or eastern edge of the great sheet of magnetite. This edge has been nowhere reached as yet in the deeper mining of the southern sections. It constitutes one of the

Plate 4

Mine 21, Mineville, N. Y. looking nearly east

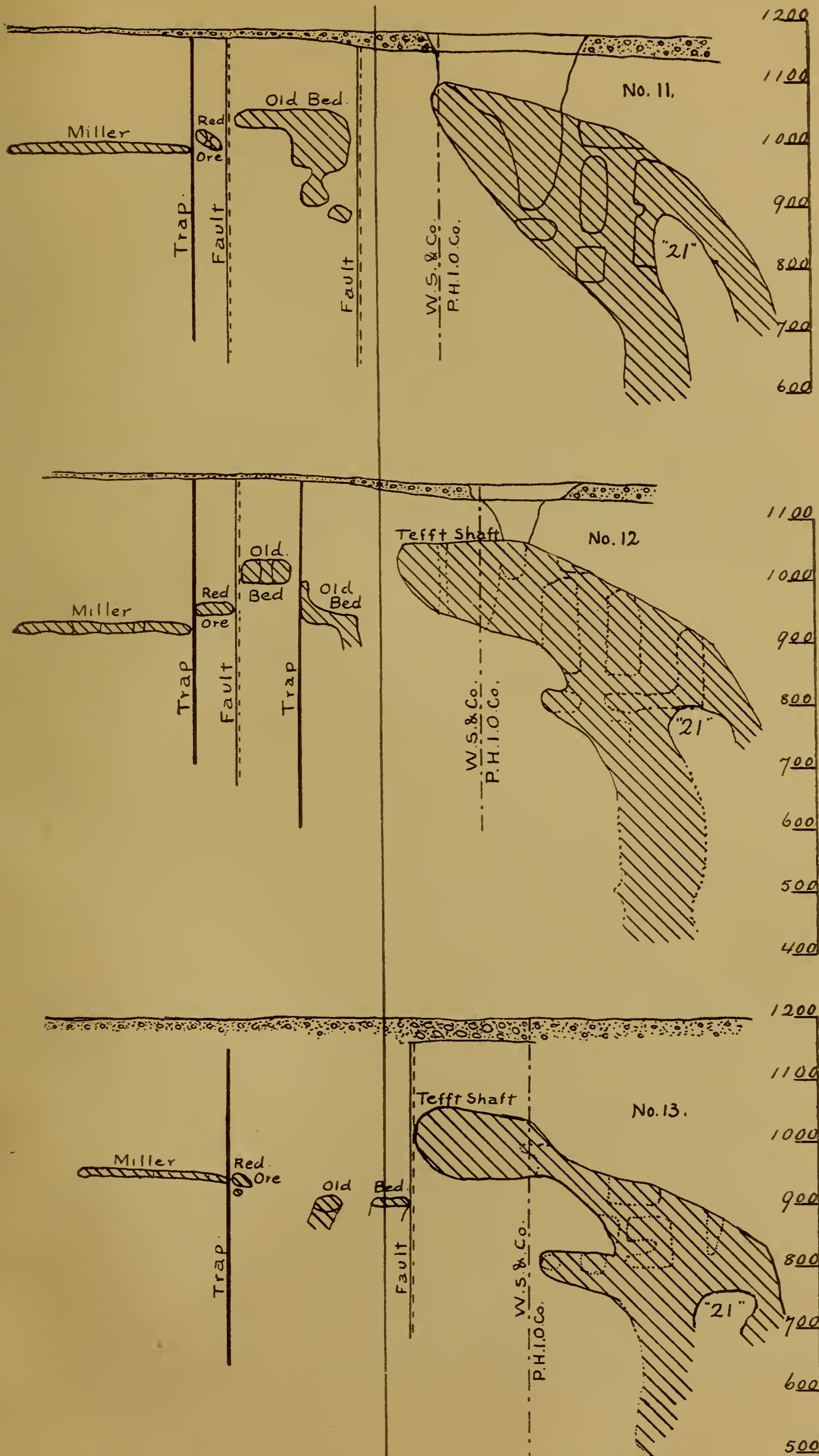


Fig. 9 Sections 11 to 13 of Old Bed ore bodies, Mineville. *See* figure 6

interesting questions for the future to develop. As to the course of the western limb, when prolonged beyond the workings as yet opened up, it is probably faulted upward in the Old Bed-Welch ore bodies. That is, it probably flattens, encounters the fault shown in sections 13 and 14, is thrown upward and constitutes the Old Bed-Welch ore body with all the convolutions of the latter. If we turn to section 10 in which Old Bed was followed up to the fault line, at about the level of 940 feet, we can see that in order to allow the western limb of "21" to flatten and come over to the fault, there must be a displacement of at least 300 feet. If the western limb of "21" rolls upward to the fault this throw will be diminished. We must not assume a purely vertical throw, since increasing experience brings home to us the conviction that almost always faults involve a diagonal shift along the fault plane.

Assuming therefore that Old Bed and Welch are the same ore body and are the faulted representative of the western limb of "21", an assumption which is corroborated by the similarity of the ores, we may follow out the curious convolutions presented by them. In sections 14 and 15 they are very indefinite and are mostly known by drill cores. The stray ore body shown in No. 15, on the center line, was revealed by a drill hole. Its identity is not known. The other one in No. 14, east of the fault and 200 feet below the Tefft shaft is also of uncertain relationships. Old Bed is first recognizable in this section, although little is accurately known about it. The ore grew small as followed many years ago and the workings were abandoned. In No. 13 Old Bed was found double, but again was not extensively opened. We know little about it. In No. 12 it develops a steplike roll of its own and is cut into two parts, by the small fault into which the trap dike has forced its way. At No. 11 the dike has pinched out and the fault was not noted. The ore is anvil-shaped and curiously pinched below. In No. 10 it is a reversed S-shaped fold and the core of rock begins to manifest itself on the west, which is of great importance in the next sections. It is similar to the ones in the Joker-Bonanza "21" fold, but dips west instead of east. It rises toward the surface and ultimately cuts off Old Bed proper, from its downward prolongation, the Welch bed, until finally beyond No. 6, Old Bed runs out into the air and is lost. Meantime the Welch limb runs along and rises, with a lima bean pod cross-section until it too goes into the air. Within the last year or two a new shaft has been sunk to tap the Welch ore on the line of section No. 1, so that we

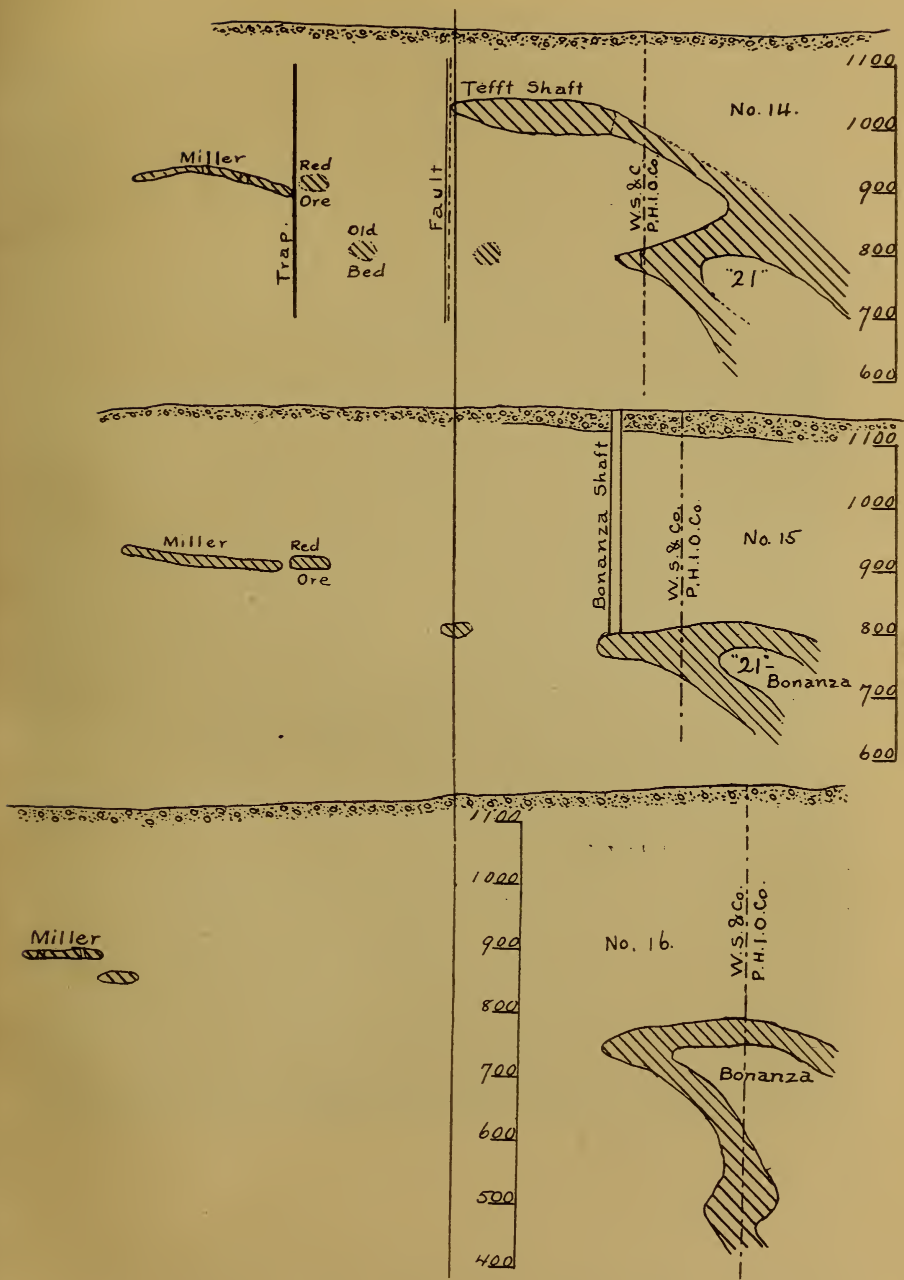


Fig. 10 Sections 14 to 16 of Old Bed ore bodies, Mineville. *See* figure 6

now know that this ore continues downward lower than was formerly shown. More recent data also show that in No. 7, rock cuts off the ore on the east, apparently before the upward curve of the ore was found and a fault is suggested.

In its western prolongation as shown in sections 8–12, Old Bed encounters faults, and an area of broken ground with one or two disconnected masses of iron-stained, apatite-bearing ore called "Red Ore." The red color is due to the crush and to the consequent alteration of some of the minerals. In the slides the color is clearly shown to be caused by red hematite infiltrations into cracks. The source of the iron oxid is without doubt decomposed pyroxene crystals.

Beyond the "Red Ore" lies the Miller pit, a very large and very interesting ore body, now practically worked out. The Miller is presumably the faulted extension of the Old Bed, which is dropped to the west, but it has in sections 7–10 a very peculiar double character. The separate parts of No. 7 coalesce in Nos. 8 and 9 and part again in No. 10, beyond which to the south the upper one, once the large one, fails entirely. We are confronted with some difficulties in following out the folds in whatever way we may try to explain them. We must consider the Miller as an expanded prolongation of Old Bed before folding; that is that the Miller was longer north and south, so as to allow for its extended pod in sections 13–18. Probably the under one of the two pods in No. 10 was connected with Old Bed and that it was doubled over on itself as shown in Nos. 7 and 8. It must either have been this or else the upper member is the prolongation and the bed was doubled under itself to account for Nos. 7 and 8. Or else the Miller is a forking pod, from a central thickened portion in Nos. 8 and 9, where the two parts coalesce. Any of these three relations is possible, but if we favor folding we can not avoid giving great emphasis to the viscosity or doughlike consistency of the rocks at the time, since in no other way could they possibly have bulged and molded themselves into these forms. So pronounced is this character that one can not well help giving serious attention to possible convolutions in a molten but ropy mass. Under the latter assumption we need infer burial in the earth at a less depth in order to make the results possible.

The following analyses illustrate the composition of the ores from the "21" pit. No. 1 was a sample of 65 carloads and No. 2 of 35 carloads from the Port Henry Co.

Plate 5

Mine 21, Mineville, N. Y. looking southwest into the Tefft shaft chamber. Mt Tom is in the background

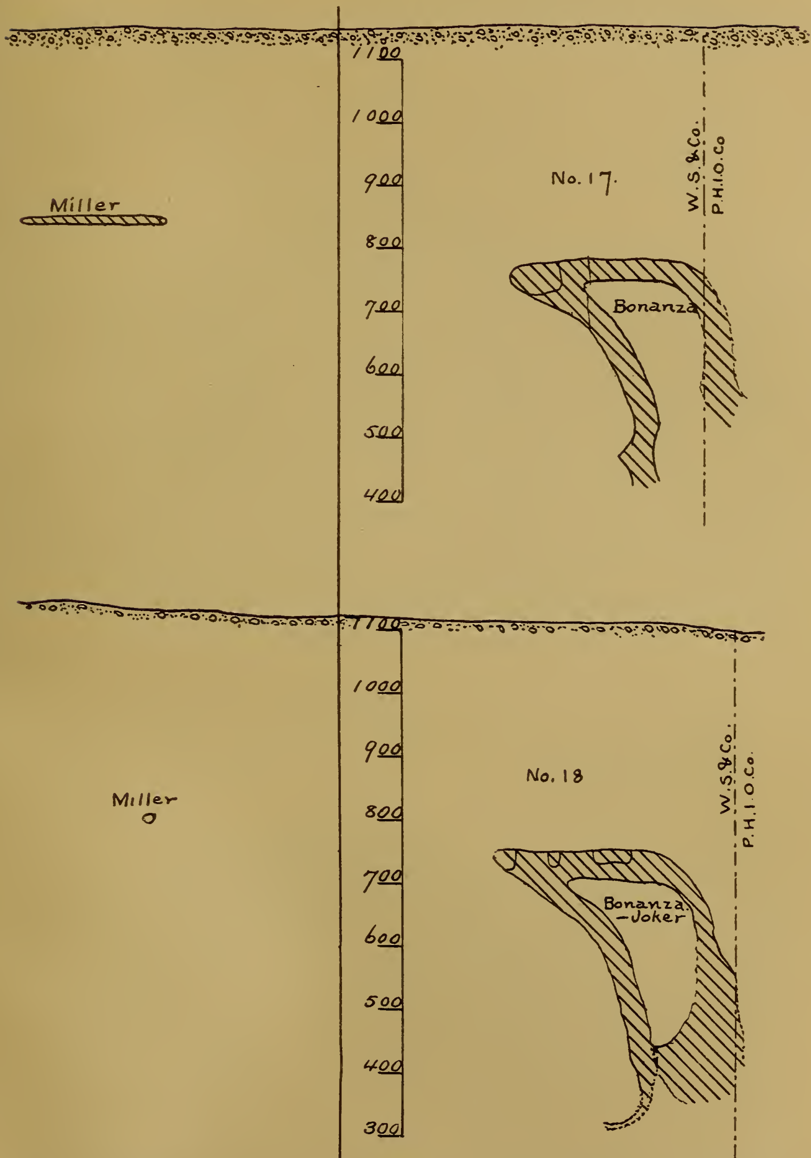


Fig. 11 Sections 17 and 18 of Old Bed ore bodies, Mineville. *See* figure 6

	1	2
Iron	60.03	60.91
Silica	4.48	4.49
Phosphorus	1.635	1.548
Sulfur	.021	.027
Titanium	.12	.03
Copper	....	.007
Moisture	.28	.25

When the phosphorus is recast as chlorin apatite, it gives for No. 1, 9.14, and No. 2, 8.83. Calculating all the iron as magnetite, this mineral then formed in No. 1, 83 per cent of the mass; in No. 2, 84 per cent. In the sample and undetermined there was more than five per cent of CaO, and probably a little Na_2O, attributable to the green pyroxene often observed in the ore.

The analyses below, taken from the *Iron Age* of December 17, 1903, show the composition of the crude Old Bed ore and the products made by its concentration at the milling plant of Witherbee, Sherman & Co. No. 1 represents the crude ore, No. 2 the magnetic concentrates, No. 3 the first grade apatite product made by retreatment of the tailings from the first concentration, and No. 4 the second grade apatite product.

	1	2	3	4
Iron	59.59	67.34	3.55	12.14
Phosphorus	1.74	.675	12.71	8.06
Bone phosphate	......	......	63.55	40.30

Harmony mines. The most recent developments at Mineville are the two Harmony shafts, A and B, which were sunk 5 or 6 years ago in order to tap a bed of ore revealed by the dipping needle and the drill to the south and somewhat to the west of the Joker workings, and at a much higher horizon. The Harmony bed strikes northwest and dips southwest at a rather flat angle. It is 10 to 20 feet thick and is cut by at least 3 narrow trap dikes with a strike a few degrees east of north and a vertical dip. They fork somewhat and are not absolutely continuous. The dikes occupy small faults of 10 to 50 feet displacement and strike in a direction to suggest that they are the same with the two in the Miller pit.

The relations of the Harmony ore to the Joker on the one side and the Barton hill group on the other are interesting. Our last section of the Joker is 500 feet above Lake Champlain, while the

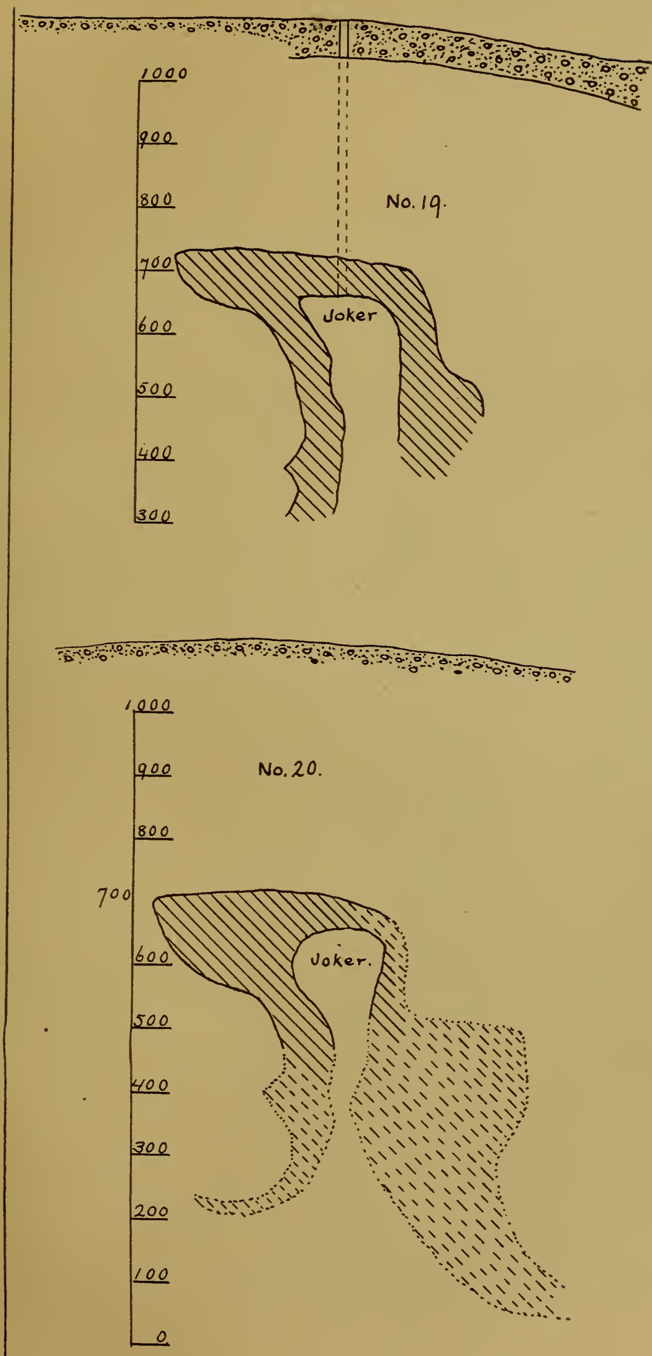


Fig. 12 Sections 19 and 20 of Old Bed ore bodies, Mineville.
See figure 6

outcrop under the drift of the Harmony bed, 400 or 500 feet away, is 450 feet higher. If the latter is the prolongation of the former there is a very great fault in the interval. On the other hand, if we attribute to the Barton hill group a swerve to the eastward under the cap of drift, there is a very strong probability of connecting up with the Harmony bed. There is unexplored ground in between with evidence of some disturbance. The composition of the Harmony ore as regards phosphorus is intermediate between the Barton hill and the Joker. It is higher than the former and lower than the latter. The percentage in iron is somewhat less than the Joker.

A third possibility must be considered, namely, that it is a totally distinct bed having no necessary connection with either of the older ones. While it is natural to seek to connect together those already known, it must be admitted that the last view can not be entirely ruled out.

Barton hill mines. These openings are distributed along a practically continuous bed whose outcrop is approximately 3500 feet long in a direction a little east of north. From the 1300 contour on the south, the outcrop rises to the 1750 on the north. From the southern end of the outcrop the underground workings follow an extended shoot of ore some 2000 feet farther on a flat dip to the southwest; and along its axis this particular branching pod must be fully half a mile long.

Taking the Barton hill bed as a whole it is characterized by swells and pinches giving the enriched and thickened shoots which have been specially followed in the mines. Their axes and therefore the workings run northeast and southwest and are therefore closely parallel with the Old Bed group, and with the Harmony beds. No doubt the relationship is due to the general system of folding which prevails in the gneissoid rocks and which has caused the rolls and attendant bulging. Upon the map of the Mineville area [fig. 6] the successive openings are given. They begin on the south with the New Bed, which is the deepest and most extensive. Then follow the North pit and the Arch pit, of moderate extent. From the Arch pit a tunnel is now being driven northwest on a slightly ascending grade so as to bring out by a gravity tram. the ore which may be tapped in the downward extension of the more northerly shoots. Already some gratifying discoveries have been made.

The next pit on the north is the Lovers Hole, the famous opening from which came the extremely rich ore and the remarkable crys-

Plate 6

The mills at Mineville, N. Y. looking northeast. The Joker shaft is on the right; the Bonanza shaft on the left

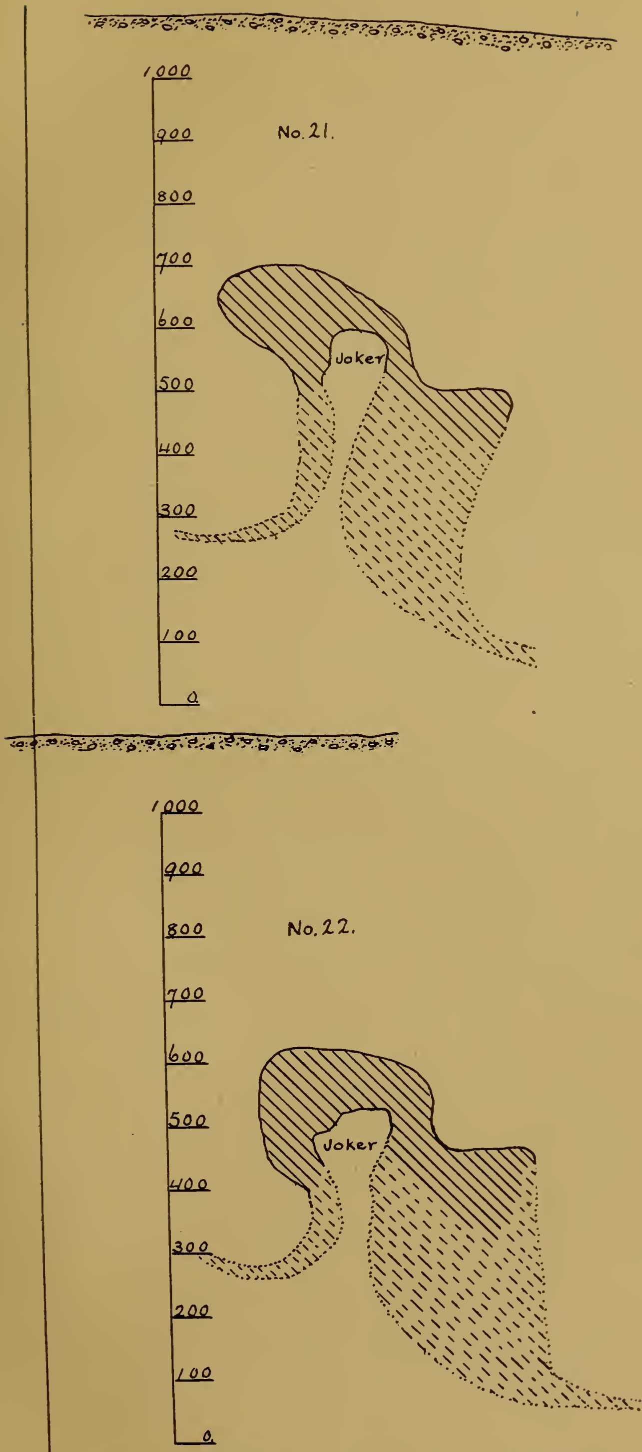


Fig. 13 Sections 21 and 22 of Old Bed ore bodies, Mineville.
See figure 6

tals of magnetite, mined about 1887–88. A total of 40,000 tons from one chamber averaged 68.6 per cent and carload lots ran 72 per cent, being almost chemically pure magnetite.

Beyond the Lovers Hole is a stretch not much mined as yet, and then as the outcrop swerves with the contours to the northwest, there are three pits, the South, the North and the Orchard. The rock dumps are large at this end, indicating leaner ore. Beyond the Orchard pit, there is an interval with no mines, and mostly with concealed bed rock, for half a mile. Within this distance there is a drop of 150 feet in the altitude and then two groups of mines, now for some years unworked, are found. These are the Fisher hill mines belonging to the Port Henry Iron Ore Co., and the Burt lot, of Witherbee, Sherman & Co. The ores are rather lean but are of Bessemer grade.

The pits are distributed across a horizontal stretch of 100 feet at Fisher hill and 250 to 300 feet at the Burt lot. They dip about 25° westward, and are therefore something like 40 feet apart vertically at the former and 115 feet at the latter. There are no marked horizons of ore within these limits. At Fisher hill the workings are 600 or 700 feet down on the incline, and at the Burt lot, 300 or 400. The railroad has been pulled up for 10 years past and the mines have been allowed to fill with water.

It is quite possible that the Fisher hill and Burt lot ores are a reappearance of the Barton hill bed after a lean interval, and that they mark a northerly continuation of the latter. It is very natural to infer these belts and especially are we prone to do so in so far as the time-honored sedimentary conceptions of origin influence us. The northern pits are double to a degree not shown by the southern, and if we are influenced by the igneous views, we may not feel justified in inferring the identity without proof of the connection. The wall rocks are practically identical and the general dip and axial trend of the pods correspond.

To the east of Fisher hill and a half mile away upon the eastern slope of a different hill is another great lens or pod now known as the Smith mine, and actively worked by Witherbee, Sherman & Co., through the Cook shaft. This pod was discovered by the needle. It does not outcrop. It dips west and pitches south like the others and furnishes a non-Bessemer ore much like Old Bed, but lower in phosphorus. A vertical shaft taps the upper end of the pod and then from the foot the two skip ways fork and proceed southwest, one going for about 1000 feet. The ore varies from 20 to 40 feet thick, and at the south drops over 600 feet below its

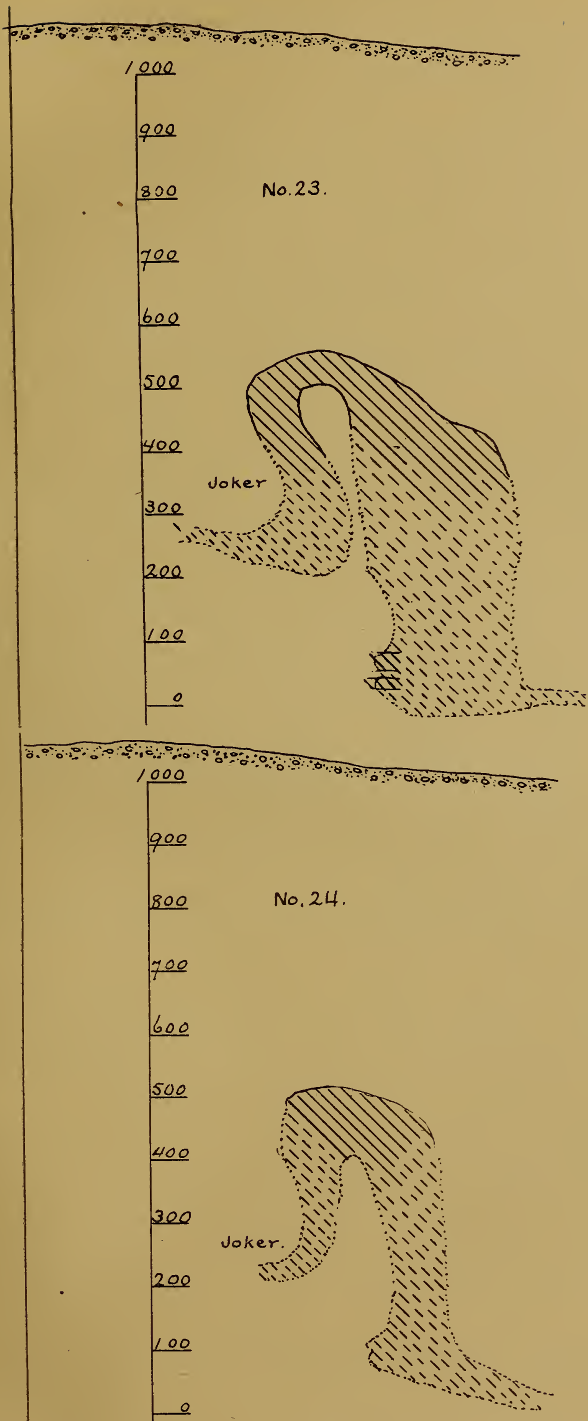


Fig. 14 Sections 23 and 24 of Old Bed ore bodies Mineville. *See* figure 6

high point on the north. At the southern end is the old O'Neill shaft, now used for pumping and in the fall of 1907 tapped by the northern workings.

Two hundred feet or so north of Cook shaft, is the Thompson, long abandoned, and beyond this an interval of some distance with no workings. Recently diamond drilling has, however, revealed ore, which may in time be worked. The hill then abruptly drops away to a small valley, on whose northern side are two old mines, the Hall and the Sherman, which were early discovered but which have long been idle. The property has passed to Witherbee, Sherman & Co., and has lately been drilled. Ore has been found in rocks the same as at Mineville, and constitutes a reserve for the future.

It is natural to consider these last mentioned beds the northern extension of the Smith mine, and it as representing the Old Bed group, farther east and lower down than the Barton hill-Fisher hill-Burt lot series; but inasmuch as the O'Neill shaft is over a mile from the last exposure of the Old Bed series with almost no outcrops between, and in rocks that are practically massive, one may quite as well regard the northern ones as totally distinct ore bodies. Again one's train of thought is necessarily influenced by the sedimentary or igneous views of origin. The axial trend of the Smith mine is parallel to the same feature in all the others to the south, and therefore shows the same great structural character, presumably due to folding whose compressive strain being at right angles to these axes, operated in a northwest, southeast direction.

Farther on to the north, no ore is known for 2 or 3 miles, and then the beds are comparatively thin and have been long abandoned.

MINERVA MINE

This is a small opening situated in the town of Minerva, about 2 miles north of the hamlet of that name. The ore body outcrops on the southern face of the long north and south ridge which rises between Minerva stream and Stony Pond brook and is known locally as Ore Bed mountain. The elevation is between 1900 and 2000 feet according to the topographic sheet. A good trail leads from the highway along Falls brook to the mine. The Burden Iron Co. operated the deposit and the ore was used at Troy. The last work was done about 1881.

The geological associations are very similar to those noted in the mines about Crown Point. The Grenville series of limestones, schists and black hornblendic gneisses outcrops in the broad valley drained by Jones brook and reaches well up the confluent valley of Minerva stream. It appears to form also much of the higher ground, though interrupted in places by a pink gneiss of granitic composition which is probably intrusive. The latter has a more massive appearance than the typical Grenville gneiss and is made up of green pyroxene crystals in a ground mass of microperthite, microcline and quartz. This gneiss was found in proximity to the ore, but not in actual contact. The immediate walls, as exposed in the pits, are formed of the darker variety, carrying hornblende and biotite as ferromagnesian minerals, and probably belonging to the sedimentary or Grenville series. Red garnet is distributed through the rock in small crystals, while pyrite occurs in considerable quantity both as individual particles and irregular aggregates.

The deposit has a northwesterly strike in conformity to the general trend of the country rocks. It has a flat dip of not more than 10° northeast, but as the surface rises sharply in that direction, the overburden soon becomes too heavy for open-cut work. There are a number of pits and trenches along the outcrop, extending altogether for a distance of 100 rods. A breast of ore 12 or 15 feet thick is exposed in the middle section. The thickness diminishes toward the ends, but it was not possible to estimate the size with accuracy owing to the partial filling in of the pits. Some drilling is said to have been done a number of years ago to test the ore body in depth; the records, however, have not been available for use in this report.

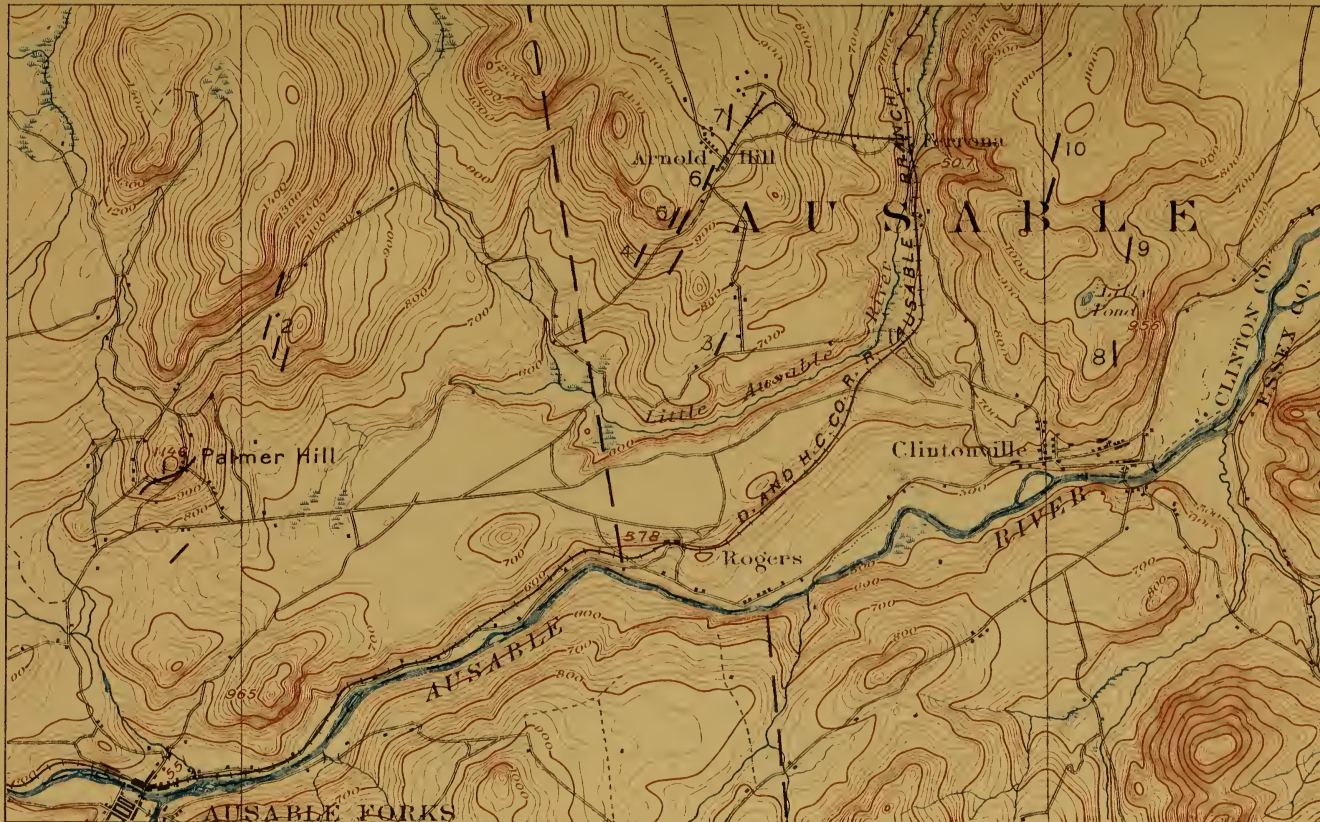
The ore is a fairly coarse, granular magnetite. Samples taken from different parts of the body indicate an iron content above

50 per cent on the average, so that it would be classed as of rich grade. The principal impurity is pyrite which seems to be concentrated in narrow bands and is not generally admixed with the magnetite. A quantity of the more sulfurous ore has been left on the surface near the openings.

ARNOLD HILL AND PALMER HILL MINE GROUP

On the southern border of Clinton county is an old mining district which includes the Arnold hill, Palmer hill and several outlying deposits. The district is easily accessible from Lake Champlain by the Ausable valley, and was one of the first in the Adirondacks to be entered by the early explorers in search of iron ores. It has furnished in the aggregate about 2,000,000 tons of furnace and concentrating ores, most of which has been used for local iron manufacture.

The mines are all found on the north side of the Ausable river within an area some 6 miles long east and west and reaching about half of that distance back from the river. Palmer hill is a knob that rises directly from the valley in the western part of the area, 2 miles north of Ausable Forks. The mines lie well up the slope and are based on an ore body that outcrops along the southern face. Northward the contours merge into a broad ridge of which Jackson hill, a slight prominence, has a few openings known as the Jackson hill mines. Still farther north, 3 miles from Palmer hill, are the Rutgers and the Dills & Lavake pits that have afforded some ore. Arnold hill occupies a central position in the area and is set off from the adjacent elevations by the trench of the Little Ausable, deep and gorgelike when it passes through the ridge to the north. The deposits are mainly near the summit, but they lie also along the southern face. On the eastern end is Cook hill with the Cook, Mace, Winter and Battie deposits. The Burt pit mentioned by Emmons has not been located; apparently it was never worked to any extent. At the foot of Palmer hill, across the Clintonville road, is an old opening which is now caved, and another called the Chalifou occurs south of Arnold hill, near the Little Ausable; both are little more than prospects. The mines are indicated on the accompanying map [pl. 7] which is reproduced from the Ausable sheet of the United States Geological Survey, with a scale of 1 mile to the inch. The mines are: 1, Palmer hill group; 2, Jackson hill group; 3, Chalifou; 4, Finch; 5, Indian; 6, Arnold; 7 Nelson Bush; 8, Winter; 9, Mace; 10, Cook mine.



PART OF AUSABLE QUADRANGLE

MAP OF ARNOLD HILL AND VICINITY

The ore bodies are indicated by heavy lines and numbered as explained in the text

General geology

The higher Adirondack ridges do not extend much beyond the Clinton county line. The Ausable in its course from the east and west branches to Lake Champlain marks the limit between the region of main uplift and the bordering foothills. South of the river the surface rises quickly to the level of the flanking ridges which is less than 1500 feet, and thence abruptly with frequent rock scarps to the interior prominences which increase in hight toward the southwest and merge into the central dominating range of Essex county. On the north side, a terraced sand plain intervenes between the river and the first ridge forming the valley wall. In the stretch from Ausable Forks to Clintonville it is from 1 to 2 miles wide but contracts below the latter place where the valley becomes very narrow. The hight of the ridge on which the mines are situated for the most part averages about 1100 feet or 500 feet above the level of the plain.

The anorthosites and associated gabbros which are so widely developed to the south do not occur in force across the Clinton county line. They compose, however, the higher prominences within a short distance of the Ausable and in the vicinity of Keeseville, east of Clintonville, even extend somewhat over the line as a narrow tongue diminishing in width toward the north. They have no bearing upon the iron ores and will not be further considered.

Gneiss series. The area surrounding the ore bodies is underlain chiefly by an acid augite gneiss, a part of the basal gneiss series (Saranac formation) which borders the northeastern Adirondacks and shows much uniformity of character throughout the area. Bands of darker gneiss and pyritous schists that can be referred to the sedimentary or Grenville series occur rarely and in limited outcrops. Of recognizable igneous rocks there are small exposures of syenite, gabbro and diabase, all intrusive in the gneiss and thus of later age.

The gneiss presents some variations from place to place, but the differences either in structure or composition are seldom so pronounced that a basis for a classification is afforded. The extremes are connected, moreover, by transition phases and are intimately associated in their field occurrence.

In its composition, feldspar, augite and quartz partake most largely. The feldspars may be microperthite, orthoclase or microcline among the alkaline varieties which are the prevailing ones or an acid plagioclase. Microperthite and orthoclase are commoner than the other varieties and their reddish color gives the predominant tone to most specimens. Both the quartz and augite fluctuate, the proportion of the former mineral being usually about that found in a moderately silicious granite, but may shrink to very small amounts. The augite gives way at times to hornblende or biotite, a result that may be traced in part to secondary alteration.

The arrangement of the constituents may be described as gneissoid, yet it often lacks the parallelism of typical gneisses. The texture is mostly granular, such as would be produced by shearing and granulation of a massive rock with perhaps a certain amount of flowage under compression. Coarse phases in which little crushing effects are observable and grading into a pegmatite rock are not unusual in the area. They may be explained as massive aggregates which have escaped the general dynamism that has effected the granulation of most of the gneisses, or possibly they represent a recrystallization of the latter under certain favorable conditions which have obtained only in portions of the mass. That they are all intrusions from a distinct magma hardly seems possible under the circumstances owing to the frequent similarity of composition to the granular varieties as well as their textural gradation into the latter. On the whole the characters of the acid gneiss indicate its relationship to the granites.

There are few exposures of sedimentary types among the gneisses. On the south side of the Ausable, just below the confluence of the two branches at Ausable Forks, a micaceous laminated rock outcrops in a small area where the overburden of sand and soil has been washed off. It has the peculiar rusty weathered appearance common to these gneisses, due to the oxidation of contained pyrite. Some layers are extremely quartzose. The exposure has special interest from the fact that the strata are cut off on one side by syenite which breaks across in an irregular manner like an intrusive. It is the only place in the district where such evidence of the nature and relative age of the syenite has been found. The micaceous gneiss can not be traced for any distance, as the river and its deposits conceal the outcrop. The elevations on the opposite side of the river just north of Ausable Forks are mostly syenite, but there are involved masses of amphibolite and of a light colored plagioclase gneiss that probably belong to the sedimentary series. Crystalline limestone has been noted by Kemp as occurring at Trout pond, 3 miles south of Clintonville; it does not appear to be present, however, anywhere in the vicinity of the mines.

The strike of the gneisses varies considerably, but is mainly in a northerly direction. The common readings are east of north, up to

45°, with rarely one to the west of north. The dip is uniformly toward the west. In many places the foliation is too obscure to permit determinations with any certainty.

Augite syenite. This rock occupies two distinct areas at least within the district. The one near Ausable Forks already mentioned is the larger and more typical of the normal character of the syenite. As near as the limits can be drawn it forms practically a connected mass or boss, the surface of which is coextensive with that of the dome-shaped hills lying between Ausable Forks and Palmer hill. The exposure south of the Ausable is probably an offshoot from this mass. Compared with the gneiss of the region the syenite shows marked differences even in hand specimens. Its color on fresh surfaces is green, with a suggestion of gray or yellow at times, while the fracture is that of a close grained igneous rock, conditioned by its massive texture. Feldspar and magnetite are the minerals most apparent to the unaided eye. Under the microscope the former is seen to be almost entirely microperthite, while associated with it are augite, hypersthene, hornblende, quartz, zircon, apatite and rarely a light colored garnet. The feldspar is built up in stout anhedra between the interstices of which the quartz occurs in irregular grains. On the borders, especially on the east side of the mass, the rock is apt to be more quartzose and the grains attain such dimensions that they are readily distinguishable.

The second occurrence of the syenite is on Arnold hill, a few hundred feet west of the Nelson Bush mine. It is here quite different in appearance from the first, having a mottled aspect which is induced by the abundant hornblende mixed with the feldspar. Plagioclase constitutes a large proportion of the feldspar. The rock is to be regarded as a basic phase of the syenite, near the borders of the gabbro rock group.

Gabbro. The only intrusion of gabbro in the gneiss series of the district that has been found is on the south bank of the Ausable, a mile east of Ausable Forks along the Clintonville road. It is a coarse dark rock somewhat laminated but with the peculiar mottling that is so often associated with gabbroic rocks. The constituents are mostly hypersthene, hornblende and labradorite. The occurrence is doubtless to be ascribed to an outlying intrusion from the large anorthosite-gabbro area to the south.

Dikes. Diabase dikes are conspicuous features of the geology of the ore bodies. They intersect the latter in different directions, apparently without following the joint systems of the walls. Their thickness ranges up to 15 feet, the maximum reached by two dikes on Palmer hill, but most are much thinner. They have little effect upon the ore and except where accompanied by faulting which is rare they do not materially interfere with mining operations. From the few examples that have been examined petrographically, they appear to be all ordinary diabases.

Arnold hill mines

The mines on Arnold hill comprise several separate openings located along the southern shoulder of the ridge. The ore bodies outcrop in parallel series or *en echelon* with a general trend of n. 20° e. Altogether they have been explored for a mile and a half along the strike, though of course not continuously. Beginning at the south end, the first opening, known as the Finch pit, lies at about the 850 foot contour. Next in order to the north after a short interval are several open cuts, parallel but at slightly different horizons, extending perhaps 500 feet. They have long since ceased to be productive. The Arnold or Big mine, with three ore bodies, is about 1000 feet farther north, and at about an equal distance from the Arnold is the Nelson Bush mine with its two shafts, the last to be worked. The small Chalifou pit lies to the south and east of the main group.

According to local records the earliest discovery on Arnold hill was made in 1806. Mining was begun on a small scale shortly after that date, and in 1812 the property was purchased by Arnold, Stickney & Howe who continued in possession for over 50 years. Up to the time of Emmons's report (1842) exploitation was confined to the southern deposits which he states were then being worked under lease. The mines have been intermittently active during the last half century. The most recent undertaking, the Arnold Mining Co., reopened the Nelson Bush mine, working it for a period of three years. A mill of 200 tons daily capacity was erected at Arnold Station (Ferrona on the map) and new mining equipment installed. The company ceased operations in the summer of 1906.

Geological relations. The deposits outcrop as rather thin bands intercalated in the gneiss parallel to its foliation. Their dip is toward the west and steep generally 70° or a little more. Their shape which is tabular has been modified by compression, producing undulations and pinches both along the strike and dip; on the north end the irregularities seem to be more pronounced than elsewhere and the lenticular form is the characteristic one.

The deposits have been subjected to faulting on a small scale. The direction of movement is across the strike, with the result that the lines of outcrop are shifted laterally. In the heading of the south shaft of the Nelson Bush mine a fault of this kind was observed. Its throw could not be determined but it is probably small. Other examples which have been noted by Emmons occur in the old workings on the southern section, where the outcropping ore is offset by slight displacements that have taken place obliquely to the dip. The maximum offset found on the surface is about 15 feet. In this case a thin dike has been intruded along the fault plane [fig. 15].

The wall rock is mainly the augite variety of acid gneiss already described. Along the contact with the ore it has been considerably altered, with the development of chlorite and biotite as resultant products from the augite, while it also contains much clear quartz of secondary infiltration. A black hornblende gneiss is encoun-

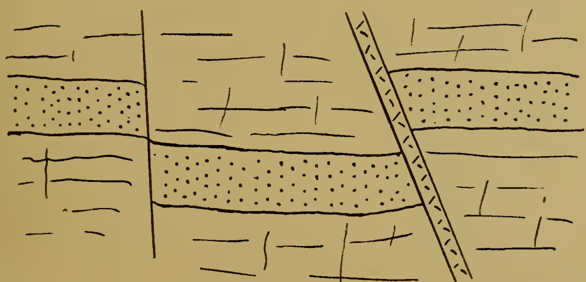


Fig. 15 Faulting of the ore bodies as seen on the surface near the Indian pit. A diabase dike has been intruded along the fault plane at the right.

tered on the walls of the Nelson Bush mine, and may represent an included band of the sedimentary gneisses to which it corresponds in composition.

Nelson Bush mine. This mine is the most northerly of the Arnold hill workings. It consists of two shafts about 600 feet apart driven on the course of two lenses which have nearly the same horizontal axis. Underground the shafts run off as inclines, the northern starting at an angle of 60° and flattening gradually to 30° and the southern at an angle varying from 42° to 35°. They are intended to follow as nearly as possible the pitch of the lenses which is about 40° north. The north shaft is down some 900 feet on the incline. The lens of ore as seen in the workings is 25 feet thick in its maximum development and averages perhaps 18 feet. In the south shaft the lens ranges from 10 to 15 feet across the walls. The two shafts are not connected underground.

The ore is coarsely granular as a rule and contains too much foreign matter to be suitable for the furnace without undergoing some form of selection or concentration. In the recent operations the product has been milled and separated magnetically. Pegmatite and quartz are the principal foreign ingredients. Small calcite veins with a deep purple fluorite also occur. In the rich ore apatite is quite abundant. The results obtained by milling operations show that a little less than two tons of crude ore are required for one of concentrates. By the method of magnetic separation some loss is entailed by the fact that the magnetite has been oxidized in part to martite, which has the chemical composition of hematite and is very weakly magnetic. The analyses given below communicated by the Arnold Mining Co., were made from samples of rich ore (1) and the admixed lean material (2). Owing to the failure to determine the alkalis present, they are not complete, but the discrepancy is important only in the case of the lean ore which contains feldspar. The small percentages of copper and nickel are, so far as known, unusual to Adirondack magnetites. These elements are probably combined with sulfur; pyrite and pyrrhotite suggest themselves as the most likely combinations in which they may occur.

	1	2
Fe_2O_3	57.85	20.30
FeO	27.50	10.15
SiO_2	7.62	50.82
TiO_2	.39	.33
S	.038	.044
P_2O_5	.618	.43
Al_2O_3	1.68	8.32
MnO	.15	.20
CaO	2.48	2.26
MgO	1.26	1.53
Cu	.006	......
Ni	.072	......
	99.664	94.384
Iron	61.90	23.00
Phosphorus	.269	.188
Manganese	.116	.155
Titanium	.24	.198

Arnold mine. This has been the largest producer of all and for many years supplied the entire output. The deepest workings are about 800 feet. The loss of the main shaft by caving, 10 or

Plate 8

North shaft. Arnold hill

12 years ago, put a stop to underground operations and it has not since been reopened. It is said that the ore bodies narrowed appreciably near the bottom, indicating that they are probably lenticular like the Nelson Bush deposits.

In the reports of Putnam and Smock the mine is described with some detail. Three parallel bodies occur, called the black, the blue and the gray veins. They are separated by gneiss with an interval of 40 feet or less between adjacent walls. The strike is n. 35° e. and the dip 70° at the surface flattening to 55° at 325 feet depth. Smock states that the bodies run off as shoots underground pitching at an angle of 40° along the strike. The first ore body on the foot-wall side is the gray vein which varies from 3 to

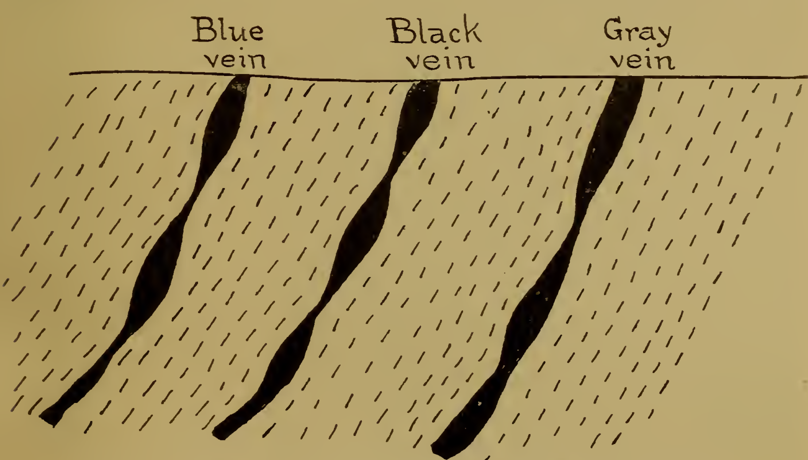


Fig. 16 Ideal section of the Arnold ore bodies. Blue vein is hematite

25 feet in thickness. The black vein in the middle is from 3 to 27 feet thick and the blue to the west about the same. There are two shafts, 500 feet apart, driven on the dip of the foot-wall vein connecting by crosscuts with the adjacent veins, and a series of levels about 700 feet long. The section included herewith [fig. 16] shows the relations of the three ore bodies.

Putnam advances the opinion that the Nelson Bush ore bodies are a continuation of the gray vein, but this can scarcely be true since the axis of the former when produced southward falls considerably to the east of the Arnold workings. No indications of a fault sufficient to account for the difference in horizon were found on the surface. It seems more probable that the two mines are located in separate horizons.

The marked variation in the character of the ore in the different veins is an interesting feature. The black vein yields a granular, friable magnetite carrying apatite and otherwise resembling the Nelson Bush ore. The gray vein is so named because of the light-colored gangue minerals which are intermixed with the magnetite so as to lend a mottled gray appearance to the ore when seen in hand specimens. It is slightly altered. In the blue vein the ore has been changed almost completely to martite, the surface of which is steel blue in color. The change no doubt is to be explained as the effect of weathering assisted perhaps by the circulation of underground waters which have found here an easier passage, possibly along some fissured strip, than in the neighboring veins. Specimens of this ore frequently show veinings of jasper and calcite, deposited by such circulations. Analyses of the ore from the blue vein are given herewith. No. 1 has been contributed by Mr S. Le Fevre. No. 2 is quoted from the paper by Maynard on "The Iron Ores of Lake Champlain"; Maynard and Wendell analysts.

	1	2
Fe_2O_3	83.14	85.54
FeO	5.27	2.39
SiO_2	7.64	7.56
TiO_2	.26	......
S	.035	.16
P_2O_5	.531	.43
Al_2O_3	1.72	2.71
MnO	.31	......
CaO	.64	.98
MgO	.108	.48
Cu	.005	......
Ni	.003	......
	99.662	100.25
Iron	62.30	61.74
Phosphorus	.232	.188
Manganese	.24	......
Titanium	.156	......

Open cuts, Finch and Chalifou pits. The open-cut workings south of the Arnold mine were the sources from which ore was obtained during the early period, but they were abandoned with the discovery of the larger deposits to the north. The only information about them that has been placed on record is contained in Emmons's report. There are four parallel deposits, according to this authority, the richest being from 2 to 8 feet wide, known as the blue vein, with martite. At the time of the report, it had

Plate 9

Mill at Arnold hill

been worked to a depth of 260 feet and for a length of 500 feet. Regarding the other deposits, he states: "The four veins upon the Arnold hill are in proximity to each other, being separated by a few feet of rock. The width of the black vein is from 3 to 11 feet, and that of the gray veins from 2 to 8. The quality of the ore furnished respectively by each is very similar and the products of reduction nearly the same; preference, however, is given to the old blue vein." Some 800 feet west of this group there is a fifth vein which has been opened in a small way. The ore is reported to have been of poor quality.

The Finch pit south of the foregoing is probably on a continuation of the same deposits. It has been sunk through several feet of drift, which has caved and nearly filled the opening. The ore is mostly unaltered magnetite. The depth of the pit is about 75 feet.

The Chalifou pit is a small prospect a mile and a half southeast of the Finch on a different horizon from the Arnold hill group. The ore is reported to have a thickness of 8 to 12 feet.

Of the analyses given below, No. 1 has been taken from Maynard's paper already quoted and relates to ore from the Indian mine which lies high upon the ridge. No. 2 which is quoted from the same source represents a sample from the Finch pit. Both analyses are by Maynard and Wendell. No. 3 is an analysis of ore from the Chalifou pit, supplied by Mr S. Le Fevre.

	1	2	3
Fe_2O_3	69.99	81.65	45.45
FeO	8.87	7.87	21.26
SiO_2	14.60	5.60	22.38
TiO_2	.....	......	.49
S	.24	.24	.045
P_2O_5	.07	.45	.430
Al_2O_3	3.67	2.12	4.76
MnO	.38	tr.	.16
CaO	1.90	1.56	2.22
MgO	tr.	.67	1.95
	99.72	100.16	99.145
Iron	55.91	63.27	48.35
Phosphorus	.03	.196	.188
Manganese	.28	....	.122
Titanium	.....	....	.295

Production of Arnold hill mines. In round figures the output of the mines on Arnold hill may be placed at 600,000 tons. Up to 1864 there had been taken out about 150,000 tons and it is estimated that 400,000 tons were mined in subsequent operations previous to the reopening of the property by the Arnold Mining Co.

Palmer hill mines

These mines form a single group. They are situated on an ore body which traverses the hill just below the summit in a northeast-southwest direction and has been explored for nearly half a mile on the outcrop. The strike brings them nearly in line with the Jackson hill deposits, a mile distant to the northeast. The several pits that have been used for ore extraction in years past include the Elliot and White Flint on the western side, the Big, Summit and Lundrigan pits in the central portion and the Little pit and Lot 29 on the east.

The period of active operations began about 1825 and lasted till 1890. The property was held as an undivided interest by the J. & J. Rogers Co., and the Peru Steel & Iron Co., who converted the ore into charcoal blooms at their forges at Ausable Forks, Black Brook, Jay and Clintonville. It is worthy of note that a separator in which magnets were employed for removing the magnetite in the crude ore was erected on Palmer hill in 1836, one of the first experiments with this process that has been recorded. Evidently the attempt was not wholly successful, as the process was later superseded by gravity methods.

Geology. The ore body consists of a band or zone impregnated with magnetite. It is on the whole leaner than the Arnold hill deposits owing to the mingling of the magnetite with the minerals of the adjacent walls. The latter are also not so sharply defined. The magnetite is distributed more or less evenly throughout the mass, or gathered into bodies that are relatively rich. In mining the higher grade ore was specially sought for and was followed in preference to the excavation of the whole deposit.

The rock on Palmer hill derives special interest from a petrographic standpoint owing to the occurrence of fluorite. This mineral is seemingly an original constituent. It forms irregular grains of about equal size with the feldspar and quartz and intercrystallized with them. Where most abundant it constitutes from 25 to 50 per cent of the rock. It is particularly in evidence in the walls of the Big pit and in a belt which can be traced north from the pit for 150 feet. The containing rock has a granitic texture and in other respects is analogous to an acid intrusive.

Two diabase dikes, each about 15 feet thick, cut the ore. One of these runs nearly parallel to but west of the outcrop, standing as a vertical wall when seen underground. It sends off a small offshoot from the eastern end but holds its width undiminished so far as it can be traced. The second dike intersects the deposit at the Big pit, crossing at an oblique angle and continuing in a northerly direction over the summit of the hill. The dikes have exerted noticeable contact effects upon the ore in the development of a black garnet (brown in thin section), which has been formed at the expense of the magnetite and feldspar, as well as by rendering it dense and exceedingly hard. A considerable quantity of the garnetiferous ore can be found on the waste dumps, having proved evidently too refractory to be used.

Description of workings. The ore body has been excavated for a long distance as an open pit, with chambers extending down the dip when the depth became too great for removal of the overlying rock. In places the surface workings have caved and are inaccessible. The Elliot slope enters the hill on the southwestern side at a little over 900 feet elevation. It pitches nearly north. The slope was the last one opened and is said to follow a shoot of ore 9 feet thick. The adjoining White Flint slope, somewhat higher up, also pitches north at an angle of 70° at first, but flattens downward; it is bottomed at 1200 feet. The breast of ore, judging from the visible part of the excavation, must have measured about 20 feet. The ore contains a good deal of milky quartz, but is rich compared with the general average. Between this and the Big pit the north-south dike intervenes and the ore body swings off toward the east. The Big pit is the deepest of all, 2200 feet on the dip which begins at 60° and is nearly horizontal at the bottom. The Summit pit at the highest point of outcrop of the deposit is credited with a depth of 1000 feet and dips about 30°. Of the other workings, the Little pit, opened by the Peru Steel & Iron Co., and lying near the eastern end, is the largest. The slope has a length of 1200 feet and follows a shoot 10 feet thick and 100 feet wide across the dip.

Character of the ore. In texture the ore is rather fine. Its appearance and mode of occurrence is much like the Lyon Mountain ore. The gangue consists mostly of microcline, orthoclase and quartz, with a very small proportion of ferromagnesian minerals in the form of augite and biotite. Phosphorus and sulfur fall within the Bessemer limits. The chemical composition is shown by the following analyses which have been communicated to the writer by Mr W. Carey Taylor.

	1	2	3
Fe_2O_3	46.152	49.757	67.274
FeO	20.735	22.354	30.224
SiO_2	31.700	26.134	3.000
S	.008	.016	.080
P_2O_5	.005	.016	.165
Al_2O_3	1.076	1.531	......
MnO	.037	.090	......
CaO	.364	.315	......
MgO	.872	.229	......
	100.949	100.442	100.743
Iron	48.43	52.22	70.60
Phosphorus	.002	.008	.07

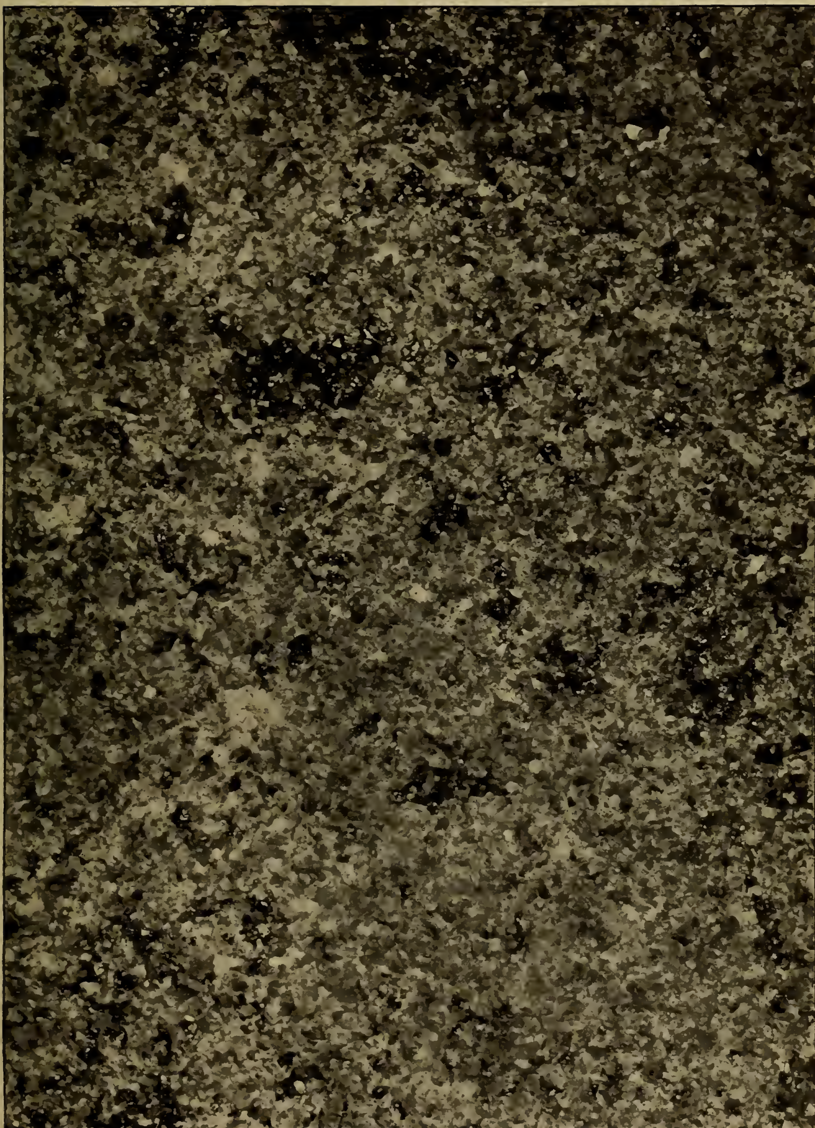
Analyses 1 and 2 are of crude ore from the mines of the Peru Steel & Iron Co., at the east end, and No. 3 of concentrates made by the same company. The higher phosphorus found in the concentrates proportionately to that shown in the analyses of the ore is abnormal and contrary to the usual experience in the treatment of magnetites, at least by magnetic methods. The concentration practice at the Palmer hill mines consisted in first roasting the ore so as to render it more friable and then crushing by stamps and passing the broken ore over jigs. The bloom iron made by the companies was mostly shipped to Pennsylvania for manufacture into crucible steel.

Production. The output of the mines owned by the J. & J. Rogers Co. averaged about 25,000 tons annually for a period of 40 years. The production by the Peru Steel & Iron Co. is not known, nor the quantity mined before the organization of the two companies. It is safe, however, to estimate the total yield at over 1,000,000 tons crude ore. The average assay in iron may be placed at about 40 per cent.

Other mines in the district

Jackson hill. The mines at this locality are based on two or three parallel bodies that outcrop north and south of the road leading from Palmer hill. They lie on the western side of the hill at from 1000 to 1150 feet elevation. Their course is n. 20° e. and dip high to the north. The two main pits are each about 500 feet long and

Plate 10



Fluorite granite from Palmer hill. White particles are fluorite, gray are feldspar and the black crystals are magnetite. A lean ore grading into rich magnetite

10 to 12 feet wide, with an extreme depth of 100 feet. In its association and nature the ore is much the same as the Palmer hill ore and it is said to have yielded equally good iron.

Dills & Lavake and Rutgers pits. The openings are situated 3 miles north of Palmer hill at an elevation of about 1400 feet, as nearly as can be determined. They are just without the limits of the Ausable topographic sheet. The Dills & Lavake is an open cut 100 feet long and 15 feet wide. The Rutgers pit north of this is nearly circular, 30 feet in diameter and about that in depth. The ore is somewhat richer than the average for Palmer hill. It contains apatite in plainly visible grains, indicating a high phosphorus content. The following incomplete analyses have been furnished by Mr J. N. Stower. No. 1 refers to a sample of ore from the Dills & Lavake pit and No. 2 to a sample from the Rutgers:

	1	2
Iron	50.60	50.10
Sulfur	.003	.022
Phosphorus	.64	.341
Titanium	.45	.45

Cook mine. On the ridge east of Arnold hill the gneiss series is well exposed. Much of it is the reddish microperthitic nearly massive variety that has been described as the predominant formation of the district, but there is less augite and oftentimes very little quartz present. In the vicinity of the Cook mine the dark constituent is biotite and the rock has the composition of syenite. A coarse quartzose hornblende variety, which looks like a sheared granite, is found in small patches that may represent later intrusions; it has a fresher appearance than the syenite and the borders are commonly pegmatitic.

The Cook mine, mentioned by Emmons as having been exploited several years before the date of his report, supplied ore to forges on the Little Ausable. It was last worked in 1856 when the forges were carried away by a flood. Two pits evidence these early operations. They are situated on the western side of the ridge nearly opposite the Nelson Bush shafts on Arnold hill. The elevation is about 1000 feet. Both are surface strippings, of which the larger exposes a breast of ore about 12 feet from wall to wall. They have a north strike and a dip 80° west. The smaller parallel pit lies above separated by 30 feet of rock. Emmons records that in exploring the deposit by a transverse trench four veins were encountered with thicknesses of 2 feet, 3 feet, 6 feet and 13 feet respectively.

The ore in places is a compact rich magnetite, yet the greater portion as exemplified by sampling the deposits consists of disseminated grains or stringers of magnetite in a gangue of hornblende, biotite and quartz. Apatite shows in some specimens. The analyses, however, indicate a phosphorus content that is well within the Bessemer limits. The following were made by Mr James Brakes, probably from selected material.

Fe_2O_3	60.226	57.857
FeO	27.486	29.314
SiO_2	7.640	5.400
TiO_2	.410	.492
S	.033	.037
P_2O_5	.052	.023
Al_2O_3	1.269	3.960
MnO	.104	.051
CaO	1.100	1.560
MgO	1.587	.846
	99.907	99.540
Iron	63.536	63.300
Phosphorus	.023	.010
Manganese	.081	.040
Titanium	.246	.295

Battie mine. This is located on a continuation of the Cook ore body, about 1½ miles north of that mine. From Emmons's account, the existence of two parallel deposits is inferred, though only one is shown by outcrop or workings. The mine was last operated about 50 years ago. It is an open cut about 600 feet long and 10 to 20 feet wide. The ore shows much variation across the dip, bands of massive magnetite alternating with rock that carries a greater or smaller proportion of magnetite in disseminated grains. It has a sheeted structure evidently due to slight movements along the walls. They are noticeably grooved and polished. The principal gangue mineral is biotite. The ore is said to have yielded good iron, similar in quality to that made from the Cook ore. Its general character is shown by the analyses below which have been communicated by Mr J. N. Stower. The analyses were made by James Brakes from samples taken at different places along the outcrop. The high titanium, reaching over 2 per cent in No. 5, is noteworthy, but seems to be traceable entirely to the presence of titanite.

	1	2	3	4	5
Iron.......	52.10	60.70	52.80	39.90	61.20
Phosphorus.	.012	.008	.029	.028	.012
Sulfur	.035	.021	.035	.019	.026
Titanium...	.225	.495	.225	.225	2.076

Winter mine. The mine is situated 1 mile northeast of Clintonville near Lilly pond. There are three or more small bands of ore outcropping in a course somewhat west of north and standing vertically or nearly so. The main band is about 10 feet wide. It has been worked by open-cast methods on the south end, while on the north it has been followed by a slope which extends into the hill for about 100 feet where it connects with an adit driven along the course of a diabase dike from the east. Beyond the entrance of the adit the workings are no longer accessible, but apparently the ore body flattens out to nearly horizontal. The relations, however, are obscured by the numerous dikes which intersect the workings. Three of these are found crossing the main slope, the largest lying along the axis of the adit already mentioned. The ore contains much white quartz; an incomplete analysis is here given.

Iron....................................	46.70
Silica....................................	32.75
Sulfur....................................	.024

Mace mine. This is based on a small deposit situated north of the Winter mine. It has been worked principally as an open pit, which has a length of about 500 feet. The width ranges from 3 to 10 feet. The ore is lean and, except for its larger proportion of magnetite, resembles the wall rock. The latter is a hornblende gneiss of granitic appearance.

LYON MOUNTAIN MINES

The Lyon Mountain or Chateaugay mines are in the town of Dannemora, near the western border of Clinton county. The central point of the group is Lyon Mountain, a settlement limited almost entirely to mine employees and their families, situated on the Lake Placid branch of the Delaware & Hudson Railroad, 37 miles from Plattsburg.

In size the mines are among the largest in the State. They are widely reputed also for the high quality of their product. The ore is all shipped in the form of concentrates which carry minute quantities of sulfur and phosphorus, much below the limits admissible for Bessemer ores. It is used in the manufacture of special grades of iron. Owing to the scarcity of such ores in this country, a steady market has always been obtained for the output.

The first mining of importance within the district was undertaken about 1871 at a locality said to be near the site of the present shaft 4, on the southwestern section of the main ore body. There is evidence, however, that the deposits had been known to the early settlers in the region and some ore was taken out many years before that date. Operations during the early period were carried on by contractors working under leases. The ore was sorted by hand, or crushed and separated in crude mills that had been built in the vicinity, and hauled by wagon to Catalan forges located at Belmont, Russia, Clayburg and Altona where it was made into bloom iron.

In 1879 the Plattsburg & Dannemora Railroad was extended to Lyon Mountain, affording facilities for shipment of the ore to more distant points. Soon afterward the Chateaugay Ore & Iron Company, which consolidated the different mining interests, instituted a more systematic plan of operations that resulted in a largely increased output. In place of open-cast methods, which were first employed, slopes were sunk in the deposits at frequent intervals and the ore mined underground. The number of slopes was increased until over 20 had been located on an outcrop of 3600 feet. The ore was mined on both sides of the slopes with occasional pillars left for support. But after the workings had obtained some depth it became necessary to adopt a different plan; levels were run at intervals of 50 feet vertically while only 6 or 8 of the slopes were used for hoisting purposes. In connection with the mines the company operated shaft furnaces at Plattsburg and Standish for making charcoal pig. The latter furnace has recently been converted so as to employ coke as fuel and is in operation at the present time.

Since 1903 the mines have been under the ownership and management of the Chateaugay Ore & Iron Department, a subsidiary of the Delaware & Hudson Railroad. They have recently been greatly improved upon the basis of a comprehensive scheme which if fully carried out will materially enlarge their production. The recent betterments to the plant include a mill of 1200 tons nominal capacity, doubling the former milling facilities, and the installation of a large central electric station for supplying power to the mines and mills. The accompanying map shows the general fea-

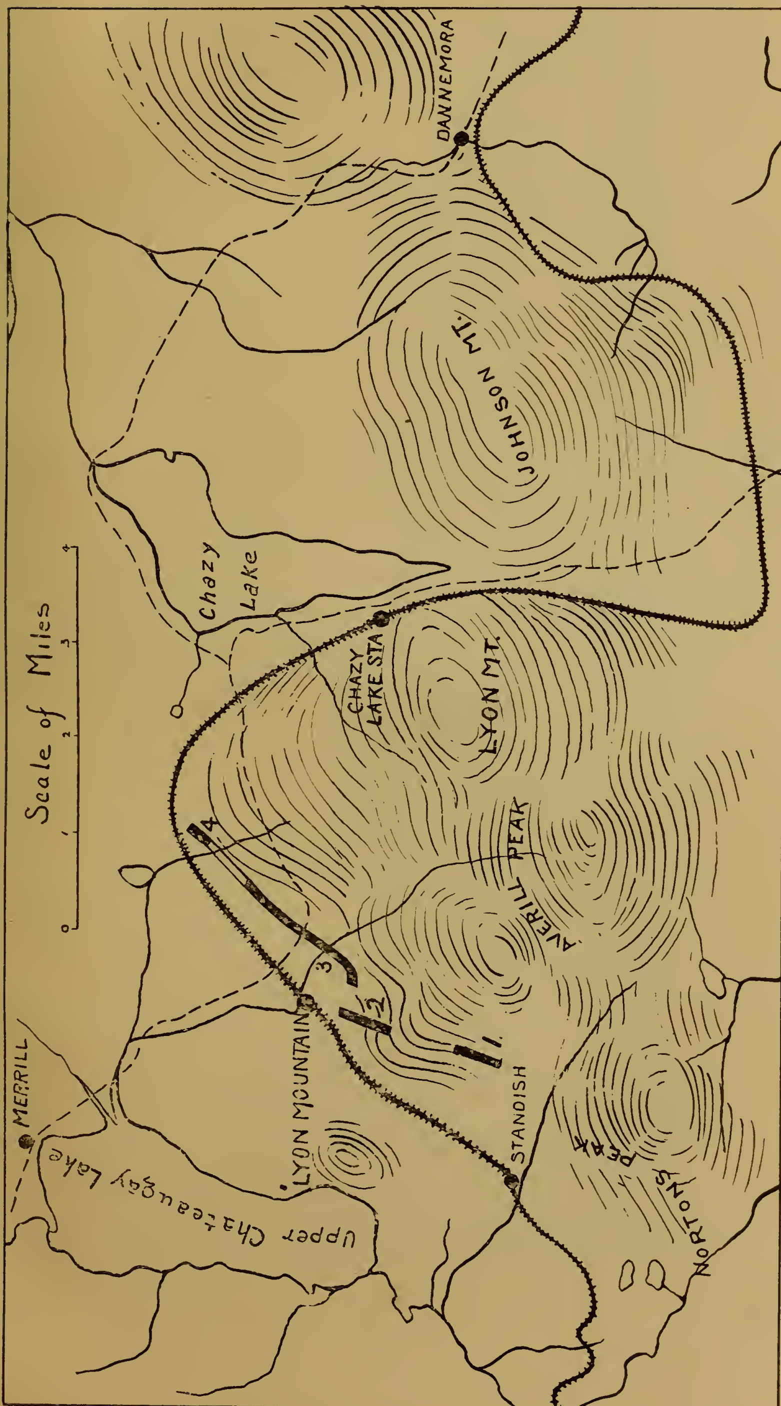


Fig. 17 Lyon Mountain. Sketch map showing distribution of ore bodies

tures of the topography about Lyon Mountain and the distribution of the magnetite deposits. The deposits indicated by the numbers on the map are as follows: 1, Standish or 81 mine; 2, Phillips vein; 3, Main group; 4, Parkhurst.

General geology

The several prominences, which include Lyon mountain in the middle, Averill peak and Morton's peak on the western flank and the Dannemora mountain on the east, constitute the main axis of elevation in this section of the Adirondacks. Towards the east the ridge is succeeded by the narrow abruptly sloping plain of Lake Champlain, while on the north the elevations gradually die out beneath the broad plain of the St Lawrence. Lyon mountain, the culminating point, rises to an altitude of 3,800 feet, and is the most conspicuous landmark in the northern Adirondacks. The ridge is separated from the parallel one to the north, known as Ellenburgh mountain, by a valley 5 or 6 miles wide, the floor of which lies at an elevation ranging from 1500 to 1700 feet. On the west the valley contracts owing to a line of spurs which offshoot from Averill peak in a northwesterly direction. Upper Chateaugay lake which receives the drainage of the valley lies in the western part while Chazy lake is on the eastern side of a low ridge that extends northeast from Lyon mountain.

The higher ridges mentioned above mark the limits of the gneisses and associated crystalline rocks in the northeastern Adirondacks. As they fade out into the bordering plains, the crystallines are succeeded unconformably by Paleozoic sediments which extend over the remaining area as far as the shores of Lake Champlain and the St Lawrence river. The present line of contact between the two series is well up on the outer slopes of the ridges but follows the main valleys for considerable distances into the interior.

Paleozoic rocks. Within the area under discussion the Paleozoic strata are of little areal importance. A narrow belt of Potsdam sandstone occupies the lower part of the depression between Ellenburgh and Dannemora mountains extending as far as Chazy lake and to an elevation of about 1500 feet. Another Potsdam area occurs on the northeastern border of Dannemora township where it is found as high as 1700 feet. According to H. P. Cushing,[1] who has mapped the areas, the rock is a reddish arkose quite different from the coarse phase usually occurring at the base of the formation.

---

[1] Geology of Clinton County. N. Y. State Mus. 49th An. Rep't. 1898. 2:537. *Also* Geology of Rand Hill, 53d Mus. Rep't. 1901. 1:63.

Plate 11

General view of Lyon Mountain. The mines lie part way up the slope of the first line of ridges in the background

Gneiss series. The gneisses are the most widespread of the rocks represented in this region. With the exception of the numerous but comparatively limited exposures of dike rocks which are hereafter described, they comprise practically all of the crystallines adjacent to the ore bodies and occupy as well most of the surrounding country. The occurrence of gabbro and augite syenite has been noted at Rand hill, east of Dannemora mountain, but so far as observed they do not appear anywhere in the immediate vicinity of Lyon Mountain.

In this series is included a complex of rocks differing in composition and physical characters. The study of their field relationships is attended with much difficulty owing to the heavy mantle of drift over the area affording limited opportunity for observation, and to the variations in the rocks from place to place. Practically all of the numerous specimens taken from typical exposures in the vicinity of the ore bodies may be classed, however, in the following groups.

Augite gneiss. This is a reddish or grayish granular rock characterized by the presence of augite. It is mentioned by Cushing as one of the predominant types in the group of gneisses designated as the Saranac formation.

In its prevailing development it consists essentially of feldspar, quartz and augite, with subordinate hornblende, titanite, magnetite and apatite. The augite is an emerald-green variety and is always abundant, sometimes composing as much as 20 per cent of the rock mass. The feldspar is mostly orthoclase, but small amounts of plagioclase (oligoclase) may be present. The orthoclase shows a microperthitic intergrowth with albite. The quartz is a fluctuating constituent, though the relative quantity is below rather than above the proportions found in typical granites. The greenish, strongly pleochroic hornblende occurs in skeletal or very irregularly bounded anhedra and may be in part derived from the augite with which it is intimately associated. Of the other components titanite alone has importance. Most specimens exhibit this mineral abundantly distributed in the form of rounded grains varying from light yellow to reddish brown in color. It also occurs as rims surrounding the magnetite. In some specimens taken from the walls of the ore bodies, the titanite constitutes fully five per cent of the rock mass.

The field appearance of the gneiss is usually massive, with but faint tendency toward a parallel grouping of the constituents. Though it has undergone more or less crushing which has broken down the feldspar into granular aggregates, it seldom shows any well developed schistosity. Near the ore the gneiss is seamed through and through by pegmatite of lighter color and is also penetrated by a fine-grained granite like that found on Birch hill. Bands of somewhat darker appearance are not infrequently intercalated in the gneiss. They are apt to be more hornblendic than the surrounding rock and are probably to be interpreted as masses of the hornblende schist, which is described on a following page, that have been penetrated by, and, to a greater or less extent, incorporated with the augite gneiss. The origin of the latter rock is believed to be igneous; in physical character and mineralogy there is a close accord with the plutonic rocks such as are found among the basal formations of the Adirondacks. That it belongs probably to the older series of this class is indicated by its cataclastic texture along with the presence of similar intrusives in the vicinity that have been but little affected by dynamic agencies. Though the chemical constitution of the gneiss has not been determined by analysis, there would seem to be little doubt that the relative proportions of the constituents agree with those of the acid igneous class, varying from syenite to a low-quartz granite.

This gneiss underlies the greater part of the area about Lyon Mountain. It constitutes most of the high ridge east of the ore bodies as well as the projecting spurs, and probably extends beneath the drift-covered valley to the north and west. It forms the walls in most of the mine openings and is invariably closely associated with the ore.

Granitic gneisses. On the top of Lyon mountain a coarse quartz-feldspar rock of slightly gneissoid appearance is exposed over an area that can not be accurately delimited, though it is probably small. Judging from surface indications it extends a few hundred feet down the slopes, which are thickly strewn with its boulders, but no contacts were found. The rock has the composition of an acid granite, with which it is allied so closely in texture and field structures as well, that little doubt of its igneous nature can exist. Its mineralogy is simple, feldspar and quartz forming almost the whole mass. The latter mineral occurs in flattened lenses and spindles which have a common orientation and give the somewhat indefinite gneissoid appearance observable on weathered surfaces. Microcline predominates over orthoclase, the two feldspars represented. Both show commonly a microperthitic habit. Of the ferromagnesian minerals there are a few scattered grains of green augite and small shreds of biotite. In outcrop the rock exhibits a massive habit with the regular jointing peculiar to deep seated intrusives. While there are no supporting evidences of inclusions of contact effects, it is regarded as igneous and probably later than the augite gneiss.

A second type of granitic gneiss, related to the preceding in mineral character but possessing a thorough cataclastic structure, was found on Birch hill between Lyon Mountain and Upper Chateaugay lake. The feldspar consists of microperthite, orthoclase and microcline, all of which have been crushed and finely granulated, though an occasional larger crystal particle is inclosed in the crushed materials. The quartz is drawn out into thin bands. Much magnetite occurs in shreds and irregular grains distributed through the mass or more frequently aggregated along parallel lines which may be continuous for some distance. Except for a little secondary biotite there are no ferromagnesian minerals present.

Hornblende schist. A dark hornblende schistose rock is occasionally found in small patches and lenses surrounded by the augite gneiss. It has a more schistose appearance than any of the other rocks and is also conspicuously banded. The principal mineral is dark green hornblende. The feldspar includes both orthoclase and plagioclase in about equal proportions. The remaining minerals comprise scapolite and titanite, the latter constituting at times fully 10 per cent of the mass, and small quantities of augite, biotite, magnetite and apatite.

Lithologically the schist is quite like the schists that accompany the series of sedimentary gneisses and the crystalline limestones. No exposures of limestone were found, but in limited areas like those at Lyon Mountain it is often absent. At the Williams pit the schist forms both walls of the deposit as a comparatively thin band that is intercalated in the augite gneiss with the axis of extension parallel to the general strike. It is seamed by layers of lighter colored gneiss and shades off at the edges into the augite gneiss through a gradual exchange of the hornblende for the augite and the appearance of microperthitic feldspar. On the hanging side of the deposit, the schist incloses a seam that is made up almost entirely of garnet, a black, nearly opaque submetallic variety, evidently high in iron. The same schist was noticed in the walls at the Dickson open cut, and much of it occurs in the rock dumps at Parkhurst shaft though not observed there in place. These observations indicate that a considerable mass of the rock, probably in interrupted bands or lenses, is inclosed by the augite gneiss in proximity to the ore zone.

Dikes. A minor feature of the geology of the region is the occurrence of dikes which are specially common in the vicinity of the ore bodies. They belong to two series of intrusions, an older represented by granite and a younger consisting of diabase.

The granite dikes vary from a few inches to several feet in width. In appearance they resemble the reddish gneiss, from which they can be distinguished, however, quite readily by their finer and more massive texture. Mineralogically they consist of quartz and feldspar, with subordinate augite, magnetite, titanite and zircon. The feldspar is prevailingly orthoclase, but a triclinic variety, probably oligoclase, is usually present. The dikes are almost identical in composition with the Birch hill granite which strongly points to the conclusion that the two rocks are genetically related. The granite dikes can be best observed at the Williams and Burden openings. At the former locality there are several running parallel to or slightly diverging from the course of the ore body. The only contact effect consequent upon the intrusion of the dikes is a slightly bluish tint assumed by the magnetite.

The diabase dikes occur in numbers both on the surface and in the underground workings. They range up to 15 feet thick, the largest one observed being near slope 15. They do not follow any one direction, though the majority of them have a nearly east-west strike, while most of the others run about n. 30° w. New dikes are frequently encountered in the course of the mining operations.

The petrography of the dikes has been described by Kemp and Marsters,[1] who state that they are all diabase, though showing some variation in individual cases. One dike from the Hall slope is said to be characterized by the presence of small hornblende crystals in addition to those of augite, showing a transition to camptonite. The writer's observations are in accord with the view cited as to the diabase nature of the dikes. With one or two exceptions examination of thin sections revealed little that is noteworthy in their composition or texture. A small dike from slope 4 is characterized by a pronounced porphyritic habit due to the inclusion of augite phenocrysts in a fine ground mass of augite and plagioclase. Some dikes are peculiarly rich in magnetite which has probably been absorbed from the ore bodies during the period of intrusion. This mineral frequently takes the unusual form of long needles which are arranged in parallel groups crossing one another at

[1] The Trap Dikes of the Lake Champlain District. U. S. Geol. Sur. Bul. 107. 1893. p. 447–48.

definite angles. The large dike near Slope 15 is a mica diabase containing abundant biotite in the place of augite which is the normal ferromagnesian mineral.

Geology of the ore bodies

The ore bodies as previously stated are closely associated with the augite gneiss, which is strongly developed throughout the district and belongs to the Saranac formation. So far as the relations can be observed in mine workings and outcrops, they appear to lie in immediate contact with the gneiss throughout most of their extent, the only exceptions being at the Williams and Dickson pits (and possibly the Parkhurst mine) where they are bordered for some distance by schist. The latter rock is limited to small bands included in the augite gneiss.

The bodies consist of parallel zones of the gneiss, in which magnetite forms a relatively large proportion of the mass. The zones possess a marked persistency along the strike and on the dip, which with their small lateral dimensions gives them a prevailing tabular shape. In structural arrangement they conform closely to the foliation of the gneiss. Their geologic horizon appears to be approximately a constant one, as they are alined in a general northeast-southwest direction, parallel to the main strike of the region.

The borders of the deposits are not sharply defined. Stringers and disseminations of magnetite extend into the gneiss for some distance, forming zones of lean ore on either side of the main bodies. This gradation is, however, a variable feature more evident in some places than others. The gneiss itself shows no noteworthy change as the ore bodies are approached.

In character the deposits possess much uniformity throughout their extent. The present main workings at Lyon Mountain are practically continuous along the strike for a distance of 4000 feet, with few variations noticeable in the occurrence or distribution of the ore. In this respect they are in contrast with most magnetite bodies which have been found to show frequent irregularities, specially in form, from place to place.

The ore is a mixture of magnetite and gangue minerals, the latter mostly feldspar (orthoclase, microperthite, microcline and oligoclase), augite, hornblende and quartz. The different constituents may be intermixed so as to show an even distribution, but more frequently perhaps they have a rudely parallel arrangement, that simulates the gneissoid structure of the wall rock. This is particularly noticeable on weathered outcrops where the narrow bands of magnetite stand out in relief like small veins. The magnetite occurs in granular particles, or irregular masses made up of many grains, with rarely any tendency toward crystal development. When specimens are examined under the microscope the particles are seen to occupy the interspaces, occurring on the borders of the other minerals or completely inclosing them, a relation which suggests that they have been the last to form. A few small crystals of magnetite having octahedral boundaries are generally observed in the slides and are doubtless of an earlier generation. In the average ore there are about equal proportions of magnetite and gangue minerals. Among the less important components of the ore may be mentioned apatite, titanite, zircon and pyrite; they constitute only a minute percentage of the mass as shown by the analyses. At the Williams pit, a black almost opaque garnet was found in the form of rounded grains mingled with magnetite, near the contact of the ore body and the schist of the hanging wall; this mineral has not been observed elsewhere.

Pegmatite is abundant in the ore bodies. The common variety has a reddish color and is composed of alkali feldspar, augite, quartz and magnetite, resembling the augite gneiss except for its coarser more massive texture. Occasionally it contains a sufficient quantity of magnetite to be considered an ore. Another variety of pegmatite is made up of deep red crystals of microcline with plagioclase, scapolite, augite, hornblende, epidote, quartz and magnetite. The epidote is partly an alteration product of the plagioclase feldspar which is probably oligoclase. The pegmatite occurs in bodies that rarely possess any regularity of outline like dikes, though this may be due to the squeezing and shearing it has undergone. Large interlocking masses of hornblende and augite anhedra occur in both varieties of pegmatite. During the course of mining operations vugs and cavities are frequently opened within the pegmatite masses and some have afforded remarkable groups of well crystallized minerals.

Distribution of the deposits

The ore bodies which have been mined on a commercial scale lie within a narrow belt extending northeast and southwest along the eastern edge of the valley. They have been proved by magnetic attraction and borings to constitute a nearly continuous series with a linear extent of some 5 miles. The several openings in the belt comprise mine 81 on the southern extremity, the main group of workings in the near vicinity of Lyon Mountain, and Parkhurst shaft which lies about 2 miles northeast of the latter.

Mine 81. This mine is a little over 2 miles in a direct line southwest of Lyon Mountain on the southern face of a prominent ridge which offshoots from Averill peak toward Upper Chateaugay lake. The deposit strikes n. 20° e. into the ridge. It is reported to have been traced by magnetic readings across the ridge toward Lyon Mountain and its strike brings it in line with the Phillips ore body west of the main group. It has been mined along its course for a distance of 1000 feet or more. At present the only accessible workings are two drifts near the surface, the shafts being dismantled and filled with water. The eastern drift which lies higher upon the ridge is approximately 600 feet long and from 25 to 75 feet high, and is open cut for some distance from the entrance at the south end. On the western section there are three shafts, with a drift from the central shaft extended in the direction of the first, but at a slightly lower level. Two of the shafts have been carried down to a depth of 400 feet and a series of levels was opened shortly before the mine was abandoned. The ore averages about 18 feet thick with only minor pinches and swells. It stands nearly vertical, inclining slightly to the east in some places and in other parts slightly to the west.

The adjoining gneiss is the augite variety, almost massive and carrying little quartz. Specimens from near the contact show abundance of titanite and some hornblende. There is little or no gradation along the walls; practically the entire width of the ore zone is occupied by the workings.

Several dikes are found in the eastern drift. They are all diabase. The smallest is about 3 inches and the largest about 3 feet wide. Their direction is northwest-southeast, except in one instance near the heading of the drift where a 2-foot dike occurs on the north side of the ore body running nearly parallel to it. According to local records, the mine was the first one to be explored in the Lyon Mountain district and was worked to some extent as early as 1840. No systematic mining was undertaken, however, until 1878 when the western drift was opened. The eastern drift was opened in 1880. The ore was hauled by wagon to the forges at Clayburg. According to Smock, mining was suspended about 1885; but operations were resumed a few years later and continued up to 1902, since which time the mine has been idle.

The ore does not differ in appearance from the general run of the mines at Lyon Mountain. It is a granular aggregate of magnetite, feldspar and augite. The feldspar is mostly oligoclase, with subordinate orthoclase. Incomplete analyses quoted by Putnam, No. 1 from a sample of 300 tons crude ore and No. 2 from 150 tons concentrates, show the following percentages:

	1	2
Iron	34.81	65.14
Titanic acid	nil	pres.
Phosphorus	.041	.017

The sulfur was not estimated. The percentage of phosphorus in both crude ore and concentrates is somewhat higher than the average obtained from present operations at Lyon Mountain, yet the concentrates are superior in this respect to most Bessemer ores. Determinations made on 33 samples of drill cores taken from different localities, reported by Mr H. H. Hindshaw, gave an average of 41.87 per cent iron and .025 per cent phosphorus.

Main group of mines. The ore deposits now under operation at Lyon Mountain comprise the middle section of the belt on the northwestern slopes of the high ridge. The mean elevation of the outcrop is about 2000 feet above sea level and 300 feet above the floor of the adjoining valley.

In the southern portion of the group three parallel series of deposits occur and are known locally as the front or main vein, the middle vein and the back or Dickson vein. The main vein which is the one most extensively worked has been proved by actual development to constitute a continuous ore body for a distance of about 2500 feet and its further continuity indicated by test pits and magnetic determinations for an additional 2000 feet. The back vein has been opened only on the southern portion; it outcrops parallel to the main vein at a horizontal distance of about 200 feet. The middle vein between the two is undeveloped and little is known about its extent. A plan of the surface and underground workings is shown in figure 18.

It is only in the extreme southwestern part of the group that any evidence of a marked structural break is found. For most of the distance the outcrop follows an almost straight line in a general direction n. 20° e. Near shaft 5, however, a rather sharp fold enters causing the outcrop to swing around to nearly west and this direction is followed for the remaining distance of 1000 feet in which the deposits have been mined. Beyond the Burden open cut which is the most westerly working on the southern wing of the fold the continuation of the ore has not been clearly estab-

In

Fig. 18 Plan of main workings, Lyon Mountain

The elevations indicated by contour lines are based on sea level. After a map by N. V. Hansell and H. H. Hindshaw

lished. The geologic relations are obscured by the heavy drift covering the lower slopes of the ridge and the valley floor. The results of magnetic surveys and diamond drill tests, so far as they can be interpreted, indicate the probable interruption of the deposits at a point not much distant from the Burden pit.

Another group of deposits has been shown to occur, though completely buried beneath drift, on a low ridge 2000 feet west of the main group and is known as the Phillips vein. Its northern extremity lies about 2000 feet northwest of the Burden while its trend is southwest toward the 81 ore body. It consists of two parallel veins which correspond quite closely with the front and back veins of the main group and like them have a northwesterly dip. Their position and similarity of relations suggest the possibility that they are a displaced portion of the main ore zone. The existence of a fault with a throw to the northwest would explain the sudden termination of the ore near the Burden pit and may be considered also not improbable owing to the severe dynamic strains to which the strata have been subjected, as manifested by the folding and by the minor flexures and shearing effects that are observable in the adjacent ore bodies and inclosing walls. The indicated throw of the fault is a little west of north, approximately parallel to the axis of the main fold.

Mining operations are confined at the present time to the southern section of the ore zone. In this part there are some 20 slopes or inclined shafts, besides open cast workings, located at intervals along the outcrop of the front and back veins. Beginning at the southwestern extremity, the first openings on the front vein are the Weston and Hammond, then follow in order Nos. 1, 2, Hall, 3, 4, and so on up to No. 16, which is near the old mill. On the back vein are the Burden, Cannon and Dickson pits.

Most of the ore is now obtained by underground mining in the Hall slope and the adjacent slopes 3, 4 and 5, and by open-cut workings at the Burden and Cannon pits. The deepest working is No. 4 which has been carried down to a depth of 1400 feet on the course of the deposit or about 800 feet vertically. The Hall and No. 3 slopes have reached nearly equal depth. The dip of the ore bodies in this section is about 45° north at the surface but gradually flattens downward to 25° or less.

At the Burden and Cannon open cuts the width of the back vein is fully 150 feet measured along the surface. In the bottom of the Hall slope the horizontal drifts are 200 feet wide. Such thicknesses are unusual, however, and in the former instance may be ascribed to a local bulge that has probably resulted from the folding. The large ore body found in the Hall slope very likely represents the combined front, middle and back veins which have converged in depth. The walls are not well defined in this part, as the ore grades along the contact into the country rock. Between slopes 5 and 16 the main or front vein averages about 20 feet across the dip and is quite regular. The dip ranges from 45° to 60° n. w., being steeper at the north. The main workings here are slopes 7, 8, 12 and 14. A section across the ore bodies on line of the Hall slope is given herewith [fig. 19].

The Williams or 82 mine lies 2000 feet northeast of slope 16 on the prolongation of the same zone. It has not been operated for many years. The workings comprise a shaft 180 feet deep and an open cut extending north of the shaft for a distance of 200 feet. The geologic relations here differ from those in the southern part in that the wall rock is an amphibole schist. The deposit consists of stringers and impregnations of magnetite in the schist, with bands of lighter augite gneiss intercalated parallel to the foliation. The ore varies in richness across the outcrop. The dip of the strata is 80° northwest at the surface, but is said to incline away from the vertical gradually with depth.

Drill tests. Mention may be made of the diamond drill borings which have been put down to explore the ore bodies and which show their approximate position outside the limits of present workings. A drill hole located on the west side of West Mine street, 1200 feet from the entrance to the Hall slope and in line with its direction, found the ore at 663 feet depth with a thickness of 100 feet. The indicated average dip of the ore body from the outcrop to the point intersected by the hole is thus about 45.°

At a locality on the continuation of the same line but 800 feet farther north, the ore was encountered at 1031 feet and showed a thickness of 74 feet. The dip flattens considerably between the two holes, averaging only 22° for the interval.

On line with slope 15 and 600 feet distant from the shaft a drill hole found the ore at 986 feet with a thickness of 80 feet. The indicated dip is about 60°. A second body of lean ore 20 feet thick was found below the first separated from it by 15 feet of rock.

A negative result was obtained by drilling 700 feet northwest of the Weston pit. The hole was put down 1859 feet but failed to find ore. The position of the hole is somewhat west of a line drawn from the Burden pit, which approximately marks the southwestern limits of the main zone as present known, to the

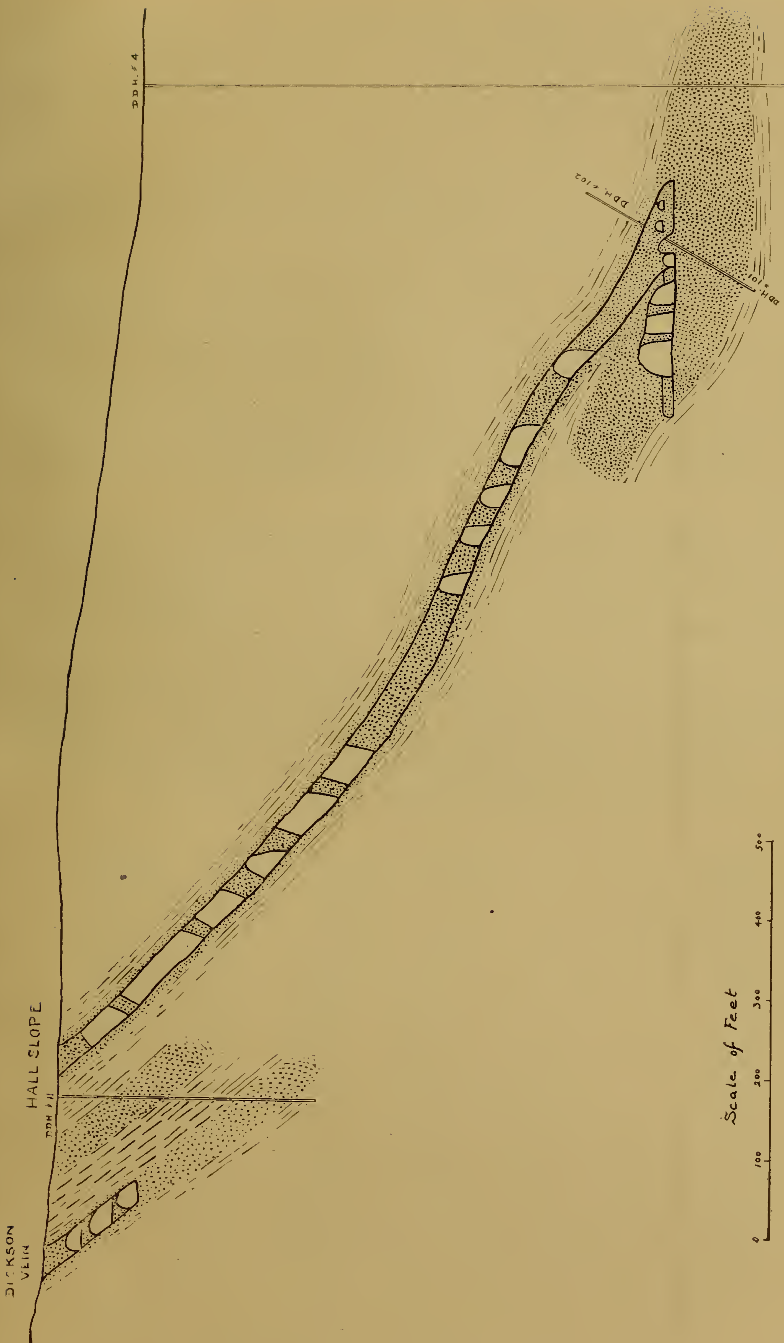


Fig. 19 Lyon Mountain. Vertical section across the ore bodies on line of the Hall slope

indicated northern extremity of the Phillips vein. If the presence of a fault is assumed to account for the relations of the latter to the main zone, the line would coincide with the probable direction of displacement so that the drill hole actually may be considerably above the horizon of the ore bodies.

The Phillips vein has been tested by two drill holes. Two parallel bodies of ore have been found with a thickness of 50 feet. The dip is 80° northwest.

Chemical analyses. There is a wide range in the mineral composition of the ore and consequently in the chemical composition. Some portions of the deposits have only small amounts of admixed gangue minerals so that the iron content may run as high as 50 per cent or even more. The quantity of such ore mined, however, is not large when compared with the total output. On an average the iron runs between the approximate limits of 30 and 35 per cent.

The analyses below furnish the essential details as to the chemical composition of the crude ore and of the concentrates made by magnetic separation as now practised. No. 1 represents a sample of relatively rich ore, such as was formerly shipped without concentration. No. 2 is an average of concentrating ore, and Nos. 3 and 4 of concentrates. For analyses Nos. 2 and 3 the writer is indebted to Mr James Brakes, chemist at the mines. Analysis No. 1 is quoted from an article by James M. Swank published in the volume of the "Mineral Resources" for 1883 and 1884.

	1	2	3	4
Fe_2O_3	47.38	31.48	60.128	63.062
FeO	21.32	15.81	28.850	28.996
FeO (gangue)	......	2.83	.257	......
SiO_2	20.89	33.16	6.880	4.740
TiO_2	......	.427	.417	......
S	.084	.027	.022	.031
P_2O_5	.057	.043	.023	.012
Al_2O_3	4.02	4.90	.900	.339
MnO	.21	.115	.107	.134
CaO	3.72	4.96	.660	.740
MgO	2.11	2.10	.405	.434
K_2O	......	1.438	.494	......
Na_2O	......	2.283	.777	......
H_2O	......	.25	.040	......
	99.791	99.823	99.960	98.488

Iron	49.750	36.50	64.72	66.695
Phosphorus	.025	.019	.010	.005
Manganese	.162	.089	.083	.104
Titanium	......	.256	.250	......

The small quantity of titanium shown in analyses Nos. 2 and 3 is interesting, though metallurgically negligible. It seems to be carried by the mineral titanite which is intergrown with the magnetite. The phosphorus averages about .008 in the concentrates now made.

In the report by Putnam are given the following incomplete analyses of furnace ore and concentrates. The latter were prepared by jigging, a system of concentration formerly employed at the mines. The sample of furnace ore (1) was an average of 22 carloads; that of concentrates (2) an average of 120 tons.

	1	2
Iron	45.21	66.00
Titanium	nil	pres.
Phosphorus	.011	.003

The character of the gangue material, which in a way may be regarded as closely allied to the country gneiss, is shown by the subjoined analysis of tailings from magnetic treatment. The analysis has been supplied by Mr Brakes.

SiO_2	58.56
Al_2O_3	10.72
Fe_2O_3	4.57
FeO	8.36
MgO	4.06
CaO	8.24
Na_2O	2.99
K_2O	1.61
H_2O	.12
TiO_2	.457
P_2O_5	.064
MnO	.124
S	.035
	99.910

It is apparent that the percentage of free silica in the form of quartz must be small. The relative proportions of the chemical constituents agree quite closely with those found in many syenites.

Parkhurst mine. This mine has been opened on the northeastern part of the ore belt. The shaft is about 2 miles from Lyon Mountain station. Within a short distance north of the Williams mine the outcrop of the deposits passes beneath drift and is nowhere exposed over the northern section. There is no interruption in the lines of magnetic attraction, however, so that it seems safe to assume that the ore continues unbroken in the interval which is something over a mile.

The shaft has been put down on the slope of a small hill at a point a few hundred feet east of the railroad and perhaps a hundred feet above it. The shaft was located with a view to striking ore near the outcrop, the line of which had been previously approximated by magnetic determinations. The first work on the shaft was done over 20 years ago. After passing through 70 feet of drift, rock was encountered and sinking was discontinued for a time. Later on a drill hole which had been put down in the bottom of the shaft showed ore at a depth of 145 feet from the surface with an apparent thickness of 48 feet and an average iron content of 40.41 per cent. The shaft was then sunk to the ore and mining begun. In the period of operations from 1889 to 1892 inclusive the output according to company records amounted to about 40,000 tons, of which 37,500 tons was classed as furnace ore and was smelted without concentration in the furnace at Standish.

The shaft is now partially filled with water, preventing access to the underground workings. The character of the rock dumps about the shaft indicate that the walls are made up of a schist similar to that at the Williams mine. There is much pegmatite in both ore and country rock and the existence of one or more diabase dikes is inferred.

The magnetite has a granular texture, coarser than the average of the ore found in the workings farther south, and is intermixed with a gangue consisting mainly of quartz and feldspar. It contains apatite in crystals and grains of macroscopic size, indicating a fairly high phosphorus content. According to analyses that were made during the period of operations, the ore shipped to the Standish furnace averaged 49.73 per cent iron and about .1 per cent phosphorus. The following two analyses furnish additional particulars as to the character of the ore.

Plate 12

The new mill at Lyon Mountain

	1	2
Fe_2O_3	42.157	56.559
FeO	23.096	23.313
SiO_2	23.340	13.700
S	.038	tr.
P_2O_5	.433	.205
Al_2O_3	4.791	1.900
MnO	.129	....
CaO	4.700	4.390
MgO	1.643	....
	100.327	100.067
Iron	47.374	55.779
Phosphorus	.189	.095
Manganese	.100	....

From samples collected recently from the mine dump, the following percentages were obtained, No. 1 being a sample of the rich ore and No. 2 of leaner material:

	1	2
Iron	56.10	34.20
Silica	13.85	34.08
Titanic oxid	nil	.20
Sulfur	.015	.033
Phosphorus	.156	.031
Manganese	.05	.04

Aside from its richer character, the principal feature of the ore from this mine, as compared with that from the other workings of the district, is the relatively high phosphorus which as will be observed exceeds the maximum admissible in Bessemer ores. It is largely for this reason that the present company has not continued exploitation of the ore body.

A magnetic survey of the ground about Parkhurst shaft carried out in 1906 affords strong evidence for the regularity and continuity of the deposit for a distance of at least ½ mile to the northeast of the old workings, while to the southwest the lines of attraction continue without break to the Williams mine and the main group. There is reason for believing also that the deposit here is above the average in thickness. This is indicated by the results obtained in the shaft itself, and is further supported by the record of a drill hole put down about a half mile to the southwest. The hole referred to is located in a swampy tract 200 feet northwest of the apparent outcrop. It is bottomed at 469 feet. Ore was cut at 185 feet from the surface with a thickness of 167 feet. As the hole is vertical allowance must be made for the dip of the ore body which is not accurately known though it is supposed to be about 40° n. w.

Production of the Lyon Mountain district. The output of the district since the beginning of active work in 1871 may be placed approximately at 3,500,000 long tons. This estimate is based on incomplete records, but it is believed to be not far from the actual total. In the period from 1881 to 1889 inclusive the shipments amounted to 1,539,520 long tons. There are no statistics on record for the period from 1890 to 1900, but in the six years following 1900 the shipments have aggregated 606,573 tons. During the early years the output included a proportion, varying from year to year, of selected ore which was shipped in its crude state and which carried from 45 to 50 per cent iron. This practice was discontinued later on, and the more recent shipments have consisted solely of concentrates, assaying from 60 to 66 per cent iron.

MINES IN THE SARANAC VALLEY

In the towns of Saranac, Black Brook and Dannemora, along the Saranac valley, there are old mines that were once operated in connection with local iron works. During the middle of the last century when the bloomery process of making iron was generally used this section supported one of the largest industries of this kind anywhere in the State, its importance having been due to the great timber tracts which afforded a plentiful supply of charcoal for fuel and to the abundant water power on the Saranac river, one of the principal Adirondack streams. Forges were built along the river at Clayburg, Redford, Russia and Saranac. The ore was drawn not only from the local deposits but from Lyon Mountain and other points many miles distant. The industry was discontinued about 1880 and brought about a cessation of mining in the region, though one or two deposits were worked some time after that date.

Geologic features. The gneiss series is most extensive. In it are represented varieties more or less distinct in their mineralogy and appearance, but of which the augite gneiss described as the ore-bearing formation at Lyon Mountain and the granitic gneisses have the largest areal development. They are characteristic members of Cushing's Saranac formation, indeed the latter takes its name from their extensive occurrence along the Saranac river in this section.

In his report "Geology of Clinton County," Cushing describes as belonging to a separate type, a silicious gneiss, resembling quartzite in appearance, but composed of microcline and quartz, with garnet and a mineral that corresponds optically to sillimanite. It occurs along Trout brook which enters the Saranac at Russia. From its composition he is inclined to consider the rock a sedimentary derivative and he further suggests that there may be a belt of related gneisses and crystalline limestone within the drift-covered valley. The exposures are insufficient to establish the extent of the sedimentary or Grenville rocks, but it is probable that such a belt exists. Further evidence confirming this view was found by the writer near Clayburg where a biotite schist is exposed along the west bank of the Saranac river. The schist has been injected by granitic materials, though its characters are plainly those of the Grenville series, shown by its crumbling well foliated texture, pyritic inclusions and variation of composition across the strike.

Small areas of gabbro are found at two localities in the district. The largest exposure is just north of Clayburg and is about 50 yards wide; the second outcrop is west of Russia on True brook. They occur as dike intrusions in the Saranac gneisses.

Diabase dikes are numerous. Cushing has listed 26 within the townships of Saranac and Black Brook and several more occur in the mines that have not been recorded. They are the latest of the recognizable igneous rocks.

Of the sedimentary rocks the Potsdam sandstone composes a part of the surface geology of the district, occupying a large area in Saranac township east of the river. It is not exposed anywhere in the vicinity of the ore bodies.

Averill mine. Near Dannemora village are the Averill, Ellis, Fairbanks and Dannemora mines, all of small size. They lie on the slopes of the high ridge which forms the north side of the Saranac valley and of which Dannemora mountain marks the culmination in this part.

The Averill mine is the largest of the group. The ore body is first encountered a few hundred feet southwest of the State Prison and can be traced in a northerly direction for 1000 feet. It is inclosed in a basic hornblende-biotite gneiss, the ore itself consisting of streaks and bands of magnetite alternating with the materials of the wall rock. The latter is cut by reddish granite of which there is a large exposure on the hill back of the prison that has furnished much of the building material for local use. The granite consists of microperthite and quartz and is rich in magnetite, resembling the type found on Birch hill near Lyon Mountain. The deposit is inclined 10° to the west and has been worked to a depth of about 100 feet. The main openings are on the southern portion, where there is an open pit 300 feet long and 10 to 30 feet wide. Several hundred feet north of the pit a shaft was sunk in the hanging wall, with the intention of mining the deposit, but the shaft was abandoned after reaching a depth of 100 feet. A drill hole put down near the shaft is said to have found ore at 150 feet from the surface. The ore is mostly of lean character, with an average probably of not more than 35 per cent iron. The mine was opened in 1842. For several years it was worked by the State, but was abandoned with the discovery of the Dannemora mine which is located within the prison grounds. The latter mine is no longer accessible.

Ellis mine. This is situated 2½ miles northwest of Dannemora. It is based upon an ore body from 8 to 10 feet wide consisting of disseminated magnetite in reddish granitic gneiss. The strike is about north and south and the dip 15° west. The pit has a length of 50 feet; it is filled with water so that the extent of the underground workings can not be ascertained. Judging from the small amount of rock on the dump, the mine was not very productive.

Fairbanks mine. The Fairbanks mine is about 2 miles west of Dannemora. It was opened nearly 50 years ago and worked for only a brief period. The ore is from 3 to 5 feet thick.

Bowen & Signor mine. This is located on a belt of deposits which show a nearly continuous line of magnetic attraction extending several miles along the Saranac river in the towns of Black Brook and Saranac. The outcrops are concealed for most of the distance by drift and river sands, but the horizon of the ore has been approximately fixed by magnetic measurements. These show a line of maximum attraction which begins 1 mile east of Redford and runs in a broad curve southwest at first to Clayburg and thence westerly and northerly to a point on Cold brook about 1½ miles north of its junction with the Saranac. The principal lines of magnetic attraction are indicated on the accompanying sketch map [fig. 20].

The Bowen & Signor mine lies 1 mile south of Redford on a drift-covered ridge that rises from the south bank of the Saranac. There are some 6 or 8 pits and shafts, now dismantled and filled by caving of surface materials. At the date of Putnam's report the ore had

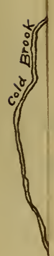

Cold Brook

Fig. 20 Mines near Redford and Clayburg and lines of magnetic attraction. After a map compiled by the Saranac Iron Mining Company

been mined for 1600 feet on the first level 100 feet below the surface, while a second level 75 feet below the first had been opened on the west end. The width of the deposit according to the same authority averaged 20 feet, thickening to 30 feet in places. In 1905 the deposit was tested by diamond drilling, the results of which have shown that it is irregular and pinches in places to a thin seam. Of the 12 holes put down along the strike, ore was found in all but three and the maximum thickness was 22 feet which was encountered near the central part of the old workings. On the western end, the body apparently is broken up into several parallel bands. The dip estimated from the data obtained in the drill holes ranges from 45° to 65° east, being steepest on the west. Several diabase dikes intersect the ore body and are said to mark lines of faulting.

The wall rock, judging from specimens collected along the surface, is not the usual reddish granitic variety exposed in the district. It has a light gray color and is made up almost entirely of plagioclase, quartz and magnetite. The plagioclase belongs to the basic end of the series, corresponding optically to labradorite. The composition can scarcely be identified with any common type of igneous rocks, but rather suggests a metamorphosed sediment.

The ore is a mixture of magnetite with hornblende, quartz and pegmatite, the percentage of iron ranging within rather wide limits. The following analyses of crude ore (1) and concentrates (2) are given by Putnam as the results obtained from average samples:

	1	2
Iron	34.28	66.78
Titanium	nil	nil
Phosphorus	.124	.037

From two to three tons of crude ore were required to make one ton of concentrates by the methods of hydraulic separation formerly used.

The output of the mine from its opening in 1855 is reported by Smock at 260,000 tons; though not specifically mentioned the quantity probably represents crude ore.

Clayburg mine. Near the site of the old forges at Clayburg are two pits, the openings of which face toward the Saranac river. The larger pit, on the west bank and somewhat south of the smaller one located on the east side of the river, is several hundred feet long and some 50 feet deep. It is partly an underground drift. The strike is nearly east and west and the dip almost vertical inclining a few degrees toward the north. So far as can be estimated from the surface the breast of ore must have averaged about 15 feet. The walls in both pits consist of microperthitic gneiss of granitic character with the high percentage of magnetite nearly always present in this rock. No analyses of the ore have been obtainable; the general average is probably about that given for the Bowen & Signor deposit.

Tremblay mine. This deposit is situated in the town of Saranac 2 miles west of Clayburg. The workings which consist of one or more pits are now filled with water so that neither the deposit nor the walls can be seen. Putnam has recorded that in 1880 the main pit was from 150 to 200 feet long and 75 feet deep. Little work was done after that date. The analyses of ore (1) and concentrates (2) are quoted from his report.

	1	2
Iron	28.62	65.01
Phosphorus	.017	.004

ST LAWRENCE COUNTY MINES

On the west side of the Adirondacks, St Lawrence county contains the only deposits of nontitaniferous magnetites that have been extensively mined. The principal workings are at Jayville, Benson Mines, Fine and Clifton in the southeastern part, near the headwaters of the Grasse and Oswegatchie rivers. They are reached most readily by the Carthage & Adirondack Railroad, which affords direct communication with Lake Ontario at Sacketts Harbor and crosses the main railway lines at Watertown and Carthage. The accompanying sketch map [fig. 21] gives the location of the larger deposits.

The deposits were discovered many years ago. Some of them are mentioned by Emmons who did not, however, consider them as available resources at the time owing to their remote situation. On that account they received little attention from the early iron manufacturers of St Lawrence county. Most of the ore used in the old furnaces came from the hematite deposits around Gouverneur and Antwerp. The region about the mines is largely wilderness with few beaten routes of travel.

General geology

The Adirondacks fall by gradual stages toward the St Lawrence plain. The surface in this section has a mean elevation of from

1000 to 1500 feet increasing to the southeast in the direction of the interior uplifts. Though the contours are generally rugged, due to succeeding lines of ridges, there are few notable prominences and the hills rise scarcely more than 500 feet above the valley bottoms.

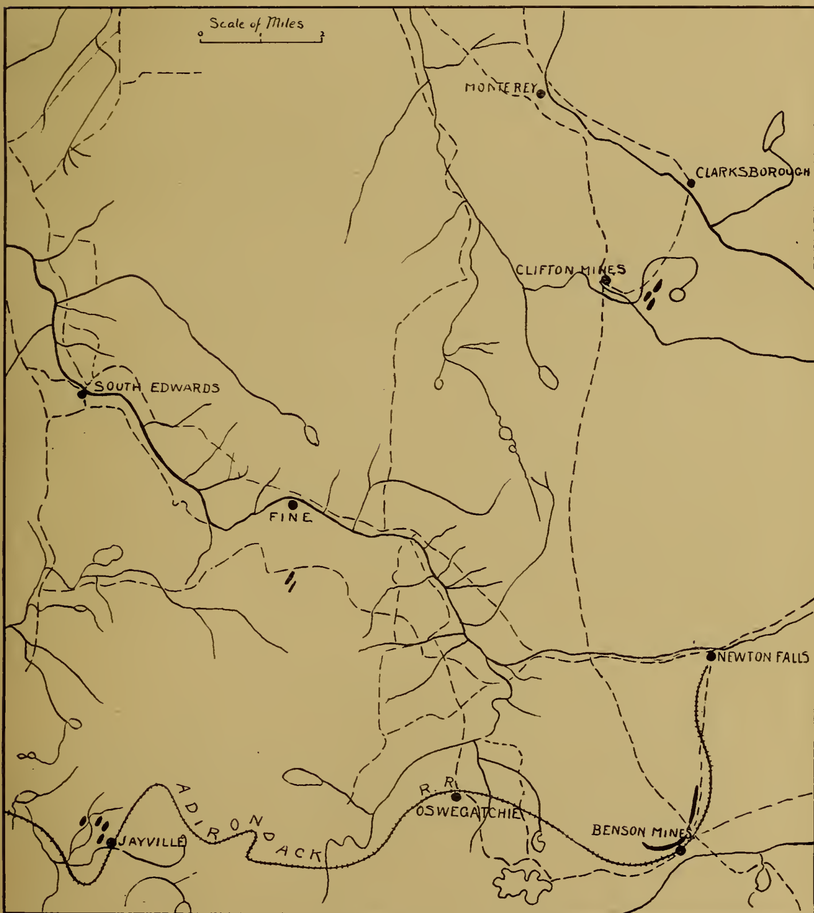


Fig. 21 Sketch map of the St Lawrence county magnetite deposits. Ore bodies shown by heavy lines

The geology of this part of the Adirondacks has been investigated only in its broad features. No maps adequate for a detailed survey are available, and until they are forthcoming a systematic investigation must necessarily be postponed. It is to the reconnaissance carried out during recent years by C. H. Smyth jr, that we owe most of our knowledge concerning the subject.[1] Professor Smyth has worked mainly in the outlying sections, including central and western St Lawrence county and eastern Lewis and Jefferson counties, but the salient facts of structure and stratigraphy he has brought to light apply as well to the region under discussion.

The rocks which have widespread development comprise crystalline limestones, schists, gneisses and a series of intrusives ranging from granite to basic varieties represented by the gabbros. They are lithologically analogous to the prevailing rock types that are described in connection with the mining districts of Clinton and Essex counties and in some cases no doubt can be correlated as parts of the same geologic formations, though it is not to be inferred that they are strictly equivalent as to time. All are older than the most ancient of the fossiliferous strata in the region, the Potsdam sandstone, and underlie the latter unconformably.

The Grenville limestones and their associated schists (called the Oswegatchie series by Professor Smyth) are relatively less important in the interior than in the western part of St Lawrence county. A belt of these rocks traverses the town of Pitcairn and extends across the line into Jefferson county, with a length of 15 miles from northeast to southwest. There are good exposures of the limestone at Harrisville and on the east side of Bonaparte lake, in the middle portion of the belt. This is the most easterly of the larger areas, as elsewhere in the interior the rocks occur in isolated patches of no great size. The limestone is always thoroughly crystalline; the schists belong to the hornblendic, micaceous, pyroxenic or quartzose types so characteristic of the Grenville series throughout the Adirondacks.

Among the gneisses which occupy most of the area in the vicinity of the mines, there is great variety. Some are closely related to the igneous rocks and have been demonstrated to be in part simply gneissoid phases of the latter. On the south side of the limestone belt referred to above, syenitic gneiss grading into massive syenite is exposed in force underlying an area estimated at 75 square miles. It is clearly igneous and later than the limestone. In association with it occurs a more acid hornblende gneiss which seems to belong to the same intrusive mass, since there is a gradual transition across the contact. On the north side of the limestone belt,

[1] For the results of Professor Smyth's work, consult the annual reports of the New York State Museum for 1893, 1895, 1897, 1898 and 1899.

north and east of Harrisville, recognizable gabbro outcrops have been found. These rocks, it may be noted, are comparatively rare, in contrast with their wide distribution elsewhere in the Adirondacks.

A prominent member of the gneiss series is a coarse reddish hornblende rock which has the composition of granite. It is abundant in the region east of Harrisville, particularly between Benson Mines and Cranberry lake and the section northward. Its affinities are with the igneous rocks, as indicated by field evidence in places, though further investigation is needed to prove that the gneiss is of uniform character and derivation.

Certain representatives of the gneisses are undoubted metamorphosed sediments, yet contain no included bands of limestone. Their sedimentary origin is traced by their mineralogical and textural peculiarities. They have a variable composition, light colored quartzose varieties alternating across the strike with dark varieties in which there is a considerable proportion of hornblende, mica or pyroxene. Garnet is a frequent constituent and pyrite is seldom wanting. Sillimanite also appears, but rarely in crystals sufficiently large to be distinguished without the aid of the microscope. The constituents have a granular habit, without the definite arrangement or texture which obtains in igneous rocks. These gneisses are to be classed as members of the Grenville series. They are very much like the hornblende and mica gneisses that occur over large areas in the eastern Adirondacks and which have been assigned to the base of the Grenville.

Description of mines

Benson mines. The deposits are in the town of Clifton, on the north side of Little river. Benson Mines is a hamlet and a railroad station, 43 miles east of Carthage. The valley lies at an elevation of about 1600 feet, while the limiting ridges are somewhat more than 2000 feet.

In his report on the Second District,[1] Emmons mentions the occurrence of magnetite bodies on the Oswegatchie river near the crossing of the former highway known as the Albany road. From the accompanying description it is evident that the present Benson mines are referred to; and the stream now known as Little river was probably designated on the old maps as the Oswegatchie of which it is a tributary. Emmons states that a considerable quan-

[1] Survey of the Second Geological District. 1842. p. 347.

tity of ore had been taken from the locality and transported to Canton for reduction.

Systematic mining was not started until the extension of the railroad into the region in 1889. A mill was then erected on the property for the purpose of concentrating the ore into a commercial material, and was run until 1893 when, owing to a depression in the iron trade, the operations became unprofitable. Mining was again resumed in 1900, but only for a short period.

The total production subsequent to 1889 has been estimated at 370,000 tons crude ore, or 150,000 tons mill concentrates of above 60 per cent iron. The mines were developed and worked by the Magnetic Iron Ore Co., who have recently been succeeded by the Benson Mines Co. Mining operations were resumed in the fall of 1907.

Geology and occurrence of ore. In their general nature the deposits are much like those at Lyon Mountain. They consist of bands of gneiss charged with magnetite which is mainly disseminated more or less evenly through the rock mass. The bands are directed by the prevailing foliation so as to conform to it in strike and also probably in dip. A series of these parallel and coalescing bands constitutes the ore belt in which the mines have been opened.

The country gneiss has the appearance of a metamorphosed sediment and the writer feels little hesitation in placing it in the Grenville formation, though the absence of any limestone restricts the evidence bearing upon its origin to lithologic considerations. Observed in the field it exhibits no constancy of character from place to place. It is variously a hornblende, biotite or pyroxene gneiss and again may be destitute of dark minerals except magnetite. The different types occur as interpositions rapidly changing from one to another across the dip. The foliation, which is not particularly well developed, seems to follow consistently the division planes between them. Pyritic impregnations lend a rusty stain to the surface in places. In the composition of the gneiss, feldspar, quartz and the ferromagnesian minerals above mentioned partake most largely. The feldspar is orthoclase with subordinate oligoclase and microcline. Scapolite, sillimanite, zircon, apatite and garnet are among the less common constituents.

The principal ore belt lies near the base of a ridge which rises north of the railroad. The ridge has a northeasterly trend with a gradual slope in the lower part where it falls away toward the river. At the locality of the open pits by the mill, the surface is only from 50 to 100 feet above the river and it continues practically at the same level for a distance of 500 feet or so to the north.

The strike of the ore is here about n. 60° e. West of the pits the deposit follows that course nearly in a straight line for a distance of 1000 feet; it then turns quite abruptly toward the northwest, at nearly right angles to its former direction, and ascends the ridge. It apparently dies out or disappears in a swampy tract about a mile west of the railroad station. The outcrop is concealed over considerable intervals, but the magnetic determinations serve to fix its course with reasonable accuracy. North of the pit the continuation of the ore can be traced across the highway and brook. There is some uncertainty as to the further extent of the deposit owing to the heavy covering of drift, though the magnetic surveys indicate that it wedges out or grades into the country rock within a few hundred feet north of the brook. The strike in this part is nearly due north.

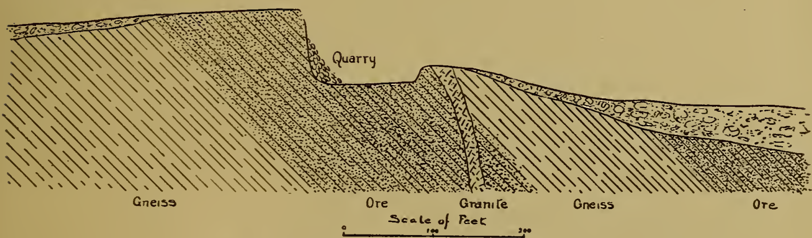


Fig. 22 Benson Mines. Section across the ore bodies, near middle of quarry

Observations of the dip of the ore and inclosing strata show a monoclinal arrangement for the central and northern parts of the ore belt. The gneiss on top of the ridge lies nearly flat. Passing across the strike to the southeast the dip increases gradually until at the pits it is about 45° southeast. This inclination is maintained with little variation for 1000 feet along the outcrop of the ore to the southwest. At the bend or fold in the deposit where it swings toward the northwest, the dip is 60° southeast. Beyond the bend there is a flattening of the dip, and over the remaining distance in which the ore can be traced the outcrops show the strata lying nearly horizontal or slightly inclined to the northwest. The change in the dip takes place within an interval of 100 feet and would seem to indicate a structural break, though there has been no discernible displacement of the ore by faulting.

Besides the deposit described, there are indications of another belt of ore to the north of Benson Mines that has never been explored or developed. The belt lies to the east of the first and higher up in the gneiss. It begins on the south, according to magnetic readings, nearly opposite the north end of the pits and on line with the railroad. It extends in a northerly course toward Newton Falls in which direction it has been traced for nearly 2 miles. There is little evidence to be obtained from outcrops, the drift being heavy, so that the size and character of the deposit are practically unknown. The magnetic attractions are reported to be fully as strong and continuous as those recorded over the belt that has been mined. The cross-section, herewith, is intended to show the relation of the deposits [fig. 22].

Description of workings. In the open pit, which represents the result of the former productive operations, the deposit has been quarried from the south or hanging side back into the ridge for a horizontal distance of 150 feet. The working face, at first but a few feet above the floor, increases across the dip and is now 50 feet high on the average. The bounds of the deposit have not been reached either on the hanging or foot-wall side. An additional width of fully 50 feet can be gained on the foot-wall, where the ore has been uncovered by stripping of the soil and glacial materials and it is not improbable that the workings may be carried still farther west before reaching the limit of pay ore. The width of the ore, it may be noted, is determined only by arbitrary standards of what can be mined and treated at a profit. There is every gradation between the country rock and the ore, so far as relates to the proportion of magnetite present. Along its course the deposit has been worked for a distance of nearly 1200 feet, the length of the pit from east to west. At the west end there is a face from 15 to 40 feet high in which the ore appears to be of average grade. Its continuation in this direction is assured for several hundred feet by the outcrops and the test pits excavated through the light overburden of glacial material. At a point 1000 feet west of the workings, a ledge is exposed for 100 feet which is reported to average about 40 per cent iron. On the east end the deposit runs out into the valley and has not been uncovered.

The exploration of the deposit in depth, below the level of the open pit, has been limited to a few borings that were made several years ago. Four of these borings are on record, of which the deepest is 180 feet vertically from the outcrop. It encountered ore all the way with a range of from 32 to 44 per cent iron, as shown by assay of 10 samples taken at succeeding intervals. The holes are said to

Plate 13

Benson mines. Open pit with face of ore

have been put down somewhere in the vicinity of the pit, though their exact location is not now known.

Within the limits of the exposures the ore exhibits much uniformity. This feature is naturally of prime importance to the economic working of a low grade body such as the present one. Occasional stringers of pegmatite and a fine reddish granite are encountered which carry little magnetite, but they have not proved a serious obstacle to exploitation. In the previous working, the deposit was quarried without leaving any waste and the entire output was sent to the mill.

The deposit has apparently undergone little disturbance in the way of faulting. A slip seems to have taken place near the hanging wall at the pit entrance parallel to the strike of the ore body, but it is probably slight, as there is ore showing on both sides with no marked brecciation. A thin dike has been intruded along the fault fissure. The ore next to the fault has been partially altered to martite.

Character of the ore. The minerals accompanying the magnetite are quartz, feldspar, garnet, biotite, pyrite and apatite. Quartz and feldspar constitute the matrix for the most part, while the magnetite functions as a binding material. The feldspar is mainly the orthoclase variety. The pyrite and garnet are intimately associated with the magnetite, the former occurring as small included grains and the latter as rims on the borders of the magnetite particles. From the manner in which the magnetite and pyrite are intergrown, it is evident that they have been deposited at the same time. The garnet, however, is a later crystallization formed by a reaction between the magnetite and the feldspar in which the chemical constituents of both have been combined. It is a red garnet and responds strongly to tests for manganese. As a rule the ore is rather fine grained, though coarser in this respect than the country gneiss. Like the latter it shows a gneissoid texture. Occasionally the magnetite is segregated in thin bands interleaved with the silicates.

The following analyses give details as to the chemical composition of the ore. No. 1 is the result obtained from a sample of the ore exposed in the present workings, the sample being made up of numerous specimens selected so as to give an average for the entire face of the quarry. The sample was gathered and analyzed by E. Touceda. No. 2 represents a sample of concentrates, an average of 132 cars; and No. 3 a sample of concentrates recently taken from a small lot in the storage bin at the mines.

	1	2	3
Fe_3O_4	49.43	88.08	85.94
$Fe\,S_2$	1.61	.864	......
SiO_2	33.32	5.97	5.91
TiO_2	1.07	......	1.06
P_2O_5	.43	.086	.11
Al_2O_3	6.92	2.26	3.63
MnO	.32	2.04	.43
CaO	1.42	.28	.68
MgO	.91	.18	.08
K_2O	2.77	......	.87
Na_2O	.58	......	
CO_2	.68	......	.42
H_2O	.35	......	.42
	99.81	99.76	99.55
Iron	36.56	64.18	62.24
Phosphorus	.186	.037	.048
Sulfur	.86	.461	.37
Manganese	.246	.158	.33
Titanium	.64	......	.64

It will be observed that the ore in its crude state is not of Bessemer grade. The concentration, however, eliminates sufficient phosphorus so that the product can be used for Bessemer pig. As a result of the milling operations it was found that the quantity of phosphorus passing into the concentrates could be regulated to some extent by the crushing. With fine crushing the apatite which carries the phosphorus is mostly released and under the magnetic treatment goes into the tailings.

Of the shipments made in the first period of operations, a large part averaged over 60 per cent iron with less than .03 phosphorus. The coarser concentrates carried as high as .47 per cent phosphorus. In the last campaign in 1900 and 1901, the product of some 70,000 tons averaged from 63 to 64 per cent iron, about .037 per cent phosphorus and .46 per cent sulfur. The concentrates were used by Pennsylvania furnaces for Bessemer and foundry irons.

The following analysis is of interest as showing the chemical constituents of the gangue, which may be considered closely analogous in all respects to the country rock. It was made from a sample of mill tailings produced during the regular course of operations.

SiO_2	67.18
Al_2O_3	17.97
Fe_2O_3	1.02
FeO	6.13
CaO	1.84
MgO	1.50
Na_2O	.44
K_2O	1.12
P_2O_5	.36
MnO	.30
S	2.06
	99.92

Jayville mines. Jayville is 14 miles west of Benson Mines and 29 miles by rail from Carthage. With the cessation of mining in 1888 the buildings and machinery were removed and the place has since been practically abandoned, leaving only the waste heaps and pits as witness to the former activity. The mines were last operated by the Magnetic Iron Ore Co., who instituted extensive developments in 1886. The existence of the larger deposits at Benson Mines soon led the company, however, to give up the undertaking in favor of that locality. The mines are credited by Smock with an output of 25,000 tons during the last period of operation.

The ore occurrence presents a phase quite dissimilar from that at Benson Mines and more like the magnetite deposits on the east side of the Adirondacks. There are innumerable shoots, lenses and irregular bunches in which the magnetite is found showing sharp boundaries in contact with the wall rock. The latter is for the most part a hornblende-biotite gneiss of sedimentary appearance. The horizon of the ore lies close to the contact of the gneiss with a red pegmatitic hornblende granite. Outcrops of the granite occur to the north and east within short distances where they break through and cut off the gneiss area in such a way that their intrusive character is plainly evidenced. In some of the openings the granite can be seen in immediate contact with the ore.

The openings are on the northeastern and northwestern slopes of a low ridge of the gneiss that rises just west of the railroad. The pits nearest the station are Hart no. 1 and no. 2, of which the first is said to be 300 feet deep following a shoot 20 feet wide and 10 feet thick. Hart no. 2 is much shallower. At the northeastern end of the ridge where it curves to the west are the pits called New

York no. 1 and no. 2, both of inconsiderable depth. Benson no. 1 farther to the west is reported by Smock to have a depth of 350 feet on the incline; of its two levels the upper is about 25 feet long and the lower driven at a point 60 feet from the bottom of the slope runs off in a southerly direction for 160 feet and then north 60 feet. This pit supplied most of the shipping ore. Between Benson no. 1 and no. 2 an adit has been excavated into the hill on a lead which in the interior develops into a lens some 60 or 70 feet long and 20 feet wide. The Fuller and Essler pits are located at the extreme west, the former being opened on a pod of ore 50 feet wide, dipping 45° west.

The distribution of the ore in disconnected bodies which pitch and strike in all directions has probably resulted from the intrusion of the granite. The bodies occupy approximately the same horizon and have the aspect of an originally continuous band which has been disrupted and faulted. The intrusion has exercised also a metamorphic influence upon the deposits shown by the abundance of garnet and hornblende that often replace the magnetite almost completely. Well developed titanite crystals of unusual size are found in the contact zone.

The analysis below taken from Putnam's report, gives the composition of the Jayville ore. It was made from a sample of 500 tons mined in 1880 and shipped to the furnace at Alpine. It represents the selected lump ore, sufficiently high in iron to be used without concentration.

Iron	56.72
Titanium	nil
Phosphorus	.009

Mines on Vrooman ridge, Fine. This locality is 4 miles northwest of Oswegatchie on the Carthage and Adirondack Railroad, in the town of Fine. Vrooman ridge is the first of the elevations bordering the Oswegatchie river valley on the south.

From a cursory examination of outcrops it appears that the ridge is mainly composed of reddish hornblende gneiss, with one or more included bands of dark pyritic schists and limestone which are doubtless altered sediments. The ore deposits are associated with the latter. They have been explored by shallow pits; apparently no active mining has been undertaken. So far as could be determined by surface observations, there are two parallel veins that strike about north and dip 50° or so to the west. On the eastern vein, which seems to be the principal one, two pits have been sunk, 330 feet apart, to a depth of about 30 feet. The indicated width is from 8 to 12 feet. The hornblende schist forming the walls is streaked by limestone in which phlogopite, titanite and coccolite are abundantly distributed in small crystals. Hornblende and pyrite are mixed with the magnetite and much of the ore is lean. The two pits on the western vein indicate a width for the ore of 5 feet. According to a report rendered by Mr George D. Grannis, who superintended the exploratory operations, the deposits have been prospected to some extent by diamond drilling. One hole was put down on the north pit of the eastern vein to a depth of 85 feet, all in ore. A second boring was started 100 feet west of the pit for the purpose of intersecting the body at an angle and encountered two veins, one 4 feet and the other 10 feet wide separated by 4 feet of rock. These may represent the western vein above mentioned, here split by a horse of the wall rock. Another hole in line with the second but farther south showed the two veins to have a thickness of 4 feet and 6 feet respectively with 6 feet of rock between them. The following analyses have been copied from a report on the property made by Mr Spencer B. Newberry.

	1	2	3
Iron...........	71.12	61.46	62.02
Silica..........	.860	......	6.36
Titanium.......	tr.	nil	......
Sulfur.........	.005	.025	.03
Phosphorus.....	.049	.009	.024
Manganese.....	tr.	......	......
Lime..........	.051	......	......
Magnesia.......	tr.	......	......

Clifton Mines. The Clifton deposits are situated about 10 miles north of Benson Mines, in an unsettled forested district that is somewhat difficult of access. They were opened over 50 years ago but have not been worked recently. A charcoal furnace was built at Clarksboro by the falls of the Grasse river, 3 miles distant from the mines, and was run for some time on the ore. In 1868 the Clifton Mining Co., which then owned the property, erected a plant for manufacturing steel by a direct process, a venture that soon proved a failure. The mines were at one time connected with the Rome, Watertown & Ogdensburg Railroad near DeKalb Junction by a 20-mile wooden railway.

In approaching the mines from Oswegatchie, the highway after leaving the Oswegatchie river at Fine passes over a belt of hornblendic and micaceous gneisses and schists that continues for a mile or more and is then succeeded by a red granitic gneiss with porphyritic feldspars. This rock prevails in most of the exposures as far as Monterey. Between that locality and the Clifton mines the granitic gneiss gives way to a belt of schists and limestones having a northeast-southwest trend parallel to their general strike. These are the predominant rocks in the vicinity of the ore bodies. They seem to have been somewhat broken and disturbed as they show sudden changes in dip; the inclination, however, in most cases is toward the southeast at angles of 15° to 45°.

The openings are located on the sides and summit of a hill rising 100 feet or a little more above the site of the steel works in the adjoining valley. The principal working is an open cut on the summit which exposes a vein 20 feet wide for a distance of about 500 feet. This is known as the Dodge vein. The immediate wall rock is a hornblende schist. Bands and fragments of the schist interleave the ore, and on the borders the two are intimately mixed. The hornblende gangue carrying the magnetite makes an exceedingly tough material. On the northeast side of the hill the vein has been tapped by an adit and in the walls crystalline limestone is exposed in what seems to be an included band about 5 feet thick. The southwest continuation of the vein has been explored by a shaft that follows the dip for 30 feet, showing about 20 feet of ore all the way. East of this deposit and higher up in the schists is the St Lawrence vein, 8 feet thick, that has been explored by open cutting and by an incline said to be 100 feet deep. The ore from it is very sulfurous, in places almost solid pyrite and pyrrhotite. A third vein is known to underlie the Dodge vein, but its width and character have not been determined.

The ore found in the different openings varies from a coarse and nearly pure magnetite to a fine grained mixture of disseminated magnetite and the minerals of the wall rock which are chiefly hornblende, biotite, garnet and quartz. Pyrite is less in evidence in the middle of the veins than on the borders. The ore was subjected to heap roasting before it was smelted to reduce the sulfur. The analyses that follow are quoted from a paper on the Clifton mines by Professor Silliman.[1]

---

[1] Am. Inst. Min. Eng. Trans. 1871–72. 1:364.

	1	2
Fe_3O_4	79.29	80.91
SiO_2	8.32	8.77
S	.35	.08
P_2O_5	.32	.03
Al_2O_3	3.45	......
MnO	.35	......
CaO	4.46	......
MgO	3.09	......
H_2O	.51	......
	100.14	......
Iron	57.42	58.59
Phosphorus	.14	.01

The analyses were made from crude ore, but the quantity of sulfur shown is rather low for the run of mine, specially in the second sample which also contains very little phosphorus. It is of interest in this connection to quote Professor Silliman's analyses of the pig iron made from the Clifton ores in the old Clarksboro furnace. The ore was fluxed with an impure limestone containing a considerable proportion of silica.

	Open grain gray pig	Close grain gray pig
Carbon	3.94	3.30
Silicon	2.21	4.48
Manganese	.11	.12
Sulfur	.04	.11
Phosphorus	.22	.15
Iron and undet	93.48	91.84
	100.00	100.00

In the same vicinity occur two other deposits that were found by the early prospectors and were known as the Tooley Lake and Sheridan veins. They outcrop in a swampy tract, 7 and 2½ miles distant respectively from the Clifton mines. The localities were not visited by the writer. In character the ores are similar to those just described, as shown by the following analyses, no. 1 being from a sample of the Tooley Lake vein and no. 2 of the Sheridan vein.

	1	2
Iron	54.32	57.81
Silica	13.34	8.55
Sulfur	.08	.41
Phosphorus	.01	tr.
Manganese	.29	.50

Parish ore body. This deposit is 8 miles east of Monterey, on Tracy pond outlet, Clifton township. Its outcrop has been uncovered by trenching for a short distance, but it has not been explored in depth. The width shown is about 8 feet. The deposit appears to have a steep dip so that the actual width is probably near the figure given. The wall rock is fine grained grayish gneiss, while nearby reddish granitic gneiss is exposed, and within a mile distant an area of crystalline limestone and sedimentary schists. The magnetite is mixed with the minerals of the gray gneiss and with red garnet, yet is fairly rich. It has a coarse granular texture. It contains no pyrite so far as observed. It is reported that a line of magnetic attraction can be traced for 800 feet north and south of the tract along the course of the vein. The analysis below is from a sample of the ore.

Iron	50.3
Phosphorus	.58

SALISBURY MINE, HERKIMER COUNTY

This mine is in the town of Salisbury, 5 miles north of Dolgeville, the present terminus of the branch railroad running north from Little Falls. It is the only magnetite mine in this section of the Adirondacks that has been actively worked.

The deposit apparently was discovered about 1840. Vanuxem who has given a brief description of it states that a small amount of ore had been taken out at the time of making his report.[1] It is probable that the old pits located along the outcrop of the ore body date from this period. The quantity of ore mined during the early operations is not a matter of record though the size of the openings leads one to infer that it did not exceed a few thousand tons.

Geological relations. The locality lies within the Little Falls topographic sheet, the geology of which has been mapped and described by H. P. Cushing.[2]

[1] Fourth Annual Report of the Geological Survey of the Third District, 1840.

[2] Geology of the Vicinity of Little Falls. N. Y. State Mus. Bul. 77. 1905.

The immediate area about the mine is occupied by the Adirondack Precambrics. These rocks extend southward as a belt of gradually diminishing width to within 4 miles of Little Falls, passing at the borders beneath the Lower Siluric strata (Beekmantown, Trenton and Lorraine) which spread over the region to the south. There is a large outlier of Precambric syenite at Little Falls and smaller ones of the same rock at Middleville, northwest of Little Falls, and at a point about half way between the latter locality and the southern end of the main area. The contact between the Precambric and Paleozoic strata on the east side of the belt is marked by a heavy fault which begins south of the Mohawk river and runs northeast passing about 2 miles east of the mine.

The principal representative of the Precambric rocks is syenite, a greenish augite-bearing variety that is identical mineralogically with the great syenite masses in the central Adirondacks. It has a gneissoid appearance in most cases and shows strong crushing effects in the granulation of the feldspar. Occasionally uncrushed remnants of feldspar may be observed surrounded by granular material, like an augen gneiss. The syenite is exposed over most of the area north of Salisbury Center.

The Grenville series of gneisses and schists form the southern extension of the Precambric belt south of Salisbury Center and is exposed north of the mine in two areas which are bordered by the syenite. It consists of light colored quartzose gneisses interbanded with darker hornblendic or micaceous varieties. Crystalline limestone, usually a prominent member of the series, apparently has a very limited development within the area; the only outcrop that has been recorded is one observed by the writer at a point a little north of Salisbury Center. The gneisses are believed by Cushing to represent original sandstones and shales.

A reddish gneiss comprised mainly of quartz and alkali feldspar occurs at a few places in association with the syenite and rocks of the Grenville series. Its field relations as well as its composition suggest an original granite that is probably intrusive in the sedimentary gneisses. Cushing mentions also the occurrence of black gneisses, containing hornblende and biotite and occasionally pyroxene, and gray gneisses of granitic composition which are regarded as igneous derivatives.

Ore bodies. The deposit which has been principally worked extends nearly east and west along the highway 2½ miles north of Salisbury Center. It consists of an elongated zone made up of magnetite in one or more bands intercalated between layers of magnetite-bearing rock. The thickness of the zone as shown in the workings ranges up to an extreme of 12 or 14 feet in width. The bands of rich ore vary from mere films to 2 or 3 feet. The ore body can be traced along the strike by outcrop and dip-needle readings for fully a mile.

A second smaller body occurs about a mile south of the first. It has been opened by a short adit at one point. The strike is parallel with the main deposit, but the dip is toward the north at a low angle, while the latter has a high dip southward. An area of granitic gneiss intervenes between the two deposits.

The wall rock at both localities is gneissoid syenite. Of the ore association, Cushing[1] has given the following account:

> Inclosing the ore and grading into it, is a very basic gneiss composed of hornblende, magnetite, augite, feldspar and quartz, the black minerals constituting 75 per cent of the rock. Hornblende is much the most abundant of these. About equal amounts of quartz and feldspar are present, the feldspar being part oligoclase and part orthoclase.
>
> So far as can be judged from specimens obtained from the dumps, this gneiss grades rapidly into a more feldspathic hornblende gneiss, and the latter into syenite gneiss, at first basic but rapidly becoming more acid.

The gradation between ore and country rock is very noticeable; no well defined walls exist, but there is a shading off by imperceptible stages from one to the other.

The workings. The mining developments which have been carried on during the last two or three years by the Salisbury Steel & Iron Co. have been concentrated on the western portion of the deposit in proximity to the old pits. A vertical shaft has been sunk a short distance north of the main pit. It has been carried down about 200 feet. At a depth of 100 feet a drift has been extended easterly along the body, while a second level with drifts to the east and west has been opened at 150 feet. The workings are about 14 feet wide near the shaft on the second level, diminishing to 3 or 4 feet at either end.

Some prospecting has been done at points east of the shaft, the farthest being about 4000 feet away. The deposit appears to be much thinner in this part.

Character of the ore. The ore consists of granular and massive magnetite, the former being a mixture of magnetite and the minerals of the wall rock and the latter a nearly pure magnetite of very dense

---

[1] *Op. cit.* p. 91.

structure. The granular ore has a fine texture; the particles of magnetite are intimately intermingled with pyroxene, hornblende, quartz and feldspar. Veinlets of jasper and white quartz are quite common. Pyrite occurs in noticeable quantity on the east end of the zone, but is not much in evidence elsewhere. When examined under the microscope, sections of the rich ore show inclusions of augite, quartz and apatite, but the proportion of these minerals to the whole mass is small and the material would be classed as shipping grade. The lean ore would require concentration. An analysis furnished by the Salisbury Steel & Iron Co. shows the following composition:

Fe_3O_4	86.99
SiO_2	6.39
S	.034
P_2O_5	1.36
Al_2O_3	1.14
MnO	.46
CaO	2.83
Mg O	.65
	99.854
Iron	62.99
Phosphorus	.52

Part III

TITANIFEROUS MAGNETITES

Under this class are included the magnetic ores of the Adirondacks that carry titanium as an essential ingredient. While the percentage of this element fluctuates within rather wide limits as shown by analysis of specimens taken from different localities, the minimum is always above the proportions encountered in the magnetites previously described. In the general run it amounts to at least 8 or 9 per cent (as TiO_2) and will average perhaps 15 per cent in the majority of the deposits. It is due solely to the titanium content that the ores have not been more actively exploited. Except for the early work at Lake Sanford, of which further mention is made on a subsequent page of this report, there has been no active mining of the deposits in the region, and till recently little interest has been shown generally in the matter of commercial utilization of titaniferous ores.

The Adirondack region is a familiar one in the literature relating to these ores. The descriptions of Emmons[1] who was the first to draw attention to the large ore bodies of Lake Sanford, the metallurgical experiments of Rossi[2] in connection with the same bodies, and more recently the detailed accounts by Kemp[3] covering practically the entire series of occurrences may be specially noted. The investigation of the geological features of the Adirondack ores has been carried out by Professor Kemp in a manner that leaves little to be added, and his descriptions and conclusions have been closely followed in the present work.

Distribution of the ores

The distribution of the titaniferous magnetites is conditioned primarily by the occurrence of the gabbro-anorthosite intrusions. As has been previously noted, the principal area of these rocks is

---

[1] Survey of the Second Geological District, 1842.

[2] Titaniferous Ores in the Blast Furnace. Am. Inst. Min. Eng. Trans. 1892–93. 21:832. Also article in the Iron Age, Feb. 6 and 20, 1896.

[3] Preliminary Report on the Geology of Essex County. N. Y. State Mus. 49th An. Rep't. v. 2. 1898. The Geology of Moriah and Westport Townships. N. Y. State Mus. Bul. 14. 1895. The paper "Titaniferous Ores of the Adirondacks," published in U. S. Geol. Sur. 19th An. Rep't. pt III, 1899, contains much additional matter relating to the origin and chemical nature of the ores.

in Essex and southern Franklin counties and consists of a connected mass which spreads over a surface of some 1200 square miles. There are smaller outlying intrusions in Clinton and Warren counties and in the western Adirondack region. The greater number of deposits are found within the bordering portions of the main anorthosite area in the townships of Westport, Elizabethtown and Newcomb, Essex co. In the central part no large bodies are known. A deposit near Port Leyden, Lewis co., is the only occurrence outside of the main area that has been the object of exploitation.

General geological relations and origin of the deposits

The titaniferous deposits constitute a well marked type of ore occurrence that is quite widely distributed in this and foreign countries. They are known to be of considerable extent in Minnesota, Wyoming and Colorado, in the Provinces of Ontario and Quebec, and in Sweden, Norway and Brazil. The Taberg deposit in Sweden was mined for a number of years and the ore used for the manufacture of iron. The various localities for titaniferous magnetites have been described briefly in a paper by Professor Kemp.[1] The occurrences throughout show a remarkable degree of uniformity in the essential features of their geological surroundings and composition of the ores.

With a single exception the country rocks of the Adirondack deposits, as is generally the case elsewhere, are members of the gabbro family. The prevailing rock in the Adirondack region is the variety known as anorthosite, the predominant constituent of which is a basic plagioclase feldspar, usually labradorite. The rock is the first of a series of related intrusions in the region that were derived apparently from a common magma. Gabbro in the restricted sense, syenite and probably granite are represented among the later intrusions derived from the same source. Most of the deposits are found within dikes and masses of gabbro which occur at intervals throughout the anorthosite area. Some of the large bodies at Lake Sanford, however, are inclosed directly by the anorthosite.

The general characters of the gabbros and anorthosites have already been set forth in the part of this report relating to Adiron dack geology. The following analyses taken from Professor Kemp's paper give details as to the chemical composition of typ-

---

[1] A Brief Review of the Titaniferous Magnetites. Columbia Univ. Sch. of Mines Quarterly, July 1899.

ical examples. No. 1 relates to the gabbro at the Split Rock mine; No. 2 to gabbro at Lincoln pond; and No. 3 to anorthosite from Mt Marcy.

	1	2	3
SiO_2	47.88	44.77	54.47
TiO_2	1.20	5.26	......
Cr_2O_3	tr.	......	......
Al_2O_3	18.90	12.46	26.45
Fe_2O_3	1.39	4.63	1.30
FeO	10.45	12.99	.67
NiO.CoO	.02	tr.	......
MnO	.16	.17	......
CaO	8.36	10.20	10.80
SrO	tr.	......	......
BaO	tr.	......	......
MgO	7.10	5.34	.69
K_2O	.81	.95	.92
Na_2O	2.75	2.47	4.37
Li_2O	tr.	......	......
H_2O	.61	.60	.53
P_2O_5	.20	.28	......
V_2O_5	tr.	......	......
CO_2	.12	.37	......
S	.07	.26	......
	100.02	100.75	100.20

The Port Leyden ore body on the west side of the Adirondacks seems to be an anomaly among the titaniferous occurrences. The wall rock is not a basic variety belonging to the gabbro-anorthosite family, but a quartz gneiss with potash feldspars and a small quantity of ferromagnesian minerals. Yet it is not unlikely that the deposits may represent only an aberrant type of the ordinary occurrences. If the country rock is igneous, as is believed, it probably belongs to the general series of intrusives that originated from a common parent mass. The ultimate source of the iron minerals may thus have been the same as those of the gabbros.

In the relations they bear to the inclosing rocks, the ores are sharply differentiated from those of the nontitaniferous class which occur in the sedimentary gneisses and schists. They are themselves only a phase or development of the igneous magma from which the walls have been derived — that is they are rocks differing in composition but of the same genesis as the anorthosite and gabbro. The magnetite and ilmenite of which they are aggregates exist in the country rocks as accessory constituents. A concentration that took place probably during the cooling of the magma effected the segregation of the heavy minerals into compact masses forming ore bodies of variable size and richness. This view of the relation of the Adirondack ores has been clearly brought out by Professor Kemp[1] in the following terms:

In the preceding pages the point of view has been consistently maintained that the ore bodies are integral portions of the igneous rocks in which they occur and are merely local enrichments of the mass with unusual amounts of one of its normal constituent minerals. This has not been done with the purpose of advocating one conception of the relations of the ore and wall rock to the exclusion of others, but because the observed phenomena admit of no other reasonable interpretation. There is no evidence of the replacement of preexisting material by an entering foreign substance, nor of faults and vein formation, nor of crushed zones different from the neighboring walls; nor are the ores at the contacts of intrusions with country rock. On the contrary, the masses of ore, of irregular shape, are far within the intrusions, and especially in the gabbros they vary from rich titaniferous iron oxide, through leaner and leaner examples, until normal gabbro is reached. No minerals or elements occur in notable amounts in the ores which are not characteristic components of the wall rock. The difference between ore and rock is one of degree and not of kind. At Calamity brook the ore itself forms a series of dikes in country rock of a different kind.

The causes acting to produce such a concentration or magmatic differentiation are little understood. Gravity, convection currents, magnetism, and diffusion consequent upon variation in the rate of cooling are some of the agencies that have been appealed to by the leading investigators to account for the accumulation of the deposits.

It is of interest to note that the igneous theory of derivation for these ores which has come into prominence in recent years and is now generally accepted by geologists the world over, was foreshadowed by Professor Emmons in his report on the Adirondack region for 1842. The ore occurrences at Lake Sanford were designated by him as "masses," to distinguish them from the "veins" or tabular bodies occurring in the gneisses, and they are described as of contemporaneous origin with the inclosing rocks which he recognized to be igneous.

[1] Titaniferous Iron Ores of the Adirondacks, p. 417.

Shape of the ore bodies

The form assumed by the ore bodies is not always apparent from the field evidence. It is only the smaller ones as a rule that are well exposed in outcrop. The large bodies have nowhere been uncovered or explored sufficiently to afford an idea as to their precise outlines. The smaller bodies, with a few exceptions found at Lake Sanford, occur in gabbro which generally appears in dikes cutting the anorthosite, and partake of the usual tabular form with the longer axis parallel to the strike of the dikes. They show gradation at the edges into the normal gabbro and their materials have no doubt come up with it from a common reservoir below. As to the deposits inclosed by the anorthosite, it is not conclusive whether the ores have separated in place from the surrounding rock, or whether they represent later concentrations in the interior that have been intruded into the anorthosite after its partial solidification. In the former case we should expect the bodies to be quite irregular, with no well defined walls, and to shade off at the borders with a gradual increase in the proportions of gangue material or rock. From the evidence at hand, the large bodies like the Lake Sanford would appear to be allied rather to that type than to the dike form.

Mineralogy of the magnetites

The titaniferous ores of the Adirondacks are essentially aggregates of magnetite and ilmenite. The richest ores contain little else than these minerals and show on analysis 60 per cent or slightly more of iron, the maximum percentage being somewhat below that of the high-grade nontitaniferous magnetites. From such pure aggregates there may be traced a continuous series of gradations, by the entering of gangue minerals in greater and greater proportions, to the limiting wall rocks which hold only subordinate amounts of magnetite and ilmenite.

The relations of the two iron minerals have received, hitherto, little attention. The presence of ilmenite has been inferred from the results of chemical analyses; its identification by the usual optical methods of petrography is difficult owing to its opacity and similarity of appearance to the magnetite with which it is intimately associated.

Ilmenite is not uniform in its composition and its chemical nature has been the source of considerable perplexity to mineralogists. The view that it is a metatitanate Fe TiO_3 has the support of the most recent investigations; the work of Penfield and Foote[1] affords in fact quite convincing evidence of its validity. According to that formula it contains theoretically FeO, 46.75 per cent and TiO_2, 53.25 per cent. There is always some Fe_2O_3 present and usually more or less MgO. The latter replaces the FeO, while the former substitutes probably for the ilmenite molecule, since the close similarity in the structure and crystal form of hematite and ilmenite indicates that they are practically isomorphous. A general formula for ilmenite, accordingly, is $Fe\ TiO_3.n\ Fe_2O_3$.

The fact that the titaniferous ores are not homogeneous aggregates is sometimes apparent from a macroscopic examination. The magnetite may be recognized by its parting planes parallel to the octahedron, the grains always breaking with smooth surfaces. It is the most abundant constituent as a rule. In the intervals between the grains are particles of brighter metallic luster that show rough fracture. These are only slightly attracted by the magnet and when isolated prove to be ilmenite.

To bring out the physical relations of the minerals the method of preparing polished surfaces and etching with acid can be used to good advantage.[2] Some results obtained with Adirondack ores are shown herewith [pl. 14]. The photographs were taken directly with a camera in ordinary light, as the texture of the ores is sufficiently coarse to be revealed without the use of the microscope. It will be seen that there is a good contrast between the magnetite and ilmenite, the former being dulled and pitted by the solvent action of the acid, while the latter retains the brilliancy imparted to it by polishing unimpaired. From the etched surfaces a fairly close estimate of the richness of the ore may be formed by comparing the relative areas occupied by the ore and gangue minerals, though the latter do not appear distinctly in the photograph.

In the specimens that have been examined the magnetite and ilmenite are distinguishable without difficulty. There is a clear separation of the particles and no notable tendency toward intergrowth or inclusion on the part of either. The boundaries are sharp. Both minerals belong to the same order of crystallization, though the ilmenite seems to have begun to form somewhat earlier than

---

[1] Note Concerning the Composition of Ilmenite. Am. Jour. Sci. 154. ser. 4. 1897. p. 108.

[2] Pieces of the ore an inch or so in diameter are cut with a diamond saw or ground down to a comparatively smooth surface on a wheel such as is used for preparing rock sections. The surfaces are then polished with fine emery, finishing off with putty powder on cloth. The etching is performed by submersion in a 20 per cent HCl solution for half an hour.

the magnetite. The latter being commonly in excess constitutes the ground mass through which the ilmenite is more or less regularly distributed in grains of fairly even size.

A partial separation of the magnetite and ilmenite was obtained with the ore from the Sanford pit at Lake Sanford. A sample was crushed through a 40 mesh sieve and the magnetite removed with a small hand magnet. The results from chemical analysis of the crude ore (1), magnetite concentrate (2) and the ilmenite and other residual minerals (3) are given herewith. The analyses were made by E. W. Morley.

	1	2	3
Fe_2O_3	55.9	54.39	14.28
FeO	27.5	28.66	30.93
TiO_2	14	8.93	45.23

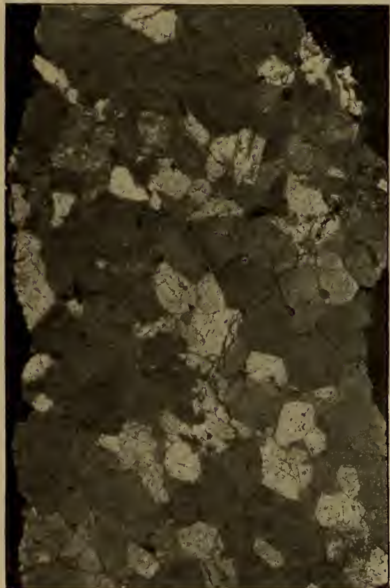
It will be observed that the magnetite concentrate still contains a considerable proportion of titanium, mostly due, no doubt, to the inclusion of particles of mixed character. By crushing still finer a cleaner separation may be made, as has been demonstrated for the same ore in recent experiments that are described on a subsequent page. The analyses are not reducible to simple terms of magnetite and ilmenite, and further work is needed before the chemical relations can be fully stated. It is quite likely that the magnetite itself carries a proportion of the titanium, in which case the entire removal of the latter would be impossible.

The remaining minerals found in the titaniferous ores include plagioclase, pyroxene, hornblende, biotite, olivine, garnet, pyrite, apatite, spinel and quartz. The plagioclase is usually labradorite or an allied variety. Both orthorhombic and monocline pyroxenes are represented. Olivine is rather rare in the Adirondack ores so far as observed. Pyrite is a fluctuating constituent, more abundant in the ores that are included by gabbro than in those found within anorthosite. Spinel has not been certainly identified, but its presence is strongly indicated by the analyses which show an excess of Al_2O_3 over the amounts required for the silicates. The analyses of concentrates on page 154 are suggestive also in that connection. Apatite is present in minute quantities only, and the ores are consequently low in phosphorus.

The order of crystallization of the minerals revealed by study of the etched surfaces is as follows: 1, silicates; 2, pyrite; 3, ilmenite and magnetite.

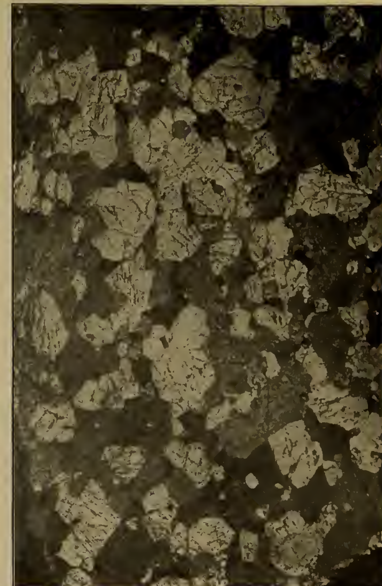
The order is thus the reverse of the normal one for igneous rocks in which the silicates predominate over the iron ores. The expla-

Plate 14



1

2



3

Etched surfaces of titaniferous ore. 1 Ore from Lake Sanford pit. 2 Same. 3 Ore from Moose mountain. Dark grains mostly magnetite with some pyrite and silicates; light particles are ilmenite

nation for this may be found possibly in the introduction of the magnetite and ilmenite after the congealing of the walls, the silicates representing material that was caught up during the progress of the iron magma toward the surface.

Commercial utilization of the titaniferous ores

The use of ores containing high percentages of titanium is generally regarded as impracticable under present furnace practice. They have been smelted, however, on a small scale in England and Sweden, as well as in the Adirondacks, under conditions approaching those of today, but the operations were short-lived and probably financially unsuccessful. It has been frequently suggested that the difficulties they present in the blast furnace might be overcome by adopting some changes either of furnace construction or of metallurgical process, but there has been, in the past, very little incentive to a practical investigation of the subject. The experiments by Rossi carried out in 1892 comprise about all that has been done along that line since the early work above mentioned.

The objection to the use of titaniferous ores in the blast furnace is based upon the infusibility of their slags. They yield a good quality of iron which contains only a slight trace of titanium. This element enters mostly into the slag, and with the employment of fluxes in ordinary proportions forms a viscous mass that adheres to the furnace walls and can not be readily withdrawn, while accumulations of the infusible nitro-cyanide of titanium also complicate the operation. Rossi sought to overcome the difficulty by proportioning the fluxes (quartz and limestone) so as to obtain compounds, mainly multiple-titanates, into which the titanium entered as a chemical constituent approximating the structure of the more fusible known titanates. By working with a small laboratory furnace, ores running as high as 20 per cent TiO_2 were reduced, with a production of pig iron and a fluid of slag. The experiments have not been repeated, so far as known, on a commercial scale.

It is not unlikely that a solution of the problem of dealing with the ores may be found by reducing the amount of titanium before entering the furnace. The small amount of the element found in most Adirondack magnetites now mined seems to have no noteworthy influence upon the smelting process. Furnaces have been run upon ores containing two or three per cent of titanium without serious trouble, and under special circumstances even larger percentages have been handled. There would thus seem to some room for adjusting the difficulity, either by mixing the with others that are nontitaniferous or by concentration.

The Lake Sanford ores carry about 15 per cent TiO_2 on the average. They are probably the most regular in titanium content and highest in iron of the Adirondack ores. By employing them in mixture in the proportions of say 1 to 2 or 1 to 3, the titanium of the ore charge could be brought down to three per cent or less. Their low phosphorus and sulfur would make them specially valuable for that purpose.

Another feature which may promote the use of the ores from that locality is their amenability to concentration, whereby the titanium can be reduced by at least a third of the total, or to less than 6 per cent probably as maximum limit. To the courtesy of F. E. Bachman, General Manager of the Northern Iron Co., the writer is indebted for information concerning an experimental run made upon Lake Sanford ores at the Mineville magnetic concentrating plant within the past year. A 40 ton sample was passed through one of the mills and the concentrates showed the following percentages: Fe, 60.60 per cent; TiO_2, 9.66 per cent (equivalent to 5.8 per cent Ti). The tailings from the treatment gave: Fe, 42.84 per cent; TiO_2, 32.22 per cent. A sample of the concentrates recrushed so as to pass through a 16 mesh screen and reconcentrated by hand showed the following percentages on analysis:

Fe	63
SiO_2	1.08
TiO_2	5.25
Al_2O_3	5.65

Another sample was crushed through a 40 mesh screen and subjected to separation under water with a hand magnet. Analyses of the concentrates are given below: No. 1 is by A. S. McCreath & Son, and No. 2 by P. W. Shimer.

	1	2
Fe	65.35	64.69
Mn	.186	....
SiO_2	.14	....
TiO_2	5.32	6.49
Al_2O_3	2.76	2.59
CaO	.05	....
MgO	.76	....
P	.012	.0045
S	.041	....

While it would scarcely be practicable, perhaps, to crush the ore to a size that would permit a reduction of the titanium to the limits indicated in the last analyses, there would appear to be no difficulty in the way of preparing concentrates with an average of 8 or 10 per cent TiO_2. The loss of iron in the tailings is the only drawback to concentration, but in the case of immense deposits like those at Lake Sanford which can be worked very cheaply this could hardly be critical.

The electric furnace has been suggested for titaniferous ores, yet the expense of making iron by this method must operate against its extended use so long as coke is available at anything like present prices. The open-hearth method of steel manufacture seems to offer a field that is worthy of investigation. Crude ores are employed now quite largely in the process instead of scrap metal. From what can be learned it appears that the use of titaniferous ores for that purpose has not been experimented with to any extent.

LAKE SANFORD DEPOSITS

This group of ore bodies, undoubtedly the most important of the kind in the Adirondacks, is situated in Newcomb township, western Essex county, on the slope of the rugged mountain complex that has Mt Marcy as its central and culminating point. Lake Sanford is the largest of several lakes in the vicinity which form the head waters of the Hudson. The site of the former Adirondack village (now occupied by the Tahawus Club) which was built by the early iron workers, lies in the midst of a wild, heavily forested region, shut in by high elevations on all sides except the south where the river has worn a narrow valley. North Creek, the terminus of the Adirondack branch of the Delaware & Hudson Railroad is about 30 miles distant by wagon road, and Port Henry on Lake Champlain about 50 miles. The ore bodies outcrop at elevations ranging from 1800 to about 2100 feet above sea level. Their distribution is indicated on the accompanying map which reproduces a part of the Santanoni quadrangle of the United States Geological Survey [pl. 15]. The scale of the map is 1 mile to the inch.

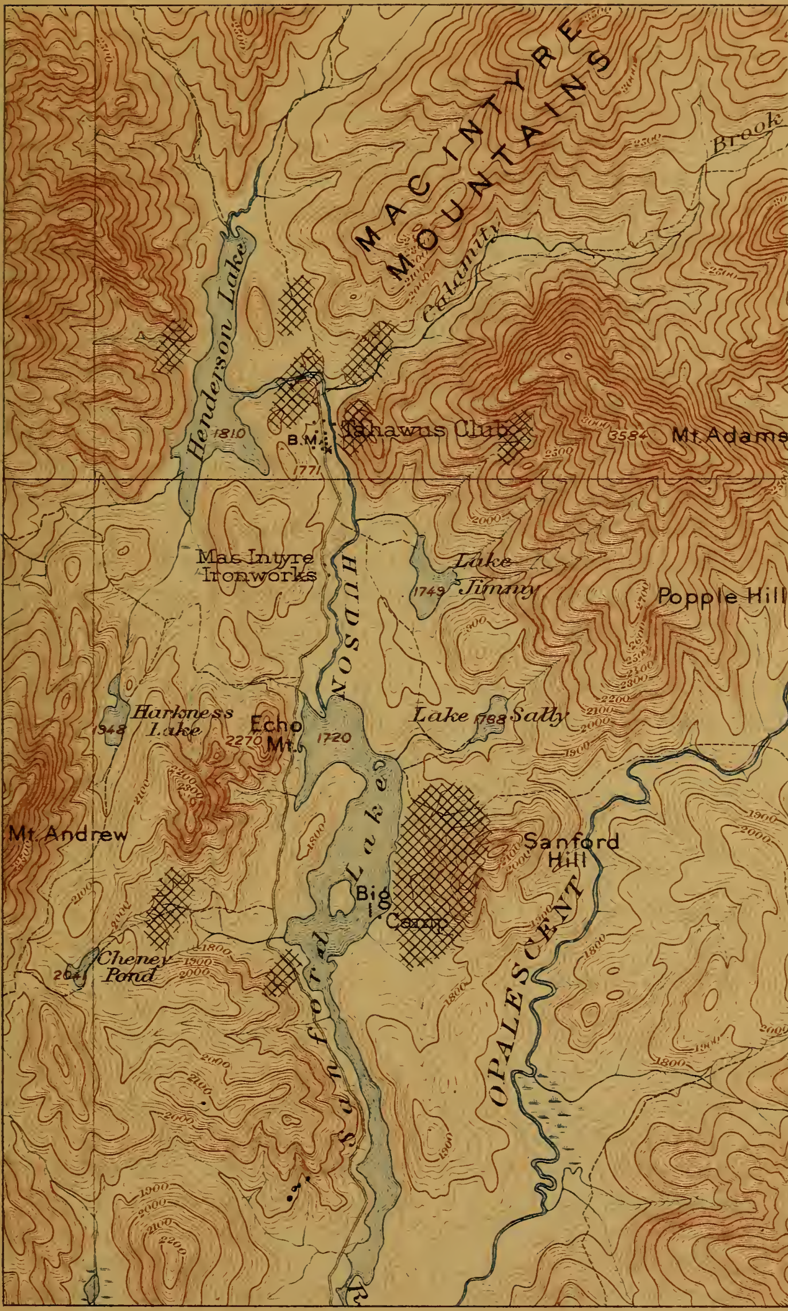
Unusual interest attaches to the events connected with the first development of the Lake Sanford deposits and the establishment of the local iron-making enterprise to utilize the ores.[1] Following

[1] A good historical account of the discovery and exploitation of the deposits will be found in Watson's "History of Essex County." The reports by Emmons contain a description of developments up to 1840. For details as to the blast furnaces and metallurgical operations consult Rossi, "Titaniferous Ores in the Blast Furnace." Am. Inst. Min. Eng. Trans. v. XXI. 1892–93.

the discovery, which is reported to have been made in 1826, a tract of land comprising the deposits was secured from the State by Mr A. McIntyre and associates who soon after began active work. The investigations of Professor Emmons in connection with the Geological Survey of New York then in progress no doubt gave a stimulus to the undertaking. Professor Emmons published in his reports an extended account of the ore bodies which he recognized to be of enormous size and regarded as eminently adapted to utilization. He recommended the location of iron-manufacturing enterprises in the vicinity. Soon after the publication of his first report, or about 1840, a blast furnace of three or four tons daily capacity was built and placed in operation. This was afterward remodelled so as to enlarge its capacity, and a second furnace of 12 to 15 tons was put in blast in 1854. Drawings of the large stack which remains to the present day with all its essential features have been made by Mr Rossi and published in the article already referred to. The installation included also puddling furnaces and the necessary equipment for making bar iron. The works were closed down in 1856, after which they were not again operated for any length of time. The product of the furnaces was hauled over a difficult mountain road to Crown Point for shipment, and the expense of transportation must have been a heavy tax upon the enterprise.

There seems to be little doubt, judging from all accounts, that the iron turned out in the early days was of good quality; in fact it was specially commended by Emmons and others; nor does it appear that the sudden termination of iron making was due to metallurgical difficulties in reducing the ore, though it is probable that the operators, at least in the early years, were unaware of the titaniferous character of the material. From considerations based on an analysis of slag which was taken from the dump near the old furnace, Mr Rossi has expressed the opinion that the furnace charges were made up on somewhat different lines than usually practised, in that a proportion of the country rock (anorthosite) was added to the limestone for flux. It may be noted, however, that the crude ore, such as was employed in the operations, contains more or less of admixed rock, so that the presence of the latter may have been accidental rather than intentional.

After lying idle for 50 years the property was taken over in 1907 by a new organization, the Tahawus Iron Ore Co., with a view to the exploitation of the ores. This company has conducted a thorough investigation and intends to enter upon active mining in the near future. The construction of a railroad is a requisite before commercial shipments can be made.



PART OF SANTANONI QUADRANGLE

MAP OF THE VICINITY OF LAKE SANFORD

Ore bodies are indicated by cross-hatching

Geology. The district lies within the main anorthosite area, but not far from its western bounds. As delimited in the preliminary survey of J. F. Kemp,[1] the gneiss series occupies approximately the western half of Newcomb township, the line of contact with the anorthosite which extends over the eastern half trending somewhat west of north. It is not easy to fix accurately the limits of the formations owing to the drift which chokes the valleys and reaches well up the slopes of the ridges. Anorthosite has been found by the writer to outcrop on Santanoni mountain, about 5 miles directly west of Lakes Sanford and Henderson, so that it probably continues in unbroken mass that far. The gneiss series first appears on the shores of Newcomb lake and in the east-west valley occupied by Rich and Harris lakes, whence it stretches westward as far as the confines of the Adirondacks.

The gneiss series bordering the anorthosite has been subjected only to a cursory examination. Apparently it consists of a complex in which both sedimentary and igneous types are represented. The former have particularly strong development around Newcomb, where there is one of the largest Grenville exposures in the interior of the Adirondacks. They comprise the usual rusty micaceous and hornblendic gneisses and schists, with interfolded belts of crystalline limestone carrying graphite and other characteristic minerals. A limestone ledge on the east side of Newcomb lake was a source of flux for the early furnace operations. Professor Cushing in his recent mapping of the geology of the Long Lake quadrangle has noted the presence of extensive masses of syenite and granitic gneisses, and it is not unlikely that upon further investigation they will be found to constitute an important part of the area farther east along with the Grenville formation. The region about the mines is included in the Santanoni quadrangle which adjoins the Long Lake sheet on the east.

The principal interest in connection with the iron ores is attached, of course, to the anorthosite. Where exposed near the mines this is generally a very typical variety of the rock as developed in the Adirondack region. It consists essentially of labradorite in grayish or bluish black crystals, that occasionally exhibit a play of colors on cleavage surfaces. The crystals are generally large, up to 3 or 4 inches in length, and are closely interwoven with a coarsely granitic texture. While as a rule the feldspar constitutes practically the only mineral observable in hand speci-

[1] Preliminary Report on the Geology of Essex County. N. Y. State Mus. 49th An. Rep't. 1898. 2:604.

mens, the microscope reveals the presence of augite and hypersthene in small amounts and usually some magnetite or ilmenite. In portions of the mass that show effects of crushing in the breaking down or mashing of the feldspar, there is found a development of secondary minerals such as garnet, biotite and calcite. The garnet has a tendency to form aggregates about the magnetite, which owing to their red color stand out plainly from their surroundings. The mineral has drawn upon the magnetite for the iron and the feldspar for the lime and silica necessary to its growth. Biotite is not so common as the garnet with which it is closely associated and no doubt genetically related. The following analysis, quoted from a paper by Prof. Albert R. Leeds, will serve to show the chemical character of the anorthosite. The sample from which it was made was taken from the summit of Mt Marcy.

SiO_2	54.47
Al_2O_3	26.45
Fe_2O_3	1.3
FeO	.66
CaO	10.80
MgO	.69
K_2O	.92
Na_2O	4.37
H_2O	.53
	100.19

In places the typical anorthosite, as above described, gives way to a much finer grained rock in which the pyroxene minerals are more prominent, showing a transition to gabbro. With this mineralogic change the feldspar individuals decrease in size and number and the color becomes greenish. Such phases are apt to have a gneissoid texture as they are less resistant to metamorphic influences than the anorthosite, a feature that is illustrated as well by the development of hornblende in the place of the pyroxene minerals and of abundant garnet. They are undoubtedly a differential product of the anorthosite, but it is not always clear whether the gabbro has separated in place or has come up through the anorthosite in the form of dikes.

Ore bodies. Ore is found in both the anorthosite and the gabbro. The anorthosite is the commoner wall rock and the ore bodies which it incloses have perhaps the greater possibilities for commercial utilization, due to their uniform character and higher average of

Plate 16

Blast furnace at Lake Sanford, once used on the titaniferous magnetites. Built in 1853

iron. They are also coarser grained as a rule than the ores in the gabbro.

The deposits outcrop on both sides of the narrow valley occupied by Lakes Sanford and Henderson and their outlet which is one of the head-streams of the Hudson river. The valley bottom lies at an elevation of from 1700 to 1800 feet. The situation of the more important ore bodies is shown on the map reproduced from a section of the Santanoni quadrangle [pl. 15]. The outlines of the bodies as sketched are to be considered as approximations only, since they have not been fully proved. It will be observed that the deposits are grouped along a north-south belt about 2 miles wide and 4 or 5 miles long.

On the south end are the Sanford and Cheney ore bodies situated on the east and west sides respectively of Lake Sanford. The Sanford is perhaps the most important of the whole group. It lies between the crest of Sanford hill and the lake shore, occupying in its widest part the entire interval of about ¼ mile and running north and south for fully twice the distance. Outcrops are found on the west shoulder of the hill, at a point about 300 feet above the lake level where a small quantity of ore has been removed, and at many points directly south. For the most part the outcrop is concealed, however, by a light covering of soil and glacial materials. The Sanford deposit was prospected with considerable care by Professor Emmons who has left a circumstantial and faithful record of the results.[1] Five lines of excavation were made under his direction, four running transverse and one parallel to the length of the body. The middle transverse section began at the base of the hill and ran eastward at right angles to the course of the ore, a distance of 514 feet. Its exact location is not now ascertainable though probably it was about on a line with the opening mentioned above. The record of this section which is given in greatest detail affords a good idea as to the general character of the ore body and is here quoted.

Record of the middle transverse section of the Sanford ore body made by Professor Emmons

Pit no.	Interval feet	
1	..	Fine granular feldspar, intermixed with iron, garnet and hornblende
2	36	Rich ore breaking into tabular masses

[1] Survey of the Second Geological District. 1842. p. 249.

Pit no.	Interval feet	
3	10	Rich ore, as above
4	15	Rich ore
5	20	Rich ore, mixed in a small proportion with granular feldspar
6	12	Granular feldspar in a decomposing state containing only a small proportion of ore
7	20	Rich ore, mixed with a few scales of black mica and feldspar
8	22	Rich ore, mixed with garnet and feldspar
9	24	Nearly the same as No. 8, but brighter
10	24	Rich ore, with a very small portion of feldspar
11	22	Loose decomposed rock
12	17	Rich ore
13	15	Rich ore, with feldspar
14	39	Rich granular ore, with a resinous luster
15	15	Lean ore
16	22	Principally rock
17	28	Pure ore
18	35	Pure ore
19	36	Rich ore
20	22	Pure ore
21	27	Pure ore
22	30	Pure ore
23	29	Pure ore
24	30	Ore mixed with garnet
25	14	Rock mixed with particles of ore

The other sections are not so detailed but show about the same relations. Section No. 2 was run 268 feet south of No. 1 or middle section and gave a width of 610 feet of ore without apparently encountering the walls. Section No. 3 crossed the ore body 210 feet south of No. 2, and No. 4 was run 231 feet north of No. 1; their length is not stated. On the basis of this work Professor Emmons estimated the ore body to contain 6,830,000 tons at a depth of 2 feet below the adjoining surface. The results obtained by diamond drilling during the years 1906 and 1907 have demonstrated that the ore continues westward practically to the lake side considerably farther than Emmons was able to trace it, while they have also proved its continuity to a depth of 300 or 400 feet, as far as the drills have penetrated. Recent magnetic surveys show the existence of lines of attraction which cross the lake to the western shore where they merge with the smaller ore body which outcrops just south of Big island as indicated on the map. The latter is thus probably an extension of the Sanford, the two being connected by a belt beneath the lake.

The Sanford deposit is conveniently situated for working, and a quantity of ore that is not subject to careful estimate but which must amount to several millions of tons can be removed by ordinary quarry methods before reaching the level of the adjacent lake. Its position directly in the valley will facilitate transportation when once the district is provided with railroad communication. In quality the ore is above the average of the district. Except for admixture with feldspar it is nearly a pure aggregate of iron minerals. The feldspar is segregated to a great extent along certain bands, though it occurs in smaller amount all through the mass. The separation of the rich ore from the admixed ore and rock could be performed without much difficulty during the quarry operations.

The Cheney deposit lies about a mile west of Lake Sanford, and has apparently no connection with the Sanford body. It is known to be of large size, though it has been little explored. In one place a pit of some 20 feet deep has been opened. Professor Kemp has described the occurrence as follows: "The wall rock is a gabbro-gneiss as already stated, and the ore contains more sulfur and phosphorus than do the others in the anorthosites. It emits a sulfurous odor when broken with the hammer. In thin sections it is seen to be lean. Apatite is abundant, and brown hornblende, red brown biotite, chloritized augite, and some plagioclase make up a large part of the aggregate." The ore is at times quite rich, but its average is not as high as the Sanford ore.

About 2 miles north of the Sanford deposit, on its line of strike, there is an exposure of fine grained ore which is mentioned by Emmons as a probable continuation of that deposit. There is said to be a nearly continuous line of magnetic attraction between the two. An opening has been made well up on the side of Mt Adams. In addition to plagioclase the ore, according to Kemp, contains some spinel.

In the vicinity of the Tahawus Club and north and west of there towards Lake Henderson, there is a complex of deposits forming an almost connected series distributed over an area of perhaps a square mile. Ore shows on both sides of the river near the outlet of Calamity brook, and on the west side is the Millpond opening from which most of the ore in the early days was taken to supply the furnace. This pit is about 100 feet long and from 10 to 40 feet wide, the walls are like those of the Sanford deposit and the iron made from it was highly commended by Professor Emmons. It was used without concentration. The so called "iron dam" is a dike of ore which cuts across the river back of the Tahawus Club in a northeasterly direction. It has a width of 10 feet or a little more, but includes a good deal of feldspar.

Along Calamity brook, beginning a short distance from the outlet, ore is exposed for a distance of 500 or 600 feet and can be traced to the west for several hundred feet. It is mostly a fine grained intimate mixture of iron minerals and feldspar, pyroxene and garnet. In the leaner phases it is a ferriferous gabbro. It would appear that this ore occurrence, as well as others of this type, represents an intrusion of a highly ferriferous gabbro in the anorthosite. This ore contains considerable pyrite and is consequently quite sulfurous. The magnetite is in part concentrated in small stringers or veinlets which intersect the gabbro in all directions.

Between the latter locality and Lake Henderson there has been uncovered by the exploratory operations conducted during the last two years an important ore-bearing area that seems to have been overlooked in the earlier investigations. No mention of the occurrence is made by Emmons or Kemp. The tract is heavily wooded and covered with a stratum of soil and glacial boulders. By excavating a line of trenches, ore has been shown to exist in practically a continuous body, the bounds of which have not yet been determined. The ore ranges from an almost solid mixture of magnetite and ilmenite to leaner material in which labradorite predominates. The deposit has been tested in several places with the diamond drill, of which one of the records is here given.

	Feet	Inches
Lean ore, consisting of disseminated magnetite with feldspar and pyroxene	19	3
Rich ore	30	6
Rock and lean ore, alternating	15	....
Rich ore	33	6
Rock carrying some ore	11	1
Lean ore	12	....
Rock and lean ore	8	....
Rich ore alternating with seams of rock	10	7
Rock	5	....
	144	11

Character of the ores. The difference in character of the Lake Sanford ores depending upon their geological associations has

Plate 17

Valley between Lake Sanford and Lake Henderson; looking north. Ore bodies outcrop in the middle distance and on the ridges to the left and right

already been noted. The ores which have anorthosite for walls are more uniform than the others in their physical appearance and mineralogy, and also appear to be somewhat richer in iron. As a rule they are coarsely textured; the constituent grains of magnetite have a mean diameter of ¼ to ½ inch. When free from feldspar they can scarcely be distinguished in hand specimens from the nontitaniferous magnetites. Variations in granularity can be noticed in different parts of the same ore body, but the grain seldom approaches the fineness of the ores included by the gabbro. With the exception of inclusions of labradorite and occasional crystals of pyroxene, they are remarkably pure ores. The ores found in the gabbro usually carry these minerals in quantity, as well as garnet and small amounts of pyrite and apatite. Their texture approaches that of a normal gabbro, owing to the presence of the silicates, and they are very dense and tough.

The following analyses furnish particulars as to the chemical composition of the ores from the principal deposits. They have been obtained from the papers by Kemp and Rossi, except Nos. 5 and 11 which have been communicated by Mr W. L. Cumings and No. 6 which was made by Prof. E. W. Morley from a sample gathered by the writer.

	Sanford deposit					
	1	2	3	4	5	6
Fe_3O_4	70.80	71.03	70.73	87.60	......	a83.4
SiO_2	1.39	1.34	2.46	.87	2.09	......
TiO_2	19.52	18.70	20.03	10.91	9.45	14.
Al_2O_3	4.00	......	3.50	.53	......	......
P	.022	......	......	......	.007	......
S	.028	......	......	......	.027	......
Iron	51.30	51.44	51.22	62.65	63.36	60.5

	Millpond pit			Cheney pit		Iron dam
	7	8	9	10	11	12
Fe_3O_4	87.20	82.37	73.62	55.64	86.53	......
SiO_2	1.09	3.67	1.53	9.79	......	1.96
TiO_2	10.73	13.38	19.74	15.77	8.25	10.85
Al_2O_3	.44	1.50	3.50	7.12	......	......
P	nil	.017	.037	......	.39	.008
S	nil	.068	.08	1.00	.74	.009
Iron	63.45	59.56	53.62	40.33	62.15	64.47

[a] Fe_2O_3 55.9; FeO 27.5.

Analysis No. 5 is of a sample taken across the face of the Sanford pit. The ore here is, no doubt, above the average for the whole deposit, and the first three analyses perhaps are more representative. It will be seen that aside from the Cheney pit all of the ores are low in phosphorus and sulfur and well within the requirements for Bessemer ores.

MOOSE MOUNTAIN DEPOSITS

Moose mountain is a prominent peak 3 miles north of Hammondville, on the edge of the central anorthosite area. The deposits occur on the shoulder of the peak, a little east of the summit, at an altitude of about 2000 feet, as nearly as can be determined. They were opened several years ago by the Crown Point Iron Co., in an experimental way, but only a few hundred tons of ore have been taken out. The trail to the mines leads up the eastern side of the mountain, following the brook which empties into Paradox creek below the outlet of Round pond. At the point where the trail branches off, the outcrops are of augite syenite, but this rock gives way a few hundred feet west to anorthosite, the contact being marked by a garnetiferous zone which seems to be a metamorphosed phase of the syenite. Near the deposits gabbro appears and forms the immediate country rock. It is doubtless a large intrusion in the anorthosite. It has a strongly gneissoid texture with much red garnet that has evidently formed at the expense of the feldspar, and hornblende as the main dark constituent.

The ore bodies consist of bands or lenticular masses striking about northwest and apparently dipping northeast. The main pit is perhaps 40 feet long and from 4 to 5 feet wide. The ore in its prevailing character is but an enriched portion of the gabbro averaging not more than 40 per cent in iron. The magnetite is finely divided and is intergrown with pyrite. At one pit specimens were collected which showed a more coarsely textured material above the average in richness. The deposits appear to be of small extent, judging from the limited areas of magnetic attraction surrounding them.

SPLIT ROCK MINE

Split Rock mountain, on which the mine of that name is located, is an offshoot of the Adirondacks forming the western shore of Lake Champlain for some distance between Westport and the village of Essex. It rises abruptly from the lake level as a series of peaks of which the highest is a little over 1000 feet. The approach from the western side where it falls toward the Bouquet river is more gradual.

The mine openings are in the face of a cliff fronting directly on the lake just north of the little cove that is locally known as Snake Den harbor. They lie about 100 feet above the shore and consist of two drifts, 10 feet or so wide, which follow the ore back into the mountain for a short distance. The workings date back over 25 years, as Smock states in his report that no ore had been mined for six years previous to his visit. The concentrating works, erected on the lake shore below the mine, have fallen into decay or have been removed. A magnetic process was employed for separating the magnetite from the gangue.

The main mass of Split Rock mountain consists of light gray anorthosite, with local intrusions of gabbro. Both rocks show strong crushing effects, the former in the granulation of the labradorite which constitutes almost the entire mass, and the latter in its markedly gneissoid texture as well as a similar granulation of its constituents. Both contain secondary garnet. The gabbro in thin section is seen to be mainly composed of augite, hypersthene, brown hornblende, garnet and labradorite, with olivine and magnetite in subordinate amount. The hornblende is plainly a result of chemical reaction between the magnetite and the feldspar brought about by the dynamic metamorphism which the rock has undergone. An analysis of the gabbro quoted from the paper by Professor Kemp is given on page 148 of this report.

The deposits occur directly in gabbro of which there is a considerable area in the vicinity. The relation between the ore and wall rock is that of complete gradation, there being no line of demarcation whatever between the one and the other. The magnetite in the gabbro increases in proportion until it becomes the principal constituent; while there is a corresponding retreat of the silicates, the feldspar being the first to disappear. A peculiar feature revealed by examining thin sections is the occurrence of veinlets of magnetite that evidently are the fillings of rifts in the ore subsequent to its consolidation. The veinlets are minute, but they can be traced generally across the whole section, breaking through the silicate minerals as well as the inclosing magnetite. It would appear that there must have been a secondary infiltration of magnetite, perhaps from a fused portion of the body at depth. Another singular phenomenon, noted by Professor Kemp in the ore from this locality, is the presence of a greenish glass which forms veinlets and incrustations of microscopic size, with inclusions of feldspar and magnetite.

The ore has a fine grain and is exceedingly hard and tough. When observed in hand specimens the general run seems to be fairly rich, but closer examination shows, even in the richest material, that there is a considerable proportion of gangue minerals, The latter are distributed in small particles through the magnetite in such a manner that it would prove difficult to make a satisfactory separation of the material for commercial purposes.

The following analyses, of which No. 1 is by W. F. Hillebrand and No. 2 by George W. Maynard, give the composition of the ore.

	1	2
Fe_2O_3	15.85	38.43
FeO	27.94	23.40
SiO_2	17.90	16.46
TiO_2	15.66	14.70
Cr_2O_3	.51	......
Al_2O_3	10.23	.34
MnO	tr.	.23
CaO	2.86	3.54
MgO	6.04	2.13
P_2O_5	.04	......
V_2O_5	.55	......
CO_2	.10	......
S	.14	......
H_2O	1.33	......
	99.15	99.23
Iron	32.82	32.59
Titanium	9.40	8.82

LINCOLN POND MINE

The Lincoln pond mine, locally called the Kent mine, is about 5 miles northwest of Mineville, not far from the highway leading to Elizabethtown. It consists of a pit about 75 feet long by 15 feet wide, with a shaft at one end of unknown depth. The wall rock is a massive hypersthene gabbro, carrying more or less garnet. The ore has the usual character of the magnetites found in this association, though it is rather above the average in iron. It contains besides the silicates of the gabbro small crystals of apatite. An analysis by W. F. Hillebrand contained in Professor Kemp's paper shows the following percentages.

Fe_2O_3	30.68
FeO	27.92
Al_2O_3	6.46
SiO_2	11.73
TiO_2	12.31
CaO	3.95
MgO	3.35
K_2O	.26
Na_2O	.50
P_2O_5	.82
V_2O_5	.04
CO_2	.32
S	.04
C	.05
Cl	.12
Fl	tr.
H_2O	.64
	99.19
Iron	44.19

The presence of carbon is an interesting feature of the analysis and is probably due, according to Hillebrand, to the inclusion of graphite. Professor Kemp was unable to identify that mineral under the microscope beyond doubt, though a few black particles were observed in the chemical residues which might well have been of graphitic nature.

LITTLE POND MINES

A short distance north of Little pond, 2 miles south of Elizabethtown, two openings have been made in titaniferous bodies which appear to be of considerable size. The northern opening is about 20 feet across at the surface and 15 feet deep, while the other to the south has been excavated in the hillside and is about 30 feet long and 25 feet high at the working face. The walls consist of dark green gabbro. The ore is lean, as it carries a good deal of garnet, hornblende, feldspar and the other constituents of the gabbro. Analyses by W. F. Hillebrand, quoted from Kemp's article, show the following composition for the ore from both pits.

	North pit	South pit
Fe_2O_3	26.30	11.16
FeO	29.78	28.35
TiO_2	18.82	13.07
Cr_2O_3	.75	.37
V_2O_5	.62	.50
P_2O_5	tr.	.32
S	.06	.10
	76.33	53.87
Iron	41.57	29.87

PORT LEYDEN MINE

Near the site of the old iron furnace at Port Leyden, Lewis co., a titaniferous ore body exists in somewhat remarkable associations. It was prospected many years since by a shaft which is said to be 65 feet deep but is now filled with water almost to the surface. No ore can be seen in place either at the shaft or in the outcrops nearby, so that it is probably limited to a lens or shootlike mass of no great lateral dimensions. In the volume of the *Mineral Resources* for 1886, the following mention is made of the occurrence: "A titaniferous ore at Port Leyden (Lewis county) occasioned the erection of a blast furnace, concerning which Mr George D. Colby says: 'With a view of ascertaining the amount and quality of the ore which led to the erection of these works, the present company made borings to a depth of 300 feet. The core of the borings indicated an abundance of ore, but of such chemical composition that no attempt has been made by this company to produce pig iron from it.' "

An analysis of the ore, quoted from the same source, shows the percentages below:

Fe_3O_4	52.67
FeS_2	5.86
SiO_2	10.95
TiO_2	9.31
Al_2O_3	5.21
Mn	1.12

CaO	8.38
P	2.59
S	3.12
	99.21
Iron	40.90

The analysis is perhaps of questionable accuracy in some respects. The sulfur is certainly all combined with the iron to form bisulfid, and the ferrous and ferric oxids can hardly be present in the exact proportions to form magnetite when there is such a large amount of titanium present as ilmenite. That the determinations of iron and titanium are substantially correct as to bulk, however, has been confirmed by an analysis made by Prof. E. W. Morley, on a sample gathered recently from the mine dump. The analysis gave: Fe 50.79 per cent; TiO_2 9.90 per cent.

The immediate walls of the deposit are not in evidence, but there are abundant outcrops in the vicinity, all of quartzose gneisses. The latter include a pink, slightly foliated variety and a grayish garnetiferous one. Both show under the microscope a composition that allies them to the granites and granitic gneisses of the Adirondacks. The feldspars are chiefly microperthite and microcline, though there may be a little acid plagioclase present. Quartz is abundant. The dark minerals comprise biotite and magnetite and a chloritic product that may have been derived from augite.

The ore is an extremely dense hard mass in which the magnetite occurs in finely divided particles intergrown with larger grains of pyrite. Biotite and garnet are also present. Some specimens taken from the dump at the shaft show inclusions of a green feldspar rock resembling the Adirondack syenite in composition and appearance.

The derivation of the deposit is difficult to explain except that it may be related to some underlying magma from which the ore body represents an offshot, perhaps intrusive in the granitic gneiss. The association of syenite alluded to affords evidence of the existence of such a magma, and it is well known that the gabbros and syenites and the granites in some cases as well grade into each other and are closely connected in their genesis.

OTHER TITANIFEROUS DEPOSITS

In the town of Westport, about 2 miles south of Westport village, several pits have been excavated in deposits that outcrop cn a ridge in contact with a gneissoid gabbro. They are of small size and the ore is lean.

Tunnel mountain, southeast of Elizabethtown and directly east of Little pond, carries a deposit which outcrops on the summit and has been opened to a depth of 40 or 50 feet. The pit runs about north and south and is 10 feet wide. An attempt was made to tap the deposit by a tunnel some 200 feet below the outcrop, but was given up before reaching the ore. An analysis of the ore by Hillebrand gave the following percentages:

Fe_2O_3	20.35
FeO	28.82
SiO_2	13.35
TiO_2	16.45
Cr_2O_3	.55
Al_2O_3	8.75
CaO	2.15
MgO	6.63
P_2O_5	.02
V_2O_5	.61
CO_2	.17
S	.09
C	tr.
Cl	tr.
H_2O	1.68
	99.62
Iron	35.99

On the east slope of Tunnel mountain two small pits have been excavated in lean titaniferous ore.

The Humbug vein, north of Cook shaft, Mineville, is titaniferous and probably occurs in gabbro, though its associations have not been fully determined. The ore is reported to carry 20 per cent TiO.

Bibliography

The following list comprises the papers and reports that have special bearing on the magnetite deposits. Papers having a purely geological or mineralogical interest have been omitted, though most of them are included in the literature referred to in the subsequent pages of this report.

Anon. The Mineville Magnetite Mines. The Iron Age, Dec. 17, 1903.

——— Port Henry Mines and Furnaces. The American Railroad Journal, 1849.

This paper and the preceding one have been recently republished privately by Messrs Witherbee, Sherman & Co.

Ball, Clinton M. The Magnetic Separation of Iron Ore. Am. Inst. Min. Eng. Trans. v. 25. 1895.

Beck, L. C. Mineralogy of New York. Albany 1842.

Contains brief mention of many of the Adirondack deposits.

Bell, *Sir* Lowthian. Notes of a Visit to Coal and Iron Mines and Iron Works in the United States. British Iron & Steel Inst. Proc. 1875.

Birkinbine, John. Crystalline Magnetite in the Port Henry, N. Y. Mines. Am. Inst. Min. Eng. Trans. v. 18. 1890.

Describes the Lover's pit at Mineville, with statistics of production, analyses and other notes.

Blake, W. P. Note on the Magnetic Separation of Iron Ore at the Sanford Ore Bed, Moriah, Essex co., N. Y., in 1852. Am. Inst. Min. Eng. Trans. v. 21. 1892.

Emmons, Ebenezer. Geology of New York: Report on Second District. Albany 1842.

A comprehensive treatise on the geology of the Adirondack region, with valuable notes on the mines and mining industry.

Granbery, J. H. The Port Henry Iron Mines. Eng. & Min. Jour. 1906.

Gives an account of the Mineville deposits, mining equipment and methods employed in mining and concentration of the ores.

Hall, C. E. Laurentian Magnetic Iron-Ore Deposits of Northern New York. N. Y. State Mus. 32d An. Rep't. 1879.

A brief study of the geological associations of the magnetites, specially those of Mineville.

Hofer, Hans. Die Kohlen- und Eisenerz-Lagerstatten Nord-Amerikas. Vienna 1878.

Hunt, T. S. The Iron Ores of the United States. Am. Inst. Min. Eng. Trans. v. 19. 1890.

Refers briefly to some of the Adirondack mines.

Kemp, J. F. Titaniferous Ores of the Adirondacks. U. S. Geol. Sur. 19th An. Rep't. pt 3. 1899.

A comprehensive account of the geology, mineralogy and chemical character of the titaniferous ores.

——— Preliminary Report on the Geology of Essex County. N. Y. State Mus. 47th An. Rep't. 1894; *also* v. 2, 49th An. Rep't. 1898.

——— Geology of Moriah and Westport Townships, Essex County, N. Y. N. Y. State Mus. Bul. 14. 1895.

——— The Geology of the Magnetites near Port Henry, N. Y., and Especially those of Mineville. Am. Inst. Min. Eng. Trans. v. 27. 1898.

Gives a detailed description of the geological occurrence of the ores, with many sections, maps and analyses.

——— Geology of the Elizabethtown and Port Henry Quadrangles. *In preparation.*

Maynard, G. W. The Iron Ores of Lake Champlain. British Iron & Steel Inst. 1. 1874.

Nason, F. L. Notes on some of the Iron-Bearing Rocks of the Adirondack Mountains. Am. Geol. v. 12. 1893.

Newland, D. H. The Mining and Quarry Industry of New York. N. Y. State Mus. Bul. 93. 1905; 102. 1906; 112. 1907.

Contains brief accounts of the larger Adirondack mines.

——— & **Hansell, N. V.** Magnetite Mines at Lyon Mountain, N. Y. Eng. & Min. Jour. 1906.

A description of the mines, mining methods and concentration plants.

Putnam, B. T. Notes on the Samples of Iron Ores Collected in New York. 10th Census, v. 15. 1886.

Contains numerous sections of ore bodies and analyses.

Smock, J. C. First Report on the Iron Mines and Iron Ore Districts in the State of New York. N. Y. State Mus. Bul. 7. 1889.

A brief description of the principal mines in the State.

——— A Review of the Iron Mining Industry of New York for the past Decade. Am. Inst. Min. Eng. Trans. v. 17. 1889.

Watson, W. C. The Military and Civil History of Essex County. 1869.

Valuable for details of the early history of mining in the Adirondacks.

INDEX

Education Department Bulletin

Published fortnightly by the University of the State of New York

Entered as second-class matter March 3, 1908, at the Post Office at Albany, N. Y., under the act of Congress of July 16, 1894

NO. 426 ALBANY, N. Y. JULY 1, 1908

New York State Museum

JOHN M. CLARKE, Director

Museum bulletin 120

THE MINING AND QUARRY INDUSTRY OF NEW YORK STATE

REPORT OF OPERATIONS AND PRODUCTION DURING 1907

BY

D. H. NEWLAND

New York State Education Department
Science Division, April 16, 1908

Hon. A. S. Draper LL.D.
Commissioner of Education

My dear sir: I have the honor to submit herewith, for publication as a bulletin of the State Museum, the annual report on *The Mining and Quarry Industry of New York State,* prepared by David H. Newland, Assistant State Geologist.

Very respectfully
John M. Clarke
Director

State of New York
Education Department
COMMISSIONER'S ROOM

Approved for publication this 17*th day of April* 1908

A. S. Draper

Commissioner of Education.

Education Department Bulletin

Published fortnightly by the University of the State of New York

Entered as second-class matter at the Post Office at Albany, N. Y., March 3, 1908, under the act of Congress of July 16, 1894

NO. 426 ALBANY, N. Y. JULY 1, 1908

New York State Museum

JOHN M. CLARKE, Director

Museum bulletin 120

THE MINING AND QUARRY INDUSTRY

OF

NEW YORK STATE

REPORT OF OPERATIONS AND PRODUCTION DURING 1907

BY

D. H. NEWLAND

PREFACE

With the present issue the annual reviews of the mining and quarry industries of the State encompass a period of four years, the first having been published in 1905. The incentive for their continuance is found in the general interest which attaches to this branch of industrial activity, as illustrated by the number of requests received for information relating to all phases of the subject as well as by the rapid progress that is being made in the industries themselves.

The publication of the reports is rendered possible only through the cooperation of the many enterprises engaged in exploitation of the local resources; it is a pleasure to acknowledge the cordial manner with which their assistance has been given.

INTRODUCTION

Substantial progress was made during the past year in many departments of the mineral industry, and though conditions in some lines were not so prosperous as they had been in previous years, the general record may be regarded with satisfaction. The census of production that has been conducted for the present and preceding issues of this report covers over 30 different materials mined or quarried in the State; the total value of the output returned for 1907 amounted to $37,427,405, showing a small advance over the corresponding total for 1906 which was $37,132,832, the largest recorded up to that time. When compared with other years the status of the industry in 1907 appears in even more favorable light, as the value of the production in 1905 was $35,470,987 and in 1904 only $28,812,595. Within the four years for which returns have been collected, there has thus been a gain of 30 per cent in the mineral production of the State.

These valuations, it may be noted, are based on materials in elementary or first marketable form, so that they actually represent only a small part of the aggregates contributed each year by the mineral industry in general. The metallurgical and chemical products classed as mineral are among the largest items of local manufactures.

By comparison of the tables of production included herewith, it will be observed that iron mining has undergone uninterrupted expansion during the past few years. The output for 1907 amounted to 1,018,013 long tons and exceeded that of any previous year since 1890. There were 13 mines under exploitation, or two more than in 1906 when the production was 905,367 tons. Several additional mines have been under development preliminary to active work. The Clinton ore belt has been the center of special interest, and large tracts of land in Wayne and Cayuga counties have been taken over by companies with a view to mining operations. The Fair Haven Iron Co. began shipments from this region for the first time last year. The Adirondack region also has shared in the activity. The Benson mines in St Lawrence county and the Cheever mine near Port Henry have been reopened, while the deposits of titaniferous ores at Lake Sanford received attention and their operation is postponed only for the want of railroad facilities which are planned for the near future. With a return of the iron market to normal conditions, it may be expected that the iron ore production of New York will soon develop beyond all proportions of the past.

The clay materials reported in 1907 represented an aggregate value of $12,688,868. There was a decrease of $1,266,432 from the amount returned for the preceding year, due to the smaller output and market values of the building materials. The combined output of brick, tile, fireproofing and terra cotta used for building purposes was valued at $8,909,392 as compared with $11,063,433 in 1906. The number of bricks made was 1,366,842,000, of which 1,051,907,000 came from the Hudson river region. The decline in the output of building materials was counterbalanced to some degree by the gain in pottery manufactures which were valued at $2,240,895, against a value of $1,795,008 for the preceding year. Of the 61 counties of the State 43 were represented among the reports received last year from the manufacturers of clay products.

The quarries of New York contributed a value of $7,890,327, against $6,504,165 in 1906, showing an increase of about 20 per cent and establishing a new record for these industries. The total was divided according to the various uses into: building stone $2,208,545; monumental stone $162,359; curb and flagstone $1,064,193; crushed stone $2,812,998; other uses $1,642,232. The output of slate, millstones and of limestone used in making hydraulic cement is not included in the totals. The marble industry was specially active last year and the production valued at $1,571,936 has probably never been exceeded in the State. The stone quarries are distributed among all the counties practically, while they yield nearly every kind of material for building, construction or ornamental purposes.

The companies manufacturing hydraulic cement reported an output of 3,245,729 barrels, with a value of $2,971,820. The totals consisted of 2,108,450 barrels of Portland cement valued at $2,214,090 and 1,137,279 barrels of natural rock cement valued at $757,730. In the preceding year there were 4,114,939 barrels produced valued at $3,950,699, so that there was a loss for the year of 869,210 barrels in quantity and $978,879 in value. The poor showing has been due largely to the unfavorable conditions that obtained in the natural cement trade which has shown a steady decline for several years past.

The salt production of the State amounted to 9,657,543 barrels, as compared with 9,013,993 barrels in 1906, thus continuing the progress that has for some time been a feature of the industry. The value of the output was $2,449,178, exceeding that of the previous year by $317,528. There were six counties represented in the returns, with Onondaga county in the lead, though its output consisted mostly of salt used for soda manufacture. Livingston county made the largest quantity of marketable grade, chiefly rock salt.

An aggregate of 323,323 short tons of gypsum was taken from the mines and quarries of the State last year, as compared with 262,486 short tons in 1906. The output has increased by over 100 per cent within the last three years, due to the rapid development of the trade in wall plasters, stucco, etc., and to the use of gypsum in Portland cement manufacture. The value of the different materials was $1,038,355, as compared with $699,-455 in 1906.

The combined value of the petroleum and natural gas produced in the State was $2,536,349, a small increase over the value reported for 1906 which was $2,487,674. The quantity of petroleum taken from the wells, estimated from the receipts of pipe line companies, was 1,052,324 barrels, valued at $1,736,335, or nearly the same as in the preceding year. The natural gas production was valued at $800,014, as compared with $766,579 in 1906; the volume amounting to 3,052,145,000 cubic feet against 3,007,086,000 cubic feet in the preceding year. New discoveries of gas continue to be reported and the additional supplies thus made available have more than sufficed to maintain the rate of production.

The mining of pyrite showed a notable advance during the past year, the output amounting to 49,978 long tons, which compares with 11,798 tons for 1906. The mineral is obtained in St Lawrence county. A large amount of exploratory and development work has been done recently, with results that may lead to a further expansion of the industry. The product finds a ready sale for making sulfurous and sulfuric acids.

The talc mines near Gouverneur contributed a production of 59,000 short tons, or a little less than in 1906. The value of the output was $501,500. The production is governed chiefly by the requirements of the paper trade and shows little tendency to fluctuate from year to year.

Garnet for abrasive uses is obtained from the eastern Adirondacks. An output of 5709 short tons valued at $174,800 was reported in 1907. The returns for the preceding year showed an output of 4729 short tons with a value of $159,298.

The crystalline graphite mined in the Adirondacks amounted to 2,950,000 pounds, against 2,811,582 pounds in 1906. The value of the product was $106,951 as compared with $96,084. Almost the whole quantity was taken from the mine at Graphite, Warren co., though many other enterprises have been inaugurated during the few years.

A somewhat unusual industry not elsewhere represented in this country is that connected with the production of natural carbon dioxid, or carbonic acid gas, as it is generally known. The gas occurs in association with the mineral waters of Saratoga Springs and its collection and storage for use form an interesting, as well as important, industrial development. About 5,000,000 pounds of the gas are sold each year, chiefly to manufacturers of carbonated waters.

Mineral production of New York in 1904

PRODUCT	UNIT OF MEASUREMENT	QUANTITY	VALUE
Portland cement	Barrels	1 377 302	$1 245 778
Natural rock cement	Barrels	1 881 630	1 207 883
Building brick	Thousands	1 293 538	7 473 122
Pottery	....	....	1 438 634
Other clay products	....	....	2 592 948
Crude clay	Short tons	8 959	17 164
Emery	Short tons	1 148	17 220
Feldspar and quartz	Long tons	8 703	28 463
Garnet	Short tons	3 045	104 325
Glass sand	Short tons	11 080	8 484
Graphite	Pounds	3 132 927	119 509
Gypsum	Short tons	151 455	424 975
Iron ore	Long tons	619 103	1 328 894
Millstones	....	....	21 476
Metallic paint	Short tons	4 740	55 768
Slate pigment	Short tons	3 132	23 876
Mineral waters	Gallons	8 000 000	1 000 000
Natural gas	1000 cubic feet	2 399 987	552 197
Petroleum	Barrels	1 036 179	1 709 770
Pyrite	Long tons	5 275	20 820
Salt	Barrels	8 724 768	2 102 748
Roofing slate	Squares	18 090	86 159
Slate manufactures	....	....	7 441
Granite	....	....	221 882
Limestone	....	....	2 104 095
Marble	....	....	478 771
Sandstone	....	....	1 896 697
Trap	....	....	468 496
Talc	Short tons	65 000	455 000
Other materials*a*	....	....	1 600 000
Total value	....	....	$28 812 595

a Includes apatite, carbon dioxid, diatomaceous earth, fullers earth, marl and sand. The value is partly estimated

Mineral production of New York in 1905

PRODUCT	UNIT OF MEASUREMENT	QUANTITY	VALUE
Portland cement	Barrels	2 117 822	$2 046 864
Natural rock cement	Barrels	2 257 698	1 590 689
Building brick	Thousands	1 512 157	10 054 597
Pottery	....	....	1 620 558
Other clay products	....	....	2 603 861
Crude clay	Short tons	6 766	16 616
Emery	Short tons	1 475	12 452
Feldspar and quartz	Long tons	17 000	48 500
Garnet	Short tons	2 700	94 500
Glass sand	Short tons	9 850	7 765
Graphite	Pounds	3 897 616	142 948
Gypsum	Short tons	191 860	551 193
Iron ore	Long tons	827 049	2 576 123
Millstones	....	....	22 944
Metallic paint	Short tons	6 059	70 090
Slate pigment	Short tons	2 929	22 668
Mineral waters	Gallons	8 000 000	1 000 000
Natural gas	1000 cubic feet	2 639 130	607 000
Petroleum	Barrels	949 511	1 566 931
Pyrite	Long tons	10 100	40 465
Salt	Barrels	8 575 649	2 303 067
Roofing slate	Squares	16 460	94 009
Slate manufactures	....	....	1 000
Granite	....	....	253 955
Limestone	....	....	2 411 456
Marble	....	....	774 557
Sandstone	....	....	2 043 960
Trap	....	....	623 219
Talc	Short tons	67 000	469 000
Other materials*a*	....	....	1 800 000
Total value	....	....	$35 470 987

a Includes apatite, carbon dioxid, diatomaceous earth, fullers earth, marl, sand and sand lime brick. The value is partly estimated.

Mineral production of New York in 1906

PRODUCT	UNIT OF MEASUREMENT	QUANTITY	VALUE
Portland cement	Barrels	2 423 374	$2 766 488
Natural rock cement	Barrels	1 691 565	1 184 211
Building brick	Thousands	1 600 059	9 688 289
Pottery	....	....	1 795 008
Other clay products	....	....	2 472 003
Crude clay	Short tons	5 477	9 125
Emery	Short tons	1 307	13 870
Feldspar and quartz	Long tons	13 660	44 350
Garnet	Short tons	4 729	159 298
Glass sand	Short tons	9 000	8 600
Graphite	Pounds	2 811 582	96 084
Gypsum	Short tons	262 486	699 455
Iron ore	Long tons	905 367	3 393 609
Millstones	....	....	22 442
Metallic paint	Short tons	2 714	29 140
Slate pigment	Short tons	2 045	15 960
Mineral waters	Gallons	8 000 000	1 000 000
Natural gas	1000 cubic feet	3 007 086	766 579
Petroleum	Barrels	1 043 088	1 721 095
Pyrite	Long tons	11 798	35 550
Salt	Barrels	9 013 993	2 131 650
Roofing slate	Squares	16 248	57 771
Slate manufactures	....	....	4 150
Sand lime brick	Thousands	17 080	122 340
Granite	....	....	255 189
Limestone	....	....	2 963 829
Marble	....	....	460 915
Sandstone	....	....	1 976 829
Trap	....	....	847 403
Talc	Short tons	64 200	541 600
Other materials*a*	....	....	1 850 000
Total value	....	....	$37 132 832

a Includes apatite arsenical ore, carbon dioxid, diatomaceous earth, fullers earth, marl and sand and gravel exclusive of glass sand.

Mineral production of New York in 1907

PRODUCT	UNIT OF MEASUREMENT	QUANTITY	VALUE
Portland cement	Barrels	2 108 450	$2 214 090
Natural rock cement	Barrels	1 137 279	757 730
Building brick	Thousands	1 366 842	7 424 294
Pottery	....	....	2 240 895
Other clay products	....	....	3 023 679
Crude clay	Short tons	3 927	6 163
Emery	Short tons	1 223	13 057
Feldspar and quartz	Long tons	8 723	36 230
Garnet	Short tons	5 709	174 800
Glass sand	Short tons	1 200	1 380
Graphite	Pounds	2 950 000	106 951
Gypsum	Short tons	323 323	1 038 355
Iron ore	Long tons	1 018 013	3 750 493
Millstones	....	....	21 806
Metallic paint	Short tons	5 269	59 521
Slate pigment	Short tons	620	3 700
Mineral waters	Gallons	8 000 000	1 000 400
Natural gas	1000 cubic feet	3 052 145	800 050
Petroleum	Barrels	1 052 324	1 736 331
Pyrite	Long tons	49 978	162 430
Salt	Barrels	9 657 543	2 449 178
Roofing slate	Squares	11 686	53 625
Slate manufactures	....	....	1 175
Sand lime brick	Thousands	16 610	109 677
Granite	....	....	195 900
Limestone	....	....	3 182 447
Marble	....	....	1 571 936
Sandstone	....	....	1 998 417
Trap	....	....	941 627
Talc	Short tons	59 000	501 500
Other materials*a*	....	....	1 850 000
Total value	....	....	$37 427 405

a Includes apatite, arsenical ore, carbon dioxid, diatomaceous earth, fullers earth, marl and sand and gravel exclusive of glass sand.

ARSENICAL ORE

The mining of arsenical ore is a new industry in New York State. While arsenical minerals have been produced at different times in the past in connection with the exploitation of pyrite deposits, it does not appear that they were considered of value or employed for the extraction of arsenic. The present enterprise was started in April 1906, by the opening of an old pyrite property situated near Carmel, Kent township, Putnam co. Shipments of crude ore and concentrates were made both in 1906 and 1907, most of the material having been sold to foreign chemical works. The mine is owned by the Putnam County Mining Corporation.

The ore occurrence was described briefly in the preceding issue of this report. It consists of arsenopyrite and subordinate pyrite with a quartz gangue occurring in veins that cut the gneiss country rock in proximity to a basic dike now altered to serpentine. The veins are made up of a number of parallel stringers closely set and forming what is properly called a lode. There are two such lodes of which the one worked has a northerly strike and is from 12 to 20 feet wide while the second lode intersecting at an angle of 60° has been only prospected. The ore body is opened by a vertical shaft bottomed at 100 feet from which a drift has been run along the course of the lode. It is about 12 feet wide in the drift.

During the past year the company has installed a plant for concentrating the low grade material. The process as described by Edward K. Judd,[1] consists in passing the ore through a jaw crusher and rolls and treating on hydraulic jigs of the Joplin type. There are eight jigs run by hand and provided with ¼ inch screens. The arsenopyrite is recovered from the hutch only, the material on the screens being rejected. The jig capacity is 4½ tons of crude ore or 1½ tons of concentrates each per day. The concentrates average 25 per cent arsenic.

A sample of the high grade ore gave the following percentages on analysis:

Silica	2.90
Iron	36.11
Copper	2.17
Sulfur	22.72
Arsenic	36.00
	99.90

Arsenopyrite occurs near Edenville and at other localities in Orange county, and in the town of Lewis, Essex co., 10 miles south of Keeseville. The Edenville deposit carries also leucopyrite, the diarsenid of iron and scorodite, a hydrous arsenate of iron.

CEMENT

There were few changes of note in the hydraulic cement industry during 1907. A fairly active demand existed throughout most of the year, but as in other manufacturing lines a sharp market decline took place in the last three months. Except for

[1] Eng. & Min. Jour. Feb. 8, 1908.

this, prices were on about the same level as in 1906. The conditions in the natural rock cement trade have been less favorable than in the other branch, reflecting influences which are of general nature and have been operative for some time.

There are 10 counties in the State which manufacture hydraulic cement. The crude materials used are found in nearly every section and the development of the industry has been governed more by commercial considerations, such as fuel prices and facilities for shipment of the product to market, than by the distribution of natural resources. Over one half of the annual production of the State is made in the Hudson river region and most of the remainder in the central and western part along the main trunk lines and the Erie canal. Ulster county has long been the center of the natural rock cement industry, while Onondaga and Erie counties furnish smaller quantities of the material. The Portland cement plants are located in Columbia, Greene, Livingston, Onondaga, Schoharie, Steuben, Tompkins, Ulster and Warren counties.

For the past year there were 18 firms which reported a production as compared with 19 firms so reporting in 1906. The combined output of Portland and natural rock cement amounted to 3,245,729 barrels valued at $2,971,820. In 1906 the output was 4,114,939 barrels valued at $3,950,699, so that there was a loss for the year of 869,210 barrels in quantity and of $978,879 in value. The decrease was shared by both branches, but in greater part by the natural rock cement.

The production of Portland cement amounted to 2,108,450 barrels valued at $2,214,090, against 2,423,374 barrels valued at $2,766,488 in 1906. There were 10 companies in operation during the whole or a part of the year. The decrease is accounted for by the fact that one of the larger plants was closed down for repairs and improvements during most of the season. A new plant has been erected by the William M. Hoag Cement Co. at Rosendale, Ulster co., but made only experimental runs in 1907.

Of natural rock cement a production amounting to 1,137,279 barrels valued at $757,730 was reported, as compared with 1,691,565 barrels valued at $1,184,211 in the preceding year. The Rosendale district contributed most of the output as heretofore, its share having been 970,929 barrels valued at $679,650. In 1906 the same district made 1,514,336 barrels valued at $1,107,535. Onondaga county reported a total of 47,350 barrels valued at $22,750 against 63,043 barrels valued at $30,923 in the preceding year. In all there were eight companies active, or one less than in 1906. The plant owned by the New York Cement Co. at Rosendale was burned down in December 1906.

Production of cement in New York

YEAR	PORTLAND CEMENT		NATURAL CEMENT	
	Barrels	Value	Barrels	Value
1890	65 000	$140 000	3 776 756	$2 985 513
1891	87 000	190 250	3 931 306	3 046 279
1892	124 000	279 000	3 780 687	3 074 781
1893	137 096	287 725	3 597 758	2 805 387
1894	117 275	205 231	3 446 330	1 974 463
1895	159 320	278 810	3 939 727	2 285 094
1896	260 787	443 175	4 181 918	2 423 891
1897	394 398	690 179	4 259 186	2 123 771
1898	554 358	970 126	4 157 917	2 065 658
1899	472 386	708 579	4 689 167	2 813 500
1900	465 832	582 290	3 409 085	2 045 451
1901	617 228	617 228	2 234 131	1 117 066
1902	1 156 807	1 521 553	3 577 340	2 135 036
1903	1 602 946	2 031 310	2 417 137	1 510 529
1904	1 377 302	1 245 778	1 881 630	1 207 883
1905	2 117 822	2 046 864	2 257 698	1 590 689
1906	2 423 374	2 766 488	1 691 565	1 184 211
1907	2 108 450	2 214 090	1 137 279	757 730

CLAY

The manufacture of clay materials holds a prominent place among the industrial activities of the State. Clays suitable for making the common wares are distributed throughout every section. The rapidly growing markets for these products has led to the establishment of numerous manufacturing plants so that there is scarcely a city or community of any size which does not contain one or more of such enterprises. This is particularly true with regard to the manufacture of building materials, such as brick, terra cotta and tile, which are being employed more and more widely as elements of permanent construction. Owing to their cheapness, durability and the convenience with which they can be adapted to meet the varied architectural requirements, the use of clay materials will no doubt continue to find favor for a long time to come.

The production of the finer grades of clay wares has not attained the importance shown by the other lines. In contrast with most of the states along the Atlantic seaboard New York possesses very small resources in the finer varieties of clays and kaolin. This fact has retarded the development of industries in which such materials are employed, but with the present facilities for transport the deficiency has become less formidable to local manufacturers. There are now a number of plants in the State making tableware, electrical supplies, and other porcelain and semiporcelain wares.

Production of clay materials

The tables included herewith give full details as to the production of the different clay materials in the State. They are based on returns received from practically all of the manufacturers in every department.

The value of the products reported for 1907 indicates that the year was a fairly prosperous one for the local industries though comparing somewhat unfavorably with the two preceding years when unusually flourishing conditions obtained throughout the State. There was a smaller demand for clay building materials due to decreased building operations in New York and other large cities. This brought about a severe decline in the prices which had been raised to a high level, and to a curtailment of production. The decrease in output, however, was not so marked as might have been expected owing mainly to the number of new plants that had been placed in operation during the previous year and to the enlargement of facilities in many other plants. Aside from the branches connected with the building trade, there was little change in the industry and the production of most materials was well maintained or even showed a gain.

The aggregate value of the clay manufactures of all kinds in 1907 was $12,688,868. This compared with $13,955,300, the total reported for 1906, shows a falling off of $1,266,432 or about 9 per cent for the year. Of the 61 counties in the State 43 were represented in 1907 as having an output of this class of mineral materials. The number of individual plants in operation was 242, as compared with 265 in the preceding year and 250 in 1905.

The shrinkage in the valuation of the building brick alone was greater than the combined decrease for the entire production. The total reported by the manufacturers of this material amounted to $7,424,294, against a value of $9,688,289 for 1906, or a decrease of $2,263,995. Of the total, common brick accounted for $7,201,525, as compared with $9,302,165 in 1906, and front and fancy brick for $222,769 as compared with $386,124 for the preceding year. The production of vitrified paving brick was valued at $184,306 against $178,011. Fire brick and stove lining amounted to a value of $624,033 against $527,659. The manufactures of drain tile amounted to $162,167 against $166,645; and of sewer pipe to $463,500 against $95,142. The production of terra cotta was valued at $1,224,300, as compared with $1,037,387 in 1906; fireproofing at $45,672 as compared with $120,282; and building tile at $215,126, as compared with $217,475. In addition there were produced miscellaneous materials, including flue lining, fire tile and shapes, conduit pipes, sidewalk brick and acid-proof brick, the collected value of which amounted to $104,575, against $129,402 in 1906. The potteries of the State reported an output valued at $2,240,895, as compared with a value of $1,795,008 in the preceding year.

Production of clay materials

MATERIAL	1905	1906	1907
Common brick	$9 751 753	$9 302 165	$7 201 525
Front brick	302 844	386 124	222 769
Vitrified paving brick	180 004	178 011	184 306
Fire brick and stove lining	498 184	527 659	624 033
Drain tile	146 790	166 645	162 167
Sewer pipe	444 457	95 142	463 500
Terra cotta	874 717	1 037 387	1 224 300
Fireproofing	133 995	120 282	45 672
Building tile	251 600	217 475	215 126
Miscellaneous	75 114	129 402	104 575
Pottery	1 620 558	1 795 008	2 240 895
Total	$14 280 016	$13 955 300	$12 688 868

A distribution of the production according to the counties in which it was made places Onondaga county in the lead as having the largest clay-working industry. The value of its output was $1,331,443, the greater part representing pottery. In 1906 it ranked fourth. Ulster county which was second in the preceding year maintained that position with an output valued at $1,324,476. Rockland county fell from first to third place with a total of $1,258,467. The manufacture of brick is the basis of the industry in these counties. Richmond county advanced from sixth position in 1906, to fourth last year, and contributed $1,121,524; it manufactures most of the terra cotta made in the

State. The other counties that reported a production of over $100,000 in value in 1907 were: Orange ($789,297); Erie ($786,703); Dutchess ($781,262); Monroe ($583,664); Kings ($574,863); Albany ($540,341); Columbia ($433,357); Westchester ($390,773); Ontario ($342,810); Rensselaer ($321,016); Saratoga ($256,275); Greene ($237,620); Steuben ($186,124); Suffolk ($127,610); Chautauqua ($113,350); Allegany ($111,751); and Nassau ($105,000). Queens county should also be included in the foregoing list, but the value is withheld owing to there being but a single producer.

Production of clay materials by counties

COUNTY	1905	1906	1907
Albany	$624 238	$675 099	$540 341
Allegany	118 989	111 683	111 751
Broome	18 000	12 000	8 250
Cattaraugus	*a*........	35 500	41 234
Cayuga	25 920	17 860	14 832
Chautauqua	78 130	99 085	113 350
Chemung	96 000	90 000	88 940
Clinton	5 900	4 800	4 250
Columbia	520 500	489 750	433 357
Dutchess	1 258 937	975 410	781 262
Erie	700 527	804 159	786 703
Fulton	1 700	2 600	2 000
Greene	389 562	399 298	237 620
Jefferson	36 502	36 722	20 352
Kings	565 888	575 973	574 863
Madison	12 000	16 800	32 000
Monroe	644 411	341 870	583 664
Nassau	76 992	163 700	105 000
Niagara	3 372	10 832	16 282
Oneida	133 250	103 263	98 315
Onondaga	932 285	1 094 635	1 331 443
Ontario	345 250	343 040	342 810
Orange	1 011 006	1 170 695	789 297
Rensselaer	263 256	296 762	321 016
Richmond	645 367	896 789	1 121 524
Rockland	2 144 210	1 767 012	1 258 467
Saratoga	362 268	388 450	256 275
Schenectady	*a*........	92 700	83 637
Seneca	3 525	39 525	*a*........
Steuben	164 663	209 052	186 124
Suffolk	113 000	138 500	127 610
Tompkins	15 004	*a*........	7 100
Ulster	1 776 035	1 465 457	1 324 476
Warren	45 712	34 500	25 000
Washington	20 270	22 033	22 990
Westchester	592 705	536 189	390 773
Other countries*b*	406 542	496 886	505 960
Total	$14 280 016	$13 955 300	$12 688 868

a Included under "other counties."
b Includes in 1906: Genesee, Herkimer, Livingston, Montgomery, New York, Queens, St Lawrence, Tioga, Tompkins and Wayne counties. In 1907 the following counties are included: Genesee, Herkimer, Livingston, Montgomery, New York, Queens, St Lawrence and Wayne.

Manufacture of building brick

The output of common building brick in 1907 amounted to 1,351,591,000, valued at $7,201,525. In addition there were made 15,251,000 front and fancy pressed brick valued at $222,769, making an aggregate output of brick for building purposes of 1,366,842,000 valued at $7,424,294. The total number manufactured in the preceding year was 1,600,059,000 valued at $9,688,289, consisting of 1,575,434,000 common brick valued at $9,302,165 and 24,635,000 front and fancy brick valued at $386,124. The manufacture of building brick was carried on in 36 counties by a total of 205 companies or individuals. In 1906 there were 37 counties represented with a total of 213 producers while in 1905 there were 39 counties and 192 producers.

The average price received for common brick was $5.33 a thousand as compared with $5.98 a thousand in 1906 and $6.53 a thousand in 1905. Front and fancy pressed brick averaged $14.61 a thousand against $15.68 a thousand in 1906 and $16.20 a thousand in 1905. The prices are based on sales at the yards.

Production of common building brick

COUNTY	1906		1907	
	Number	Value	Number	Value
Albany	74 083 000	$461 399	60 210 000	$300 141
Broome	2 000 000	12 000	1 500 000	8 250
Cayuga	2 215 000	13 310	1 804 000	10 832
Chautauqua	8 567 000	52 031	7 967 000	49 876
Chemung	15 000 000	90 000	13 289 000	88 940
Clinton	800 000	4 800	650 000	4 250
Columbia	84 500 000	489 750	84 972 000	433 357
Dutchess	167 132 000	975 410	149 130 000	781 262
Erie	56 302 000	319 365	52 282 000	309 697
Greene	64 690 000	390 748	35 876 000	184 620
Jefferson	5 100 000	36 722	2 667 000	20 352
Monroe	26 077 000	158 463	25 198 000	148 462
Nassau	22 000 000	125 000	17 000 000	102 000
Niagara	2 172 000	10 832	2 681 000	16 282
Oneida	20 550 000	100 825	15 126 000	94 560
Onondaga	22 387 000	127 494	22 460 000	146 160
Ontario	3 510 000	21 700	2 600 000	18 200
Orange	189 180 000	1 170 695	154 502 000	789 297
Rensselaer	31 776 000	173 906	15 488 000	78 540
Richmond	34 769 000	172 880	39 205 000	180 569
Rockland	296 145 000	1 767 012	232 018 000	1 258 467

COUNTY	1906		1907	
	Number	Value	Number	Value
St Lawrence.....	a............	a..	800 000	$6 000
Saratoga........	70 509 000	$385 950	50 798 000	254 385
Seneca..........	6 050 000	36 400	a...........	a........
Steuben.........	4 705 000	31 800	3 287 000	29 818
Suffolk..........	21 710 000	137 500	20 130 000	124 610
Tompkins........	a............	a........	1 100 000	7 100
Ulster...........	252 665 000	1 465 457	260 404 000	1 322 476
Warren.........	a...........	a........	5 020 000	25 000
Washington......	3 300 000	18 100	2 750 000	14 300
Westchester.....	70 621 000	458 000	59 307 000	323 553
Other counties*b*..	16 919 000	94 606	11 370 000	70 169
Total.......	1 575 434 000	$9 302 165	1 351 591 000	$7 201 525

a Included under " other counties."
b Includes in 1906 the following: Allegany, Cattaraugus, Fulton, Herkimer, Livingston, Montgomery, St Lawrence, Schenectady, Tioga, Tompkins and Warren. In 1907 the following counties are included: Allegany, Cattaraugus, Fulton, Herkimer, Livingston, Montgomery, Schenectady and Seneca.

Hudson river region. The counties situated along the navigable stretch of the Hudson river constitute an exceptional region as regards the clay-working industry and deserve special consideration. No other part of the State, or indeed of the country, supports so extensive a development of brick manufacture. The district supplies practically all of the common grade of brick consumed in the building operations of New York and vicinity in which market it has a decisive advantage owing to the facilities for transport by water. The yards for the most part are placed close to the river so that the brick can be shipped to destination at a minimum of expense. In the nine counties included in the region there are more than 125 yards with a combined capacity of about one and a half billions a year.

Owing to the depressed state of the trade during 1907, there was a notable reduction in the output of the region as compared with that for the two preceding years when conditions were specially prosperous. The production of common brick reported by the 122 plants that were active aggregated 1,051,907,000 valued at $5,471,713. In 1906 the production, the largest on record, amounted to 1,230,692,000 valued at $7,352,377, distributed among 131 plants. There was thus a loss for the year of 178,785,000 in quantity and of $1,880,664 in value. The highest value for any year was reported in 1905 when the output of 1,219,318,000, the second largest ever reported, made by 119 plants, was valued at $8,191,211.

The average number of brick manufactured by each plant in 1907 was 8,622,000 as compared with 9,471,000 in 1906 and 10,246,000 in 1905. The price for the whole region averaged $5.20 a thousand against $5.98 a thousand in 1906 and $6.54 a thousand in 1905, showing a drop of 20 per cent in two years.

With the exception of Columbia and Ulster, all of the counties along the Hudson river reported a reduced output, the loss being proportioned more or less to the magnitude of the industry in each county. Ulster county showed a small gain and its output of 260,404,000 valued at $1,322,476 gave it first place, ahead of Rockland county which held that position in 1906. The latter which contributed 232,018,000 valued at $1,258,467 however, had the greater number of active plants with 31 as compared with 27 for Ulster county. Orange county ranked third in the list with a production of 154,502,000 valued at $789,297 made by nine plants.

Output of common brick in the Hudson river region in 1906

COUNTY	NUMBER OF PLANTS	OUTPUT	VALUE	AVERAGE PRICE PER M
Albany	11	74 083 000	$461 399	$6 23
Columbia	6	84 500 000	489 750	5 80
Dutchess	19	167 132 000	975 410	5 82
Greene	6	64 690 000	390 748	6 04
Orange	12	189 180 000	1 170 695	6 19
Rensselaer	9	31 776 000	173 906	5 48
Rockland	33	296 145 000	1 767 012	5 97
Ulster	26	252 665 000	1 465 457	5 80
Westchester	9	70 621 000	458 000	6 46
Total	131	1 230 692 000	$7 352 377	$5 98

Output of common brick in the Hudson river region in 1907

COUNTY	NUMBER OF PLANTS	OUTPUT	VALUE	AVERAGE PRICE PER M
Albany	10	60 210 000	$300 141	$4 99
Columbia	6	84 972 000	433 357	5 10
Dutchess	19	149 130 000	781 262	5 23
Greene	5	35 876 000	184 620	5 15
Orange	9	154 502 000	789 297	5 11
Rensselaer	7	15 488 000	78 540	5 07
Rockland	31	232 018 000	1 258 467	5 42
Ulster	27	260 404 000	1 322 476	5 08
Westchester	8	59 307 000	322 553	5 46
Total	122	1 051 907 000	$5 471 713	$5 20

The past year was uneventful in respect to the New York market. The large surplus amounting to about 300,000,000 carried over by the plants from the preceding year sufficed to meet the demand in the early months before the season for brickmaking began. Consequently the prices did not reach the high level that obtained in the first part of 1906, while there were no such fluctuations as characterized the market of that year. The range was mostly between $5 and $6 a thousand at the yard, with a tendency toward the lower value for most of the time. Some shipments were marketed for less than $5. With the severe depression that took place in the fall, building operations were curtailed to an extent as to effect a practical cessation of the demand for a time, and the manufacturers were left with an unusually heavy supply of unsold brick at the close of the year. The stocks at the yards along the river are estimated at over 300,000,000. While some improvement in the market conditions is to be expected for the current season, the production will probably show little if any gain.

Other clay materials

The manufacture of paving brick was carried on during 1907 in Greene, Onondaga and Steuben counties. There were four companies engaged in the business and the output was 12,296,000 valued at $184,306. In 1906 there were five companies which reported a production of 11,472,000 valued at $178,011. Chautauqua county which was represented in the list of counties manufacturing this article in 1906 made no output last year.

Fire brick and stove lining were manufactured in Albany, Chautauqua, Erie, Kings, Rensselaer, Richmond, Schenectady, Washington and Westchester counties by a total of 12 companies. The output of fire brick amounted in value to $384,217 and of stove lining to $239,816, a combined value of $624,033. In 1906 the value of the two materials was $527,659 reported by 13 companies. Onondaga county made a small production in 1906 but none last year.

Drain tile and sewer pipe were made in Albany, Cayuga, Erie, Genesee, Madison, Monroe, Oneida, Onondaga, Ontario, Saratoga, Steuben and Washington counties. The output of drain tile was valued at $162,167 against $166,645 in 1906; and sewer pipe at $463,500 against $95,142. The large gain in the production of sewer pipe was due to the restarting of a large plant in Monroe county. There were 19 companies engaged in these industries as compared with 26 in the preceding year. The list of counties in 1906 included Chautauqua, Kings, Seneca and Wayne in addition to those already enumerated.

The output of terra cotta, fireproofing and building tile came from Albany, Allegany, Chautauqua, Genesee, Kings, Monroe, New York, Onondaga, Queens, Rensselaer, Richmond and Ulster counties, with a total of 14 companies, or three less than in 1906. The production of terra cotta was valued at $1,224,300, against $1,037,387 in 1906; fireproofing at $45,672 against $120,282; and building tile at $215,126 against $217,475. Erie and Ontario counties reported no output last year, while Ulster county was represented for the first time.

New manufacturers of clay materials

The following list includes the names of companies or individuals who have erected plants during the past year or have taken over plants from other companies, for the manufacture of clay structural materials. The list is supplementary to the one published in the issue of this report for 1905 and together with the supplementary list contained in the report for 1906 gives the names of operators and location of plants corrected to date.

NAME	LOCATION OF PLANT
Chautauqua co.	
Dunkirk Ice & Fuel Co.	Dunkirk
Dutchess co.	
N. I. Pennock	Arlington
Oneida co.	
Mohawk Valley Brick Co.	Utica
Rensselaer co.	
Lane & Co.	Castleton
Tioga co.	
Tioga Red Brick Co.	Spencer
Tompkins co.	
Cook Brick & Tile Co.	East Ithaca
Ulster co.	
Empire Brick & Supply Co.	Glasco
Lengsholz & Diedling	Malden
Henry Toppin	Ulster Landing

Pottery

The manufacture of pottery has become an important branch of the clay-working industry of the State. Its development, however, has been due rather to the exceptional facilities afforded by the State for manufacturing and marketing the products than to the existence of natural resources of crude materials that are employed in the potteries. With the exception of the deposits of slip clay in Albany county and a limited supply of stoneware clays in Onondaga county, the raw materials are derived entirely from without the State. The kaolin used comes from New Jersey and from England, the feldspar from Canada, and much of the pottery clay from New Jersey.

In the accompanying table is shown the value of the pottery manufactures during the past three years. The total valuation of the product for 1907, as returned by the individual plants, was $2,240,895. The preceding year's output was valued at $1,795,008 and that of 1905 at $1,620,558. The growth of the industry during the period has been brought about by the increased production of the high grade products — porcelain and semiporcelain tablewares and electric and sanitary supplies. The manufacture of stoneware and earthenware has remained almost stationary. The products listed in the table under "Miscellaneous" include yellow and Rockingham wares, clay tobacco pipes, fire clay crucibles and artistic pottery.

There were 22 potteries that reported as active in 1907, the same number as in the two preceding years. They were distributed among the following counties: Albany, Chautauqua, Erie, Kings, Madison, Monroe, Nassau, Onondaga, Ontario, Schenectady, Suffolk, Washington and Wayne. Onondaga holds first place in point of production, with a total for 1907 valued at $1,095,958, as compared with $858,270 in 1906 and $718,985 in 1905. Kings county is the second largest producer, contributing an output valued at $343,121, against $306,105 in the preceding year and $308,443 in 1905.

Value of production of pottery

Ware	1905	1906	1907
Stoneware	$115 890	$84 031	$65 271
Red earthenware	30 740	30 234	28 296
*a*Porcelain and semiporcelain	800 000	835 000	1 181 162
Electric and sanitary supplies	600 325	768 236	869 378
Miscellaneous	73 603	77 507	96 788
Total	$1 620 558	$1 795 008	$2 240 895

a Includes china tableware.

Crude clay

In the foregoing tables relating to clay products no account has been taken of the crude clay entering into their manufacture. There are a few producers in the State who do not utilize the crude clay themselves, but ship their output to others for manufacture. Some of the material, like the Albany slip clay for example, is even forwarded to points without the State. In 1907 returns were received from four producers in this branch of the industry whose total shipments amounted to 3927 short tons valued at $6163. The corresponding total for 1906 was 5477 short tons valued at $9125 and for 1905 it was 6766 short tons with a value of $16,616.

DIATOMACEOUS EARTH

The production of diatomaceous or infusorial earth is carried on to a small extent in New York State. The deposits occur on the bottoms of the small Adirondack lakes, those in Herkimer county being best known, and are formed by the accumulation of the minute silicious skeletons of organisms inhabiting the waters. They attain a thickness up to 30 feet in White Lead lake from which the present supply is obtained. The material is excavated and purified by washing and settling in vats, after which it is compressed into cakes for shipment. According to an analysis published in the report for 1905 it contains about 86 per cent silica, 2 per cent or less of iron oxid, alumina and lime, and about 12 per cent water.

The earth is employed as an abrasive, particularly for polishing of metal surfaces, as a substitute for quartz in the manufacture of wood filler, and for various other purposes. The production reported in 1907 was made by George W. Searles of Herkimer.

EMERY

The source of the small quantity of emery produced in the State is near Peekskill, Westchester co. The material in crude state is a rock, made up of corundum, spinel and magnetite chiefly, and represents a phase of the basic igneous intrusions of that vicinity which are known as the Cortlandt series. The emery occurs as lenses and bands grading off at the edges into the country rock which is usually norite. The material was originally worked as an iron ore, but unsuccessfully owing to its refractory nature from the presence of so much alumina. In their geological relations the bodies resemble the titaniferous magnetites of the Adirondacks, a similarity that is strengthened by the fact that the analyses of the emery show a small percentage of titanium.

The production of emery in 1907 amounted to 1223 short tons, valued at $13,057. This is a little less than the production for the preceding year which totaled 1307 short tons valued at $13,870. In 1905 the output was 1475 short tons valued at $12,452 and in 1904, 1148 tons valued at $17,220. The valuation is based on the material at the quarries, where it undergoes only hand sorting and cobbing preparatory to shipment to outside points for grinding and manufacture into emery wheels, stones, cloth, etc.

The list of producers in 1907 includes the following: Blue Corundum Mining Co., Easton, Pa., Keystone Emery Mills, Frankford, Pa., Tanite Co., Stroudsburg, Pa., J. R. Lancaster, Peekskill, and J. H. Bugby, Peekskill. With the exception of J. R. Lancaster and J. H. Bugby, the companies mine the emery for their own use in connection with manufacturing plants.

FELDSPAR

The output of this mineral is won from occurrences of pegmatite that are found in the Adirondacks and in the southeastern section of the State. The quarries near Bedford, Westchester co., have supplied in recent years most of the feldspar suitable for pottery uses, while the Adirondack quarries have furnished material for roofing purposes, poultry grit and to a limited extent for pottery. Quartz is always associated with the feldspar and it is sometimes utilized as well.

The combined production of feldspar and quartz in 1907 amounted to 8723 long tons valued at $36,230. The total compares with 13,660 long tons valued at $44,350 in the preceding year. The value of the feldspar sold to pottery makers ranges from about $3 per ton for the crude to $7 per ton for the ground product, at the quarries or mills. The quantity sold for other purposes has not been included in the totals.

The quarries near Bedford, owned by P. H. Kinkel's Sons, have been the most important producers of pottery feldspar. A part of their output is ground before shipment. The quartz is sold to the Bridgeport Wood Finishing Co. for manufacture into wood filler. The Hobby quarry, in the town of Northcastle, opened by Otto Buresch, was also worked in 1907 by P. H. Kinkel's Sons. The feldspar occurs here in very large massive crystals, with little tendency toward the usual intergrowth with quartz, a feature of considerable importance in quarry work.

In the Adirondack region, the Claspka Mining Co. and the International Mineral Co. have been active during the past year. The quarry owned by the former company is situated near Batchellerville, Saratoga co., and the output is shipped to potteries. The International Mineral Co. has a quarry and mill near Rock pond, Essex co., west of Ticonderoga. The pegmatite is crushed and shipped unsorted for roofing material, for which purpose it takes the place of common gravel, but is considered superior to the latter owing to the fact that the feldspar with its smooth cleavage planes has greater adhesive properties when applied to tarred surfaces. The smaller sizes made in crushing the pegmatite are sold for poultry grit.

A new enterprise that began production in the early part of the present year is the Crown Point Spar Co., with a quarry near Crown Point, Essex co. The pegmatite occurs in the midst of gneissoid granite and apparently is a coarse phase of the granitic magma crystallized in place, since it shows little resemblance in form to a dike cutting the gneiss intrusively or to a vein occupying a fissure. It constitutes a mass that is traceable for several hundred feet along the strike and across the dip of the gneiss, and is as yet only partially explored. The quarry is situated near the eastern face of the ridge known as Breed's hill, 1½ miles south of Crown Point and ⅓ mile west of the Delaware & Hudson Railroad. A large mill has been erected close to the railroad, where the rock is conveyed by a cableway. The mill equipment is very complete and will enable the company to supply feldspar in any of the forms in which it is marketed. The pegmatite is an intergrowth of potash feldspar and quartz with a little mica and tourmalin. The separation of the minerals is effected entirely by mechanical means after crushing, whereas in other quarries the removal of the quartz and iron-bearing impurities is performed by hand cobbing. The feldspar belongs to the variety known as microcline, which has the same chemical composition as orthoclase, but differs in its crystallization.

GARNET

The abrasive garnet industry in the Adirondacks continued to progress during 1907, as shown by the output which exceeded all previous records, having been about 20 per cent larger than that for the preceding year. There were no new discoveries, and mining has been restricted to the usual localities.

The North River Garnet Co., owning property at Thirteenth lake, Warren co., is the largest operator in the region. The company has an unlimited supply of garnet rock which is obtained by open quarry work. The rock face now exposed measures 142 feet in hight, while there is known to be an extensive body below the level of the present workings. The material is crushed and concentrated mechanically by a process specially planned for the purpose by Mr F. C. Hooper. By the addition of another unit to the mill, the productive capacity has been raised to about 8000 or 9000 tons annually, which is considerably in excess of the present market requirements of the country.

The Gore mountain and Garnet peak properties near North River are worked during the open season, the former by H. H. Barton & Sons Co., and the latter by the American Glue Co. The garnet occurs in both places as large crystal masses in a hornblende gneiss. It is separated by hand cobbing.

On the slopes of Mt Bigelow in northern Essex co., about

5 miles south of Keeseville, there is a large body of nearly pure garnet that has been described in the issue of this report for 1905. In regard to geological features, the garnet shows a good deal of contrast to the other occurrences. Much of the material has a massive appearance, consisting of granular particles loosely bound together, though in places a tendency toward crystal structure may be observed. Exploratory operations have been conducted during the last two years by G. W. Smith of Keeseville, and a considerable quantity of the garnet was shipped in 1907 to American and foreign consumers.

The Adirondack localities furnished a total of 5709 short tons in 1907, valued at $174,800, as compared with 4729 short tons ($159,298) in the preceding year. The output during the first six months of the year was proportionately larger than in the latter half when the market fell off in sympathy with the general business depression.

GRAPHITE

The production of crystalline graphite during the past year has been attended by few developments of special interest. As heretofore, the American mine near Hague, Warren co., supplied most of the output. This mine, owned by the Joseph Dixon Crucible Co., has been operated steadily for many years and may be said to represent the only firmly established enterprise in the Adirondacks. Stimulated by its success, several other mines have been opened in the surrounding region, but in most cases without commensurate results.

The total reported by the companies in 1907 was 2,950,000 pounds, having a valuation of $106,951. The production in the preceding year was 2,811,582 pounds valued at $96,084, while in 1905 it was 3,897,616 pounds valued at $142,948. The average value of the graphite per pound was 3.6 cents in 1907, 3.4 cents in 1906 and 3.7 cents in 1905. There has thus been a shrinkage in the prices, as well as in the production since 1905, though a slight gain in both is shown for the last year over the corresponding figures for 1906.

The Crown Point Graphite Co. discontinued operations at the mine near Penfield pond, Essex co. A deposit near Eagle lake will be worked during the coming season, in preparation for which the present plant has been enlarged.

The Glens Falls Graphite Co. has erected a mill at the mine situated near Conklingville, 8 miles west of Hadley, Saratoga co. Only experimental runs have been made thus far. The deposit is reported to be extensive. It belongs to the sedimentary type, the graphite being distributed along the bedding or cleavage planes of a quartzite.

The Empire Graphite Co. has a property near Greenfield, Saratoga co., and began active work in the early part of 1908.

In St Lawrence county some attention has been given to a deposit occurring on the Indian river about 3 miles from Rossie village. The graphite forms the principal constituent of a schist, through the body of which it is distributed richly in very small scaly particles. It is a crystalline graphite, but too fine in size to be easily separated. Trial shipments of the crude material were reported to have given satisfactory results when used for foundry purposes.

The wide distribution of graphite in the Adirondack region undoubtedly makes it a promising field for prospecting and mining, but there are strict limitations surrounding the industry, the neglect of which on the part of the mining companies has led to many failures. The amount of capital expended in the erection of new milling plants and mine equipment during the last five years aggregates several hundred thousand dollars, and in many cases there has been little or no return for the outlay.

The separation and refining of graphite under the conditions presented by the Adirondack occurrences involve unusual difficulties. As described in previous reports, the deposits that have been the main sources of supply consist of disseminated flakes in a gangue that ranges from quartzite to a feldspar-quartz schist with a considerable percentage of dark silicates. While the graphite has a specific gravity somewhat below that of the accompanying minerals, the difference is not sufficient to make a separation by gravity methods alone practicable, and in fact is of less importance than the scaly habit of the mineral. The first separation is carried out by shaking tables, buddles or by the pneumatic jig, and the product secured, corresponding to the tailings in the concentration of metallic ores, contains a certain amount of slimes or dust and any other scaly minerals, as well as the graphite. The elimination of the granular impurities can be effected satisfactorily, if the graphite is relatively coarse, by the pneumatic or flotation methods of refining, but scaly silicates like mica are not readily removed.

Biotite and phlogopite are the varieties of mica commonly found in the graphite rock. Owing to their scaly habit and disseminated distribution they are somewhat difficult to distinguish from the graphite flakes in hand specimen, though under the microscope they are readily revealed by their transparency. A considerable percentage of mica will be discovered oftentimes in this way when microscopic examination fails to reveal its presence.

The size of the graphite flakes is another feature that must be taken into consideration. A rock carrying a coarse crystal, other things being equal, is the more desirable, since the economy and perfection of the separation process increase in direct relation to the size of the graphite. The coarse sizes also command higher prices in the market than the fine flake, under equal conditions of purity.

There is considerable variation in the crystallization of the graphite depending upon the character of the gangue. The schists and quartzites of the Adirondacks represent ancient sediments of the nature of sandstones and sandy shales which have been transformed under the influences of heat and pressure while they were deeply buried in the earth. The graphite is traceable to the carbonaceous constituents of plants or animals included in the sediments at the time of their deposition, and its formation which involves a distillation of the organic compounds with loss of the volatile parts was an accompaniment of the general metamorphism. It is to be expected that the graphite would show a more perfect crystal development in rocks that have been profoundly changed, and this is, in fact, the case. The schists of the eastern and interior parts of the Adirondacks carry a much coarser flake than the rocks on the western side which have been less metamorphosed. In the deposits of St Lawrence county, on the west, the flake is very fine, at times showing an approach to amorphous graphite. This is, of course, only true with respect to the deposits of organic nature in the sedimentary rocks. The graphite found in veins and dikes is quite uniform throughout the whole region, but such occurrences have little importance from an industrial standpoint.

GYPSUM

The production of gypsum is made in the central and western parts of the State, in Madison, Onondaga, Cayuga, Monroe, Genesee and Erie counties. The gypsum is associated with the Salina formation which carries the rock salt beds and is quarried or mined along the outcrop from Madison county westward. The Salina formation can be traced to the east into Albany county but with such diminishing thickness as to preclude the occurrence of workable gypsum deposits in that section.

Most of the workings are situated near the southern edge of the belt occupied by the Salina beds. The gypsum occurs below the Bertie waterlime which marks the top of the formation and above the salt horizon. Its beds are regularly disposed with respect to the inclosing rocks, dipping with them at a very low angle to the south. They afford a practically inexhaustible supply. Their greatest thickness along the outcrop is in Onondaga county where as much as 60 feet have been found, divided into several layers. In the western part of the State the beds range from 4 to 8 feet thick. Many of the borings for salt have encountered gypsum, showing its continuation for long distances to the south along the dip of the strata.

The present extensive utilization of gypsum in New York has been due to the establishment of plants for the manufacture of plaster of paris, stucco, wall plasters, etc., a branch of the industry that has grown to large proportions in the last decade. Formerly the principal outlet for the mineral was in agriculture which still affords a small market for the ground product. Another use that has become quite important is in the Portland cement trade; a considerable proportion of the gypsum listed in the accompanying table as sold in crude state is shipped to points in Pennsylvania and elsewhere for admixture with Portland cement.

The gypsum rock as found in New York has a gray or drab color. It contains a varying amount of impurities in the form of lime and magnesia carbonates, clay and silica or quartz, besides a small proportion of organic matter which is the principal coloring agent. In calcination the organic substances are broken up or driven off. The impurities on the average amount to from 5 to 15 per cent of the total.

The manufacture of calcined plasters is carried on in Syracuse and vicinity, at Wheatland and Garbutt, Monroe co., and at Oakfield, Genesee co.

Production and trade. With the exception of the last three months of the year, the demand for gypsum and gypsum materials was active, stimulating a largely increased output. The quantity of gypsum mined or quarried during the year was

323,323 short tons, as compared with 262,486 short tons in 1906; 191,860 short tons in 1905 and 151,445 short tons in 1904. The output has thus more than doubled within the last three years. It is to be expected from the present general conditions of business that there will be little if any advance made during the current year.

Of the total quantity of crude rock reported for 1907, about 70 per cent was calcined for plaster. The product of plaster of paris, wall plasters, etc., amounted to 222,502 short tons valued at $820,064, which compares with 163,451 short tons valued at $595,285 in the preceding year. The totals include only the quantities made from gypsum obtained in the State; some crude gypsum is imported each year from Canada and calcined in local plants. The amount of ground gypsum or land plaster made was 15,441 short tons valued at $38,859, against 20,656 short tons valued at $46,094 in 1906. The portion sold in crude state to Portland cement manufacturers and for other purposes amounted to 91,060 short tons valued at $179,432, against 34,626 short tons valued at $58,076 in the preceding year.

Production of gypsum

	1906		1907	
	Short tons	Value	Short tons	Value
Total output, crude	262 486	....	323 323	....
Sold crude	34 626	$58 076	91 060	$179 432
Ground for land plaster	20 656	46 094	15 441	38 859
Wall plaster etc. made	163 451	595 285	222 502	820 064
Total value	....	$699 455	....	$1 038 355

The Akron Gypsum Co. and the American Gypsum Co. made a production for the first time in 1907. Their properties are located near Akron, Erie co., where an excellent quality of rock is found, running as high as 95 per cent gypsum. The former company has a mill and warehouse under construction and will ship its output in manufactured form. The American Gypsum Co. sold the crude rock.

The Victor Gypsum Co. was engaged in the exploration of a property at Victor, Ontario co., but has made as yet no production.

The United States Gypsum Co. has taken over the quarry and mill of the Cayuga Plaster Co., at Union Springs, which has been operated in addition to its properties at Oakfield.

A new quarry has been opened at Jamesville, Onondaga co., by James E. Hubbell of Syracuse. The beds are reported to be 60 feet thick. Analyses furnished by Mr Hubbell show the following percentages:

	1	2
SiO_2	3.34	5.56
Fe_2O_3, Al_2O_3	2.92	1.88
$CaCO_3$	3.32	4.10
$MgCO_3$	2.69	3.32
$CaSO_4 2H_2O$ (Gypsum)	87.48	85.18
	99.75	100.04

No. 1 is a sample of soft weathered rock and No. 2 of the hard rock.

IRON ORES

The activity in the mining of iron ores during recent years was well maintained throughout most of 1907, as it was only in the last two or three months of the year that the production began to fall off in sympathy with the general business depression. The returns furnished by the mining companies show an advance sufficient to carry the production to a point above that recorded for any year since 1890, the total amounting to over 1,000,000 tons. With the increment supplied by the new enterprises, there would have been, undoubtedly, a still larger gain recorded for the present year if the market had continued favorable, but several mines have now suspended work and will await improved conditions before resuming.

There were 13 companies engaged in mining during the year, besides those carrying on exploratory or other preparatory work. This shows a gain of two over the number for the preceding year.

The accompanying table gives the production of iron ore, distributed according to kinds, for the period 1890–1907 inclusive. The statistics covering the years previous to 1904 are taken from the annual volumes of the *Mineral Resources* published by the

United States Geological Survey, while the figures from 1904 to date have been collected at this office. They represent marketable ores as shipped to the furnace and not the mine output which is considerably larger, since the greater portion of the magnetite ores is concentrated.

Production of iron ore in New York State

YEAR	MAGNETITE	HEMATITE	LIMONITE	CARBONATE	TOTAL	Total value	Value per ton
	Long tons	Long tons	Long tons	Long tons	Long tons		
1890	945 071	196 035	30 968	81 319	1 253 393	....	.....
1891	782 729	153 723	53 152	27 612	1 017 216	....	.....
1892	648 564	124 800	53 694	64 041	891 099	$2 379 267	$2 67
1893	440 693	15 890	35 592	41 947	534 122	1 222 934	2 29
1894	....	....	....	....	242 759	....	.....
1895	260 139	6 769	26 462	13 886	307 256	598 313	1 95
1896	346 015	10 789	12 288	16 385	385 477	780 932	2 03
1897	296 722	7 664	20 059	11 280	335 725	642 838	1 91
1898	155 551	6 400	14 000	4 000	179 951	350 999	1 95
1899	344 159	45 503	31 975	22 153	443 790	1 241 985	2 80
1900	345 714	44 467	44 891	6 413	441 485	1 103 817	2 50
1901	329 467	66 389	23 362	1 000	420 218	1 006 231	2 39
1902	451 570	91 075	12 676	Nil	555 321	1 362 987	2 45
1903	451 481	83 820	5 159	Nil	540 460	1 209 899	2 24
1904	559 575	54 128	5 000	Nil	619 103	1 328 894	2 15
1905	739 736	79 313	8 000	Nil	827 049	2 576 123	3 11
1906	717 365	187 002	1 000	Nil	905 367	3 393 609	3 75
1907	853 579	164 434	Nil	Nil	1 018 013	3 750 493	3 68

The total shipments reported by the mines in 1907 amounted to 1,018,013 long tons, valued at $3,750,493. As compared with the preceding year when the shipments were 905,367 tons valued at $3,393,609, there was an increase in output of 112,646 tons or about 12 per cent.

Classified as to variety the shipments consisted of 853,579 tons of magnetite and 164,434 tons of hematite. Of the magnetite 499,895 tons were marketed in the form of concentrates with an approximate content of 65 per cent iron. The 353,684 tons of lump magnetite included in the total are estimated to average 60 per cent iron. The hematite and limonite range from 40 to 60 per cent, with an average probably of 45 per cent.

The 499,895 tons of magnetite concentrates were made from approximately 818,467 tons of crude ore. The mine output or amount of ore hoisted during 1907 was thus 1,336,585 long tons which compares with 1,154,814 long tons in 1906 and 1,109,385 long tons in 1905. Based on the crude ore, the output last year was probably as large as that recorded for any previous year in New York State.

Of the magnetite 801,820 tons were derived from the Adirondacks. The producers in that region included Witherbee, Sherman & Co., and the Port Henry Iron Ore Co., at Mineville; the Chateaugay Ore & Iron Co., at Lyon Mountain; and the Benson Mines Co., at Benson Mines. The Arnold Mining Co. at Arnold was inactive. In southeastern New York, the Hudson Iron Co., operating the Forest of Dean mine and the Sterling Iron & Railway Co., operating the Lake mine were the only ones to report a production.

Of the output of hematite 55,409 tons were reported by the Rossie Iron Ore Co., and the Old Sterling Iron Co., who own mines near Antwerp, St Lawrence co., and 109,025 tons by the producers of oolitic and fossil hematite from the Clinton formation. The latter producers were as follows: Franklin Iron Manufacturing Co., and C. A. Borst, Clinton; Fair Haven Iron Co., Sterling; Furnaceville Iron Ore Co., and Ontario Iron Ore Co., Ontario Center. The Fair Haven Iron Ore Co. and the Ontario Iron Ore Co. made their first shipments in 1907.

Several new developments have been under way during the year. In the Adirondacks, the Cheever mine near Port Henry which has been closed down for the last 15 years, was reopened and equipped with a mill of 300 tons daily capacity. The company expected to begin shipments the present season. The exploration of the titaniferous magnetite deposits at Lake Sanford in the central part of the Adirondacks, mentioned in the preceding issue of this report was prosecuted with energy and surveys have been nearly completed for a railroad to afford access to the locality from Lake Champlain, some 40 miles distant. The results of test borings on the property have been favorable in respect to the continuation of the deposits in depth.

In Wayne county, on the western section of the Clinton deposits, there has been unusual activity and large tracts of land situated along the outcrop of the ore have been taken over by mining companies. The Furnaceville Iron Co. is the pioneer among the latter, while the Wayne Iron Ore Co., the Lake Ontario Iron Ore Co., and the Rochester Iron Ore Co. were organized in 1907. A large amount of exploration has been performed in Wayne and Cayuga counties, and with the restoration of former market conditions, it may be expected that extensive mining operations will be instituted.

Mineville. The output of ore from this locality in 1907 was probably the largest on record, and was considerably in excess of that reported for any recent year. A total of about 750,000 tons was hoisted from the mines of Witherbee, Sherman & Co., and the Port Henry Iron Ore Co. The so called Old Bed mine group which includes the "21," Joker and Bonanza workings furnished the greater part of the output, but the Harmony shafts of Witherbee, Sherman & Co. contributed a considerable share The expansion of mining has been made possible by the addition of the power facilities from the new electric station on the lake side at Port Henry. This plant supplying 800 kw. was placed in operation during the past year.

The Port Henry Iron Ore Co., has been engaged in sinking its new shaft on the "21" property east of the Bonanza shaft. It will have a vertical depth of 500 feet, with crosscuts at intervals of 80 feet extending into the ore body. It is divided into three compartments of which two are for hoisting and will have a capacity of 1500 tons a day. This will more than double the former output of the mine, bringing the total hoisting capacity of the two companies up to fully 1,000,000 tons annually.

Mining is to be resumed on the Barton hill group which has lain idle for several years. The group comprises a number of openings made at intervals along a practically continuous bed that lies to the west of the Old Bed mines and extends 3500 feet in a northerly direction over the shoulder of Barton hill. An adit starting from the Arch pit near the middle of the bed is under construction and will give an outlet to the surface for the ore in the northern section where recent exploration has disclosed the existence of bodies hitherto unworked.

Benson mines. This property belonging to the Magnetic Iron Ore Co. has been taken over by the Benson Mines Co., and was again placed in operation in the fall of 1907 after making improvements in the mining and milling equipment. Altogether about $150,000 was expended in bringing the installation up to date.

The deposits are low grade, averaging about 35 per cent iron, but they rank among the largest in the Adirondacks. In their general character they resemble those at Lyon Mountain; they consist of bands of the country gneiss carrying magnetite in disseminated grains more or less evenly distributed through the mass of the rock. A width of over 200 feet is shown in the old workings, while the ore can be traced by outcrops of magnetic attraction for a distance of over 2 miles along the strike.

The deposits are worked by open-cast or quarry methods. Under the present management some innovations have been made that are superior as regards economy over the ordinary methods in use in the Adirondack region. Instead of percussion drills of small caliber, shot drills capable of boring 4 inch holes to a depth of 50 feet are employed. The holes are heavily loaded with dynamite and break down an enormous quantity of the ore at one time. The large blocks are then broken up by secondary drilling and blasting into sizes within the capacity of the crushers. The ore is loaded by steam shovel on to cars for transport to the mill, where the first crushing is performed by a pair of 6 foot rolls. The ore then passes to smaller rolls which reduce it to the size required in the separation.

The company intends to erect a new mill in the near future, if the results of present operations are satisfactory. The ore bodies have been tested, it is said, to a depth of 600 feet on the dip, without encountering any marked change in their character.

Lake mine. The Sterling Iron & Railway Co. operated this mine during 1907. The ore body is the same one that is tapped by the celebrated Sterling mine which was located in 1750 and furnished ore for a local furnace built the following year. The underground workings approach to within a few feet of the Sterling and extend under Sterling lake. The ore is a non-Bessemer fairly rich magnetite. The following analysis is taken from Putnam's report.

Iron	57.25
Sulfur	.088
Phosphorus	1.205
Manganese	present

MILLSTONES

A small output of millstones is made each year in Ulster county, where the industry has been established for over a century, still furnishing a great part of the domestic millstones used in this country. The product is known in the trade as Esopus stone, from the early name of Kingston which was once the principal point of shipment.

The millstones are quarried from the Shawangunk grit, a light gray quartz conglomerate found along the Shawangunk mountain from near High Falls southwest toward the Pennsylvania border. The Cocalico stone obtained in Lancaster county, Pa., and the Brush mountain stone, found in Montgomery co., Va., are of similar character. In Ulster county the grit rests in unconformable position upon Hudson River shales and is overlain in places by a red shale. It has generally been correlated with the Oneida conglomerate of central New York to which it has some physical resemblance, but recent investigations have shown quite conclusively that it belongs higher up in the stratigraphic series in the horizon of the Salina. Its thickness in Ulster county ranges from 50 to 200 feet.

The grit is composed of quartz pebbles of milky color surrounded by a silicious matrix. The pebbles are of subangular form and vary from a fraction of an inch to 2 inches in diameter. The texture is an important factor in determining the value and particular use of the finished millstones.

The size of the stones marketed ranges from 15 to 90 inches. The greater demand is for the smaller and medium sizes, with diameters of 24, 30, 36, 42 and 48 inches. A pair of 30-inch millstones commonly sells for $15, while $50 may be paid for a single stone 60 inches in diameter. The largest sizes bring from $50 to $100. Besides the common type of millstones, disks are furnished which are employed in a roll type of crusher known as a chaser. The pavement of such crushers is also supplied by the quarrymen, in the form of blocks. Quartz, feldspar and barytes are commonly ground in chasers.

Most of the Ulster county quarries are situated along the northern edge of the Shawangunk mountain. Kyserike, St Josen, Granite and Kerhonkson are the principal centers of the industry while the distributing points include New Paltz and Kingston in addition to those named. The industry is carried on intermittently, many of the producers engaging in other occupations during a part of the year.

The market for millstones has been curtailed of late years by the introduction of rolls, ball mills and other improved forms of grinding machinery. The roller mill process has displaced the old type of cereal mills, particularly in grinding wheat. The small corn mills distributed throughout the southern states, however, still use millstones and furnish one of the important markets for the New York quarries. A part of the product is sold also to cement and talc manufacturers.

Besides the uses that have been enumerated, it would seem probable that the Ulster county grit might be well adapted for the lining of pebble mills, an application which has not been attempted, hitherto, so far as known. Such mills are employed quite extensively for fine grinding of feldspar and other hard materials. They are usually lined with imported French rock which is furnished in small blocks dressed to the required shape. In its general freedom from iron or other coloring agents, the grit fulfils one of the important requisites for such material, but its wearing qualities under the severe conditions can not be determined except by actual test.

The production of millstones in 1907 amounted to a value of $21,806, as compared with $22,442 in 1906 and $22,944 in 1905. The production includes also the blocks and disks quarried and sold for roll crushers. At one time the output of Ulster county was valued at over $100,000 annually.

MINERAL PAINT

The term mineral paint is here used to designate the natural mineral colors obtained by grinding an ore or rock. The materials suitable for this purpose that are found in New York State include iron ore, shale, slate and ocher.

For metallic paint and mortar colors some form of iron ore, generally hematite or limonite, is commonly employed, but only a few localities are known where the ore possesses the requisite qualities of color and durability. The fossil hematite from the Clinton formation is perhaps most widely used in this country. The mines owned by C. A. Borst at Clinton, Oneida co., and those of the Furnaceville Iron Co. at Ontario, Wayne co., supply much of the crude material. The red hematite mined by the Rossie Iron Ore Co. at Rossie, St Lawrence co., also yields a good metallic paint.

Mineral paint made from shale and slate is quite extensively used for wooden structures. When there is a considerable percentage of iron oxids present, the shale and slate may be sold for metallic paint. Their value depends largely upon the depth and durability of their color; but the degree of natural fineness and the amount of oil required in mixing must also be considered in determining their utility. At Randolph, Cattaraugus co., beds of green, brown and bluish shale occur in the Chemung formation. They are worked by the Elko Paint Co. In years past red shale has been obtained in Herkimer county from the Vernon beds at the base of the Salina. A similar material occurring in the Catskill series has been worked at Roxbury, Delaware co. The red slate of Washington county, which belongs in the Cambric, is also ground for paint. The Algonquin Red Slate Co. of Worcester, Mass., and A. J. Hurd of Eagle Bridge produce this material.

A product known as mineral black is made by grinding slate found in the Hudson River series.

The ferruginous clay called ocher occurs quite commonly in the State, but no deposits are exploited at present. A bed occurring on Crane mountain, Washington co., once supplied a considerable quantity.

Sienna, a variety of ocher, occurs near Whitehall. The deposit is a thin stratum in glacial drift and has been worked on a small scale.

In addition to the producers above mentioned, the Clinton Metallic Paint Co., of Clinton, and the William Connors Paint Manufacturing Co., of Troy, are engaged in the manufacture of mineral paints from New York materials.

The production of mineral paints in 1907 was as follows: metallic paint and mortar color, 5269 short tons valued at $59,521; slate pigment, 620 short tons valued at $3700. In the year 1906 the following quantities were reported: metallic paint and mortar color, 2714 short tons valued at $29,140; slate pigment, 2045 short tons valued at $15,960. These quantities include only the output made within the State from local materials. A part of the ore and rock is shipped each year to points outside of the State for manufacture. An output of 9667 long tons valued at $24,185 was reported in 1907 by four firms who sell the crude ore or rock to paint grinders. In the preceding year the corresponding total was 9382 tons valued at $22,949.

MINERAL SPRINGS

The mineral springs of New York afford a variety of waters suited for medicinal and table uses. There are over 200 springs in the State that have been listed and classified according to the nature of their dissolved mineral ingredients, though many have no commercial application, except perhaps for local consumption. Some of the spring localities — like Saratoga Springs, Ballston Springs and Richfield Springs — are popular resorts during the summer season and in this way the waters afford an indirect but very important source of income.

Among the spring waters that contain mineral ingredients in appreciable quantity, those characterized by the presence of alkalis and alkaline earths are the most abundant in this State. The dissolved bases may exist in association with chlorin and carbon dioxid, as is the case with the springs of Saratoga county, or they may be associated chiefly with sulfuric acid as illustrated by the Sharon and Clifton Springs.

The mineral waters of Saratoga Springs and Ballston are found along fractured zones in Lower Siluric strata, the reservoirs occuring usually in the Trenton limestone. They are accompanied by free carbon dioxid, which together with chlorin, sodium, potassium, calcium and magnesium exists also in dissolved condition. The amount of solid constituents in the different waters varies from less than 100 to over 500 grains per gallon. Large quantities of table and medicinal waters are bottled at the springs for shipment to all parts of the country. The carbon dioxid which issues from the wells at Saratoga is likewise an important article of commerce.

The waters at Richfield Springs contain the elements of the alkali and alkaline earth groups together with sulfuric acid and smaller amounts of chlorin, carbon dioxid and sulfureted hydrogen. They are employed for medicinal baths as well as for drinking purposes. The springs issue along the contact of Siluric limestone and Devonic shales. Sharon Springs is situated to the east of Richfield Springs and near the contact of the Lower and Upper Siluric. Clifton Springs, Ontario co., and Massena Springs, St Lawrence co., are among the localities where sulfureted waters occur and are utilized.

The Oak Orchard springs in the town of Byron, Genesee co., are noteworthy for their acid waters which contain a considerable proportion of aluminum, iron calcium and magnesium, besides free sulfuric acid.

The Lebanon spring, Columbia co., is the single representative in the State of the class of thermal springs. It has a temperature of 75° F. and is slightly charged with carbon dioxid and nitrogen.

A branch of the industry that has recently assumed considerable importance in New York State is the sale of spring waters which can not be classed as mineral in the usual sense of the term, but find wide use as potable waters on account of their freedom from harmful impureties. Such waters are usually shipped in bulk to the principal cities where they are bottled and distributed by wagons among the individual consumers. The Great Bear spring at Fulton and the Deep Rock spring at Oswego are examples of this class of springs.

The following list includes the names of the leading springs in the State which are employed for commercial purposes or have recently been so employed:

NAME	LOCALITY
Baldwin Mineral Spring	Cayuga, Cayuga co.
Chautauqua Lithia Spring	Westfield, Chautauqua co.
Breesport Oxygenated Mineral Spring	Breesport, Chemung co.
Chemung Spring	Chemung, Chemung co.
Magnetic Flint Rock Spring	Elmira, Chemung co.
Rockdale Mineral Spring	Rockdale, Chenango co.
Lebanon Mineral Spring	Lebanon Springs, Columbia co.
Mount View Spring	Poughkeepsie, Dutchess co.
Ayers Amherst Mineral Spring	Williamsville, Erie co.
Avon Sulphur Springs	Avon, Livingston co.
Artesian Natural Mineral Spring	Franklin Springs, Oneida co.
Glacier Spring	Franklin Springs, Oneida co.
Kirkland Spring	Franklin Springs, Oneida co.
Split Rock Spring	Franklin Springs, Oneida co.
Geneva Lithia Mineral Water Spring	Geneva, Ontario co.
Crystal Springs	Oswego, Oswego co.
Deep Rock Spring	Oswego, Oswego co.
Great Bear Spring	Fulton, Oswego co.
White Sulphur Springs	Ritchfield Springs, Otsego co.
Massena Spring	Massena Springs, St Lawrence co.
Artesian Lithia Spring	Ballston Spa, Saratoga co.
Arondack Spring	Saratoga Springs, Saratoga co.
Champion Spring	Saratoga Springs, Saratoga co.
Chief Spring	Saratoga Springs, Saratoga co.
Congress Spring	Saratoga Springs, Saratoga co.
Empire Spring	Saratoga Springs, Saratoga co.
Eureka White Sulphur and Mineral Spring	Saratoga Springs, Saratoga co.
Geyser Spring	Saratoga Springs, Saratoga co.
Hathorn Spring	Saratoga Springs, Saratoga co.
Hides Franklin Spring	Saratoga Springs, Saratoga co.
High Rock Spring	Saratoga Springs, Saratoga co.
Lincoln Spring	Saratoga Springs, Saratoga co.
Patterson Mineral Spring	Saratoga Springs, Saratoga co.
Royal Vichy Spring	Saratoga Springs, Saratoga co.
Saratoga Carlsbad Spring	Saratoga Springs, Saratoga co.
Saratoga Seltzer Spring	Saratoga Springs, Saratoga co.
Saratoga Victoria Spring	Saratoga Springs, Saratoga co.
Star Spring	Saratoga Springs, Saratoga co.
Washington Lithia Spring	Ballston Spa, Saratoga co.
Chalybeate Spring	Sharon Springs, Schoharie co.
Magnesia Spring	Sharon Springs, Schoharie co.
White Sulphur Spring	Sharon Springs, Schoharie co.
Red Jacket Mineral Spring	Seneca Falls, Seneca co.
Pleasant Valley Mineral Spring	Rheims, Steuben co.
Sulphur Spring	Hornby, Steuben co.
Setauket Spring	East Setauket, Suffolk co.
Big Indian Spring	Ellenville, Ulster co.
Elixir Spring	Clintondale, Ulster co.
Vita Spring	Fort Edward, Washington co.
Clyde Mineral Spring	Clyde, Wayne co.

The industry in connection with the production and sale of spring waters has attained to large proportions and promises to show continued growth. The quantity marketed at present may be estimated at fully 8,000,000 gallons a year with a value of about $1,000,000. Approximately one half of the total value is represented by sales of mineral waters from Saratoga co. The figures given are estimates based on a partial canvass of the industry. A more accurate statement of the production is impracticable owing to the many changes that take place in the industry each year. The commercial utilization of many springs is transitory and others are employed only locally for supplying hotels, sanatoriums, etc. It is believed, however, that the estimate is close to the actual production.

NATURAL GAS

The production of natural gas for lighting and heating purposes has been carried on in New York since the first part of the preceding century. It is recorded that the village of Fredonia, Chautauqua co., was illuminated by gas supplied from local wells as early as 1825, an event attracting widespread interest at the time and no doubt a precursor of the extensive exploitation of the natural gas fields in other sections of the country. Following this development came the discoveries of the pools in Cattaraugus county which began about 1865, and later those in Allegany county, a result of explorations conducted for petroleum. Within the last 20 years there has been a great expansion in the industry and gas wells are now scattered over most of the western part of the State, including 15 counties which are active producers.

Geological occurrence. The range of the productive gas pools geologically may be said to extend from the base of the Paleozoic sedimentary formations, the Potsdam sandstone, to the Chemung and Portage formations of the Devonic which are near the top of the Paleozoic series as represented in New York. Certain formations, however, are more prolific than others, and the wells in each field, as a rule, derive their main supply from a definite horizon.

Though small amounts of gas have been found in sandstones correlated with the Potsdam, the lowest beds which are the source of any considerable flow are the limestones of Trenton age. The wells of Oswego and Onondaga counties now supplying gas are bottomed in the Trenton, though in many instances secondary contributions are derived from the overlying Utica shale. Elsewhere, as in Oneida and Jefferson counties, these limestones have not afforded any durable supply.

The next higher horizon of importance is at the base of the Lower Siluric and includes the Medina sandstone and its eastern representative, the Oswego sandstone. The occurrence of pools in this formation is of recent discovery, but they now yield a very large portion of the production. The principal field, opened since 1890, is in Erie county beginning near Buffalo and extending eastward through the towns of Cheektowaga, Amherst, Lancaster, Clarence, Alden and Newstead. A second field occurs south of Buffalo between that city and Jewettville. The wells at Avon and Caledonia, Livingston co., are said to reach the Medina. In the last two years large pools have been encountered in what is regarded as the white Medina sandstone in northern Chautauqua county, notably at Westfield and Silver Creek. The recent discoveries at Pavilion, Genesee co., are likewise reported to be in that formation.

The remaining formations of the Lower Siluric are made up mostly of shales and limestones. They appear to be relatively poor reservoirs for gas.

In the Devonic system, practically all of the formations represented in western New York have been found to contain gas at one or more localities. The most prolific, undoubtedly, are the upper members, the Portage and Chemung shales and sandstones. They are tapped by numerous wells in Allegany, Cattaraugus and Chautauqua counties. The principal gas supplies are derived from southern Allegany and Cattaraugus counties, from the same fields which yield petroleum. Many of the wells yield both gas and oil, and a part of the gas is consumed locally in operating the oil pumps, while the remainder is run into pipe lines for distribution in the neighboring cities and villages. The original wells put down in the Lake Shore belt of Chautauqua county, at Fredonia, Brocton, Mayville and Ripley seem to have found the gas mainly in the Chemung shales. The deeper wells that were drilled later encountered reservoirs at different horizons below the Chemung, as far down as the Medina. The Marcellus and Onondaga formations of the Devonic are considered by Bishop[1] to be the sources of the gas at Gowanda, in northern Cattaraugus county.

[1]Oil and Gas in Southwestern New York. N. Y. State Geol. 19th An. Rep't. 1901, p. 116.

The geographical limits of the gas fields can only be broadly defined, but it is observable that with one or two exceptions they are situated in the western section of the State in the middle and southern tiers of counties. The wells of Oswego county, near the end of Lake Ontario, represent the most easterly points at which the presence of gas in quantity has been established, and there the pools seem to be confined to small areas. The disturbed condition of the strata has, no doubt, militated against the accumulation of gas in the eastern section of the State.

Production. There are about 850 productive gas wells distributed among the different counties and owned by 150 individuals and companies. Most of the wells in Chautauqua county are operated for private use and their combined output is small. Aside from them, the production is in the control of a relatively few companies who have pipe lines and distribute the gas for general consumption.

The production during the past four years is shown in the accompanying table, which gives the value of the output for the leading counties. The total value in 1907 amounted to $800,014, which is an increase of $33,435 over the value returned for the preceding year.

Production of natural gas

COUNTY	1904	1905	1906	1907
Allegany-Cattaraugus	$183 830	$204 430	$247 208	$250 159
Chautauqua	31 822	26 232	94 345	106 411
Erie	254 899	281 253	317 554	320 199
*a*Livingston	32 451	41 805	52 805	55 780
Onondaga	15 350	16 825	16 385	17 030
Oswego	14 990	13 583	13 182	10 585
*b*Wyoming	18 855	22 872	25 100	39 850
Total	$552 197	$607 000	$766 579	$800 014

a Includes also Seneca, Schuyler, Steuben, Ontario and Yates counties.
b Includes also Niagara and Genesee counties.

The quantity of gas produced in 1907 was approximately 3,052,145,000 cubic feet. In arriving at this total, estimates are included for certain producers who were unable to supply exact figures, but as it is only the smaller operators who do not keep records of their wells, the estimate is very close to the actual production. No account is made, however, of the gas consumed by oil companies for pumping. The quantity of gas yielded by the wells in 1906 was 3,007,086,000 cubic feet, in 1905, 2,639,130,000 cubic feet and in 1904, 2,399,987,000 cubic feet. The average value of the natural gas varies according to locality from a minimum of 18 cents to a maximum of 50 cents a thousand cubic feet. The general average for the whole State in recent years has been about 25 cents.

New developments. There has been an average amount of drilling done during the past year and the additional supplies from new wells have more than sufficed to keep up the production.

In Chautauqua county, the Frost Gas Co. put down another well at Sheridan where it first began producing two years ago The new well is said to have given an indicated flow of 2,500,000 cubic feet a day. The South Shore Gas Co. also opened a successful well at a depth of 2100 feet at Sheridan. At Westfield the Welch Gas Co. drilled its fourth well, which attained a depth of 2340 feet. After shooting, a flow of 350,000 feet a day was registered, apparently from the Medina sandstone. In exploring for oil at Levant, in the southeastern part of the county, a gas reservoir was tapped at 1200 feet depth showing a pressure of 125 pounds. The exploration of a large tract of land near Gerry is in prospect where options have been secured for that purpose by O. M. Burdick and A. L. Shaner of Bolivar.

A well flowing 200,000 cubic feet a day was put down at Elma, Erie co., and others are to be drilled during the current year. It is intended to use the gas at Elma. A successful well has been located at Ebenezer by William Vogel, the reservoir being tapped at 1600 feet.

The Pavilion Natural Gas Co. continued drilling at Pavilion, Genesee co., where important discoveries were made in 1906. The company now has nine producing wells with an indicated capacity of 10,000,000 cubic feet. The gas is supplied to the villages of Leroy and Pavilion. A well drilled on the Charles Kane farm gave an estimated flow of 2,500,000 cubic feet when first opened. The Alden-Batavia Natural Gas Co. has begun exploration at Darien in southwestern Genesee county.

A new development at Naples, Ontario co., is a well located in the valley just west of the village. Gas was found at 1092 feet depth. There are four old wells on the east side of the valley. Plans have been formed for the exploration of a large tract of land near Reed's Corners, east of Canandaigua, by a Pittsburg company.

In Steuben county, the North Side Gas & Oil Co. continued the drilling of a well at Ferenbaugh which was started in 1906. After encountering a small flow at 250 feet, the hole was carried down to 2100 feet and shot, but registered less than 40,000 feet a day. A second well of nearly equal depth gave no results. The Steuben Oil and Gas Co. of Hammondsport will sink a test well near Keuka. Drilling has been started near Canisteo on the farm of James E. Wilson. The exploration of the Troupsberg field has been discontinued for lack of success.

PETROLEUM

The oil pools found in New York State constitute the northern extension of the Appalachian field which reaches its main development in Pennsylvania, Ohio and West Virginia. They underlie small areas in Cattaraugus, Allegany and Steuben counties near the Pennsylvania border. The first well was drilled in Cattaraugus county in 1865, while Allegany county began producing about 1880. The oil is encountered in fine-grained sandstones of dark color belonging to the Chemung formation of the Upper Devonic.

In Cattaraugus county the productive area embraces about 40 square miles, mostly in Olean, Allegany and Carrolton townships. The pools occur at several horizons from 600 to 1800 feet below the surface. The principal ones are the Ricebrook, Chipmunk, Allegany and Flatstone.

The oil field of Allegany county extends across the southern townships of Clarksville, Genesee, Wirt, Bolivar, Alma, Scio and Andover and is divided into several pools that are considered to be more or less independent. The Bolivar, Richburg and Wirt pools have been most productive. The oil is found at depths from 1400 to 1800 feet. The Andover pool lies partly in the town of West Union, Steuben co., and is tapped by wells from 850 to 1000 feet in depth. The discovery of oil in the town of Granger, on the Livingston county border has been in some respects the most noteworthy addition to the productive area of late years, since the pool is much farther north than any heretofore found in the State.

There has been little change in the production of petroleum for several years past, though the drilling of new wells is not so actively prosecuted as formerly; the maintenance of the output at a nearly constant level may be ascribed in a large degree to the relative permanency of the pools. Practically all of the production is obtained by pumping. By using gas engines which are fed by the natural gas that accompanies the petroleum the pumps can be worked at small expense and wells yielding less than a barrel a day are profitable. The product is transported to the refineries by pipe lines. The following companies handle practically all of the output within the State: The Allegany Pipe Line Co., Columbia Pipe Line Co., Union Pipe Line Co., and Fords Brook Pipe Line Co., all of Wellsville; Vacuum Oil Co., of Rochester, and the Tide Water Pipe Co., Limited, of Bradford, Pa.

The output of petroleum in 1907 amounted to 1,052,324 barrels, as compared with 1,043,088 barrels in the preceding year. The following table shows the total for each year since 1891. The statistics subsequent to 1903 have been compiled from the receipts of oil reported by the companies above mentioned, while the others are taken from the annual volumes of the *Mineral Resources*.

*a*Production of petroleum in New York

YEAR	BARRELS	VALUE
1891	1 585 030	$1 061 970
1892	1 273 343	708 297
1893	1 031 391	660 000
1894	942 431	790 464
1895	912 948	1 240 468
1896	1 205 220	1 420 653
1897	1 279 155	1 005 736
1898	1 205 250	1 098 284
1899	1 320 909	1 708 926
1900	1 300 925	1 759 501
1901	1 206 618	1 460 008
1902	1 119 730	1 530 852
1903	1 162 978	1 849 135
1904	1 036 179	1 709 770
1905	949 511	1 566 931
1906	1 043 088	1 721 095
1907	1 052 324	1 736 335

a The statistics for the years 1891–1903 inclusive are taken from the annual volumes of the *Mineral Resources*.

During 1907 the exploration of the newly opened Short Tract or Granger district in northern Allegany county was carried on with vigor and additional discoveries are reported. This district was prospected to some extent five or six years ago, but without definitely establishing the presence of oil. The first of the productive wells is located on the Van Nostrand farm, 5 miles from Fillmore. An area of about 1000 acres in the vicinity has been proved to show good indications. The construction of a pipe to connect the wells with the railroad at Fillmore was begun during the year. The oil is clear and light in color and gravity, closely resembling the product from the Tiona field of Pennsylvania. Some of the wells when first opened flow under natural pressure.

Discoveries of oil were reported from Rexville, and in the town of Wayne, Steuben co., but as yet nothing definite can be stated concerning their importance.

PYRITE

As was anticipated in the preceding issue of this report, the pyrite industry of St Lawrence county experienced a notable advance during the past year. The production amounted to 49,978 long tons, as compared with 11,798 long tons in 1906 and 10,100 long tons in 1905, and was the largest ever recorded in the State. The St Lawrence Pyrite Co. at Stellaville and the American Pyrites Co. at Gouverneur were in active operation, the latter company, however, closing down its plant in July.

The property of the St Lawrence Pyrite Co. is situated 1 mile north of Hermon and includes the old Stella mine, the first to be opened in the district. This is not worked at present. The ore is taken from two new mines, to the southeast of the Stella shaft, developed since 1904 when the present company acquired the property. Most of the output is obtained from the mine adjacent to the mill. The other mine, situated ¼ mile south, is still in the development stage though producing some ore. An average of from 250 to 300 tons daily is mined. The whole mine output goes to the mill where it is concentrated to a product assaying from 47 to 48 per cent sulfur. A preliminary crushing is performed at the mine shafts by means of jaw crushers which discharge directly into cars. The ore passes through a Gates gyratory crusher and rolls at the mills. The first concentration is effected by Hancock jigs, while the middlings from this treatment are recrushed by rolls and reconcentrated on Hartz jigs. The slimes are passed over Overstrom tables. The mill has a nominal capacity of 500 tons crude ore a day.

The ore bodies have much similarity of shape and geological relations to the magnetites of the western Adirondacks. They are of lenticular form with their axes of extension alined parallel to the foliation of the wall rock, but often show a pitch across the dip. They range up to 30 feet thick. They occur in overlapping series sometimes closely set and again separated by varying thicknesses of the wall rock. The country is a dark hornblende-biotite schist belonging to the sedimentary or Grenville series of Adirondack formations.

The pyrite occurs in coarse particles and aggregates which only occasionally show crystal boundaries. The gangue consists mainly of vein quartz. Zinc blende is a common accompaniment, and pyrrhotite is encountered at times in considerable bodies. Though inclosed by sediments the deposits can scarcely be construed as original beds of contemporaneous formation, but their genesis probably has been parallel to that of the magnetites found in the Grenville which are always pyritic and not rarely richly so. There are no well defined walls, for the mineralization extends outward into the schist for some distance beyond the limits of the pay ore. The pyrite seems to have impregnated and replaced the schist to a great extent, at the same time filling small fissures and seams along the bedding planes. Its origin is traceable to iron-bearing solutions which have circulated through the schist when it was probably at considerable depth from the surface and perhaps in a less metamorphosed condition.

The crude ore carries about 30 per cent sulfur. An analysis of Stella ore showed the following percentages:

Silica	32
Iron	32
Sulfur	32
Copper	.04
Gold and silver	traces

The amount credited to silica probably includes the insoluble constituents, such as feldspar, hornblende, biotite and other silicates of the schist as well as quartz. The pyrite is free from arsenic and other deleterious impurities. It is shipped to acid makers in New York and adjoining states.

The National Pyrites Co., who formerly operated the mines at High Falls or Pyrites, has retired from business. The property has been taken over by the Oliver Iron Mining Co., a branch of the United States Steel Corporation. It is now being prospected in a thorough manner by the diamond drill. The ore occurs in lenses that strike northeast and dip northwest at an angle of 15° or so, with a pitch toward the north. The line of outcrop extends across the Grasse river under which there are workings reached from openings made on an island in the river. A striking feature of the deposits is the occurrence of pyrrhotite in segregated masses between the pyrite shoots. The mineral is not intermixed to any extent with the pyrite.

The Cole mine near Gouverneur consists of a large lens that outcrops at the surface and is worked as an open cut. It affords an ore above the average in richness, a part of the product being suitable for shipment in the crude state. The American Pyrites Co. took over the property in 1906, as successor of the Adirondack Pyrite Co. The suspension of operations, it is understood, has not been due to any failure of ore supply or technical difficulty, but to the heavy burden of royalties imposed.

SALT

The continued growth of output is the principal feature of the salt industry in the State recorded during the past year. The gain has been somewhat larger than the average and indicates apparently that the New York product is fully holding its own in the trade. Owing to its command of the large eastern markets, the local industry has been able to maintain the important position which it secured more than a century ago, notwithstanding the recent rapid development of other sources of supply.

All of the different grades of salt known to the trade are produced in the State. The rock salt mines situated in Livingston county supply more than one half of that commodity used in the country. The manufacture of salt by the solar process is carried on extensively on the Onondaga Reservation where it was first started in 1789. The brines used for that purpose are natural, while in the other localities the manufacture of brine salt is based on solutions obtained by driving wells into beds of rock salt and the introduction of water from the surface which is pumped up after becoming saturated. The grades of salt known as common fine, common coarse, table, dairy, packers, agricultural and milling salt are made by artificial evaporation of brines, the quality depending upon the methods employed and the degree to which the refining operations are carried.

In addition to the salt that is marketed as such, a very large proportion of the annual output of the State is converted into soda products by the Solvay Process Co. This company has a plant at Solvay near Syracuse, where the preparation of soda ash, carbonate, bicarbonate, etc., is carried on from brine that is supplied by the company's wells in the town of Tully, 20 miles south of Syracuse. The salt content of the brine thus used is included in the production tables herewith.

Altogether there were 31 companies in the State who reported an output in 1907, or one less than in the preceding year. Of the total number, Onondaga county was represented by 20 companies, while the remaining 11 were distributed among the following counties: Genesee, Livingston, Schuyler, Tompkins and Wyoming. The International Salt Co., the largest manufacturers of brine salt in the State, operated four plants as follows: Ithaca works, Ithaca; Cayuga works, Myers; Glen works, Watkins; and Yorkshire works, Warsaw. The Hawley and Warsaw works, at Warsaw, owned by the company were inactive. No new manufacturers have entered the list of producers during the year.

The total quantity of salt obtained from mines and wells in New York last year amounted to 9,657,543 barrels of 280 pounds, on which a value of $2,449,178 was placed. This shows a gain of 643,550 barrels, or 7 per cent, over the output for 1906 which was 9,013,993 barrels valued at $2,121,650, the largest reported up to that year. Most of the increase was contributed by the mines of rock salt, the output of which is about one third the entire total for the State.

The accompanying tables show the production of salt distributed among the various grades. The output listed under "other grades" is made up principally of rock salt and salt used for soda manufacture which are combined so as not to reveal the figures reported by the individual companies. A small quantity of other kinds not specified in the returns is also included under that item. The valuation placed on the salt thus listed is much smaller proportionately than that of the other grades inasmuch as the salt consumed by the Solvay Process Co. bears only a nominal value.

Production of salt by grades in 1906

GRADE	BARRELS	VALUE	VALUE PER BARREL
Common fine	1 164 064	$413 462	$ .35
Common coarse	182 636	62 758	.34
Table and dairy	1 211 936	603 034	.50
Coarse solar	510 800	191 551	.38
Packers	39 286	14 100	.36
*a*Other grades	5 905 271	846 745	.14
Total	9 013 993	$2 131 650	$ .23

a Includes rock salt, salt in brine used for soda manufacture, and small amounts of brine salt for which the uses were not specified in the returns.

Production of salt by grades in 1907

GRADE	BARRELS	VALUE	VALUE PER BARREL
Common fine	1 214 093	$446 618	$ .37
Common coarse	155 593	64 794	.42
Table and dairy	1 183 643	639 464	.54
Coarse solar	415 971	156 072	.37
Packers	43 614	14 993	.34
*a*Other grades	6 644 629	1 127 237	.17
Total	9 657 543	$2 449 178	$ .25

a Includes rock salt, salt in brine used for soda manufacture, and small amounts of brine salt for which the uses were not specified in the returns.

Onondaga county ranks first among the counties of the State in quantity of annual output and has contributed by far the largest total production. Between the years 1797 and 1892 there was made and sold from the Onondaga Salt Springs an aggregate of 71,284,419 barrels, equivalent to 9,979,819 short tons. If the salt utilized for soda manufacture be also included, the production of the county to date can not be much less than 20,000,000 tons. Up to the year 1880, when the beds of rock salt in the western part of the State began to be utilized, Onondaga county supplied the whole output, but since then it has gradually lost its importance in the trade and the greater part of the total now returned for the county represents the salt in brine consumed for soda manufacture.

The relative rank of the counties of the State, according to their output of marketable salt in 1907, was as follows: Livingston, Wyoming, Tompkins, Schuyler, Onondaga and Genesee.

Livingston county furnishes the entire product of rock salt which is mined at Retsof and Cuylerville. The Retsof Mining Co. has worked a deposit at the former locality for many years. The Sterling Salt Co. at Cuylerville began production in the fall of 1906 and the past year was the first one in which the mine was continuously active.

The growth of the salt industry in New York during the past 25 years is illustrated by the accompanying table which covers the output for the period 1883–1907 inclusive. It is noticeable that while the production has increased nearly six times during the period, the value of the annual total has grown at a much smaller rate. The figures for the years previous to 1904 are taken from the annual volumes of the *Mineral Resources.*

Production of salt in New York since 1883

YEAR	BARRELS	VALUE
1883	1 619 486	$680 638
1884	1 788 454	705 978
1885	2 304 787	874 258
1886	2 431 563	1 243 721
1887	2 353 560	936 894
1888	2 318 483	1 130 409
1889	2 273 007	1 136 503
1890	2 532 036	1 266 018
1891	2 839 544	1 340 036
1892	3 472 073	1 662 816
1893	5 662 074	1 870 084
1894	6 270 588	1 999 146
1895	6 832 331	1 943 398
1896	6 069 040	1 896 681
1897	6 805 854	1 948 759
1898	6 791 798	2 369 323
1899	7 489 105	2 540 426
1900	7 897 071	2 171 418
1901	7 286 320	2 089 834
1902	8 523 389	1 938 539
1903	8 170 648	2 007 807
1904	8 724 768	2 102 748
1905	8 575 649	2 303 067
1906	9 013 993	2 131 650
1907	9 657 543	2 449 178

SAND

The resources of the State in sands adapted for building, metallurgical and other uses are extensive and suffice to meet most of the local requirements for the material. The building and construction trades call for the largest quantity, consuming several millions of tons annually of the common grades which are obtained in great part within the immediate vicinity of the markets. Molding sands, glass sand, furnace sand, fire sand and filtration sands are among the other kinds produced, some of which are shipped to points without the State.

Building sand. The glacial deposits which are found in nearly all sections afford an abundance of sand for building and construction purposes. The deposits may be mixed with gravel, boulders and clay, requiring some preparation of the sand by screening or washing before it can be used. Frequently, however, the materials have been sorted by natural processes so that beds yielding clean and evenly sized sand may be found. The supplies of sand used in building operations in Albany and Rochester are derived from local morainal deposits. Alluvial sand found along the stream valleys is employed in many localities in the interior of the State. Beach sand also enters into the trade; most of the building sand consumed in New York city is obtained from the shores of Long Island, and Buffalo derives its supply from the beaches of Lake Erie principally from the northern or Canadian shore.

The extent of the trade in building sand is indicated by the statistics collected by the United States Geological Survey, according to which the production of New York in 1906 amounted to 3,369,194 short tons valued at $1,045,844. Large as the total is, it perhaps falls short of the actual production, since there is great difficulty in obtaining complete information on the subject. Little capital is represented in the individual enterprises and they are mostly of transitory nature, so that many changes take place each year. The intrinsic value of the product, aside from the costs of labor and transportation, is small.

Glass sand. For the manufacture of glass, pure quartz sand is required. The presence of dark minerals such as magnetite, hornblende, biotite, etc., which carry iron, is particularly objectionable. In the manufacture of window glass and articles of common glass, the iron is kept down to a small fraction of one per cent, while for the finer grades no more than a trace is allowable.

The glass sand produced in New York comes from the vicinity of Oneida lake. The principal localities where it is found are in the towns of Rome, Verona and Vienna, Oneida co., and Constantia, Oswego co. At one time this section supported a large industry in the manufacture of window glass, with factories at Durhamville, Constantia and Cleveland, but the cost of fuel became a serious handicap when competition was encountered with centers of manufacture in the natural gas and soft coal regions. Small quantities of the sand are now shipped to other parts of the State for making bottles and common wares. The shipments in 1907 amounted to 1200 short tons valued at $1380.

Some of the sandstones of New York have been used in the past for glass making. The Shawangunk grit was once quarried near Ellenville, Ulster co., and the output sold to Pennsylvania companies. The Potsdam sandstone has likewise been used for the purpose.

Molding sand. This material is produced largely along the Hudson river valley, in Albany, Columbia and Dutchess counties. The deposits are a part of the water-washed glacial accumulations of the region and are found in the upper section immediately underlying the soil. The valuable portion ranges from a few inches up to several feet thick. The sand contains a little clayey matter which contributes to its firmness and plasticity. The finest grades are used for stove and other castings that require a smooth finish and are shipped to Albany, Troy and more distant points. Sand used for making cores in molding is obtained from Oneida lake, from the same deposits that yield glass sand.

SAND-LIME BRICK

There have been few changes in this industry during the year. The activity shown in the erection of new plants for the manufacture of sand-lime brick was less noticeable than in the preceding year, no doubt due in part to the smaller demand that has been experienced for building materials of all kinds. Reports were received from 12 plants, of which nine were operative during the whole or part of the year, and the production amounted to 16,610,000 valued at $109,677. The seven plants that reported as active in 1906 made an output of 17,080,000 valued at $122,340. The plant of the Rochester Composite Brick Co. was destroyed by fire but is to be replaced. The following is a list of the companies engaged in the industry in the State.

NAME	LOCATION
Buffalo Sandstone Brick Co.	Buffalo
Granite Brick Co.	Glens Falls
Granite Brick Co.	Sandy Hill
Lancaster Sand-Lime Brick Co.	Lancaster
Newburgh Sand-Lime Brick Co.	Newburgh
Paragon Plaster Co.	Syracuse
Rochester Composite Brick Co.	Rochester
Roseton Sand-Lime Brick Co.	Roseton
F. W. Rourke & Co.	Brooklyn
Sand Stone Brick Co.	Schenectady
Schenectady Brick Co.	Schenectady
Watertown Sand Brick Co.	Watertown

SLATE

The quarrying of slate in New York is restricted at present to a small district in eastern Washington county. The district extends north from Salem through the towns of Hebron, Granville, Hampton and Whitehall and is practically continuous with the Vermont slate district which has attained much greater importance in the industry. The slate occurs in several horizons among the metamorphosed Paleozoic strata of the region, but belongs mostly to the Cambric and Lower Siluric systems. Extensive slate beds are found also in the southern continuation of the metamorphic region along the east side of the Hudson river, in Rensselaer, Columbia and Dutchess counties. Attempts to work the slate in this section, however, have not been permanently successful, though it is recorded that quarries were operated for a time at Hoosick, New Lebanon and New Hamburg.

The slate from Washington county is remarkable for its variety of colors. The red slate which is obtained near Granville and in the Hatch Hill and North Granville sections has no superior for beauty and permanency, while purple, variegated and different shades of green slate occur in the southern section around Middle Granville, Salem and Shushan. Nearly all of the product is sold for roofing purposes. The manufacture of other materials such as mantels, floor tiling, blackboards, billiard tables, etc., is not carried on to any extent in the State.

The production of slate for the past year amounted in value to $53,625. Of this, roofing slate represented $52,450 and mill stock $1175. The number of squares of roofing slate made was 11,686. In 1906 the total production was valued at $61,921 consisting of 16,248 squares of roofing slate valued at $57,771 and mill stock valued at $4150. The average value of roofing slate for the year was $4.60 a square against $3.56 a square in 1906. The increased value was due more to the relatively large quantity of red slate produced than to higher market prices.

STONE

The quarry industries of New York are of large and growing importance. There are few other states that possess such a variety of geological formations with so many different rock members. The resources afford almost every kind of material used for building and construction purposes and many of the ornamental stones. Still the local product falls short of meeting the requirements, specially for building and decorative stones, and large quantities are brought in annually from other states or are imported from foreign countries.

The statistics and notes incorporated in the following pages relate to the different quarry industries of the State, except those of slate and millstones, which are treated under their own titles elsewhere in this report.

Production of stone

The value of the quarry materials produced in 1907 amounted in the aggregate to $7,890,327. The total for the preceding year was $6,504,165, showing a gain of $1,386,162, or about 20 per cent. Nearly one half of the amount consisted of limestones which accounted for a total of $3,182,447 as compared with $2,963,829 in 1906. The sandstone quarried was valued at $1,998,417 against $1,976,829 in the preceding year, the larger part contributed by the companies engaged in the bluestone trade. The marble quarries reported the largest increase for the year, the production having a value of $1,571,936, as compared with $460,-915 in 1906. The output of granite showed a small falling off, with a total value of $195,900 in 1907 and $255,189 in the preceding year.

Classified as to uses, crushed stone was the largest item in the total and represented a value of $2,812,998, an increase of nearly $400,000 for the year. The use of crushed stone in road improvement work and for making concrete has been the chief factor in the development of this branch of the industry which has nearly doubled in importance within the last three years. The quantity of crushed stone made last year was approximately 3,319,706 cubic yards, as compared with 3,132,460 cubic yards in 1906. The quantity reported as used for road metal was

854,720 cubic yards, against 905,750 cubic yards in 1906. This total, however, does not represent the full amount thus used, as some of the firms are unable to classify their product. The value of the building stone, rough and dressed, amounted to $2,208,545, against $1,408,583 in 1906. Curb and flagstone aggregated the sum of $1,064,193 as compared with $999,678, represented largely by bluestone. The monumental stone, principally marble, was valued at $162,359, against $103,219 in 1906. The value of the stone quarried for purposes other than those given, including lime, furnace flux, paving blocks, riprap, rubble, etc., was $1,642,-232, as compared with $1,557,192 in 1906.

Production of stone in 1905

VARIETY	BUILDING STONE	MONU-MENTAL	CURBING AND FLAGGING	CRUSHED STONE	ALL OTHER	TOTAL VALUE
Granite	$139 414	$10 431	*a*	$69 748	$34 362	$253 955
Limestone	246 300	....	$7 297	1 193 800	964 059	2 411 456
Marble	571 810	177 557	*a*	*a*	25 190	774 557
Sandstone	530 485	....	1 029 913	37 406	446 156	2 043 960
Trap	*a*	....	....	601 669	21 550	623 219
Total	$1 488 009	$187 988	$1 037 210	$1 902 623	$1 491 317	$6 107 147

a Included under "All other."

Production of stone in 1906

VARIETY	BUILDING STONE	MONU-MENTAL	CURBING AND FLAGGING	CRUSHED STONE	ALL OTHER	TOTAL VALUE
Granite	$231 190	$4 119	*a*	$13 980	$5 900	$255 189
Limestone	229 479	....	$8 067	1 590 205	1 136 078	2 963 829
Marble	337 365	99 100	*a*	*b*	24 450	460 915
Sandstone	610 549	*a*	991 611	51 205	323 464	1 976 829
Trap	*a*	....	....	780 103	67 300	847 403
Total	$1 408 583	$103 219	$999 678	$2 435 493	$1 557 192	$6 504 165

a Included under "All other." *b* Included under Limestone.

Production of stone in 1907

VARIETY	BUILDING STONE	MONU-MENTAL	CURBING AND FLAGGING	CRUSHED STONE	ALL OTHER	TOTAL VALUE
Granite	$84 774	$9 613	*a*	$92 950	$8 563	$195 900
Limestone	189 782	....	$13 123	1 725 203	1 254 339	3 182 447
Marble	1 408 190	152 746	*a*	*b*	11 000	1 571 936
Sandstone	525 799	....	1 051 070	55 818	365 730	1 998 417
Trap	*a*	....	....	939 027	2 600	941 627
Total	$2 208 545	$162 359	$1 064 193	$2 812 998	$1 642 232	$7 890 327

a Included under "All other." *b* Included under Limestone.

Granite

Under the head of granite are grouped by the trade the crystalline rocks in which feldspar and other silicates are the predominant minerals. Besides granite in the strict sense the class comprises syenite, diorite, gabbro and anorthosite, in fact practically all of the igneous rocks, as well as many gneisses and schists, that are adapted for building construction or ornamental purposes. The fine grained crystalline rocks known as trap, however, are usually separated from the class owing to their somewhat special qualities and will be treated here under their own title.

There are two principal areas where these rocks occur in New York, the one being the Adirondack region and the other the lower Hudson valley and the bordering highlands. Both regions afford a variety of both massive and gneissoid types in great abundance, yet the quarries have not been developed as yet on a scale at all commensurate with the local markets. The present output represents but a fraction of the granite actually used each year for building or other purposes; by far the greater part is brought in from other states and some is imported from foreign countries.

The returns received from the quarries for 1907 show an output valued at $195,900, as compared with a value of $255,189 for the preceding year. The value of the building stone quarried was $84,774 against $231,190 in 1906, the decrease being due to the smaller operations in the quarries of Westchester county which supply building stone to New York city. The production of granite for other purposes was as follows: monumental stone, $9613, against $4119 in 1906; crushed stone, $92,950 against $13,980; rubble and riprap, $5600 against $2423; paving blocks, curbing and miscellaneous, $2963, against $3477. The quantity of crushed stone made was approximately 111,150 cubic yards against 16,800 cubic yards in 1906. Westchester county contributed a production valued at $76,820, as compared with $172,845 in the preceding year. The remainder of the production was distributed among the following counties: Clinton, Essex, Fulton, Herkimer, Jefferson, New York and Warren counties. There were 14 quarries operated during the year, or five less than in 1906.

Production of granite

MATERIAL	1905	1906	1907
Building stone	$139 414	$231 190	$84 774
Monumental	10 431	4 119	9 613
Crushed stone	69 748	13 980	92 950
Rubble, riprap	30 125	2 423	5 600
Other kinds	4 237	3 477	2 963
Total	$253 955	$255 189	$195 900

Quarries for furnishing crushed stone have been opened at Little Falls where there is an extensive intrusion of the Adirondack syenite. The crushing plant of the John Pierce Co. on the north side of the Mohawk river is the largest in the State, and produces road metal, railroad ballast and concrete material. Another quarry on the south side of the river has recently been equipped with a plant for making concrete blocks. The quarries are advantageously situated for shipment of their product both by railroad and the canal system of the State and should command a wide market.

The Picton Island Red Granite Co. has been engaged in quarrying on Picton island in the St Lawrence river. The stone is a biotite granite, ranging from medium to fine in texture, and has a very attractive reddish color, verging toward pink in the fine grained variety. Similar granites have been quarried in the vicinity for many years and have gained a wide repute for their beauty and durability. The present quarries have furnished building material chiefly, but the stone is well adapted for monumental and decorative work as well. It has a specific gravity of 2.653 and a crushing strength of 16,500 pounds to the square inch.

The Adirondack anorthosite affords in some places a gray or bluish gray massive stone often showing the very pleasing effect of a porphyry when polished. It has been quarried on a small scale, principally for monumental purposes. The opening of new quarries near Ausable Forks, Clinton co. is contemplated by Mr Ernest Leblond who has also a quarry property in Adirondack syenite in the same vicinity.

Limestone

The limestone quarries are first in importance among the stone-working industries of the State. Compared with sandstone which ranks second in value of output, limestone is not so generally used as building material, but it finds extensive employment for road metal and concrete. Its wide occurrence in connection with a natural fitness for the purpose, has favored the development of a large crushed stone business that covers nearly every section of the State. The manufacture of lime is also an important industry, requiring a considerable proportion of the quarry output.

The noncrystalline limestones, which are considered under this head, comprise a variety of rocks as regards their geological occurrence and physical and chemical characters. They are distributed among the Cambric, Lower Siluric, Siluric and Devonic systems. In a few localities, the crystalline limestones or marbles of the Precambric are quarried for lime making and such production is reported as limestone. In their chemical composition the limestones of New York show a range from practically pure lime carbonates to magnesian limestones and dolomites and to silicious, aluminous or ferruginous types in which the carbonates play a subordinate rôle. Light colored and white limestones are not abundant, however, in the State, the prevailing colors being grayish or drab, and for this reason considerable quantities of such stone are brought in from other States, principally Ohio and Indiana.

Production of limestone

MATERIAL	1905	1906	1907
Crushed stone	$1 193 800	$1 590 205	$1 725 203
Lime made	702 684	795 348	888 309
Building stone	246 300	229 479	189 782
Furnace flux	198 168	287 816	338 127
Rubble, riprap	40 664	32 975	14 588
Flagging, curbing	7 297	8 067	13 123
Miscellaneous	22 543	19 939	13 135
Total	$2 411 456	$2 963 829	$3 182 447

The total production of the limestone quarries last year amounted in value to $3,182,447. This is exclusive of the stone used in the Portland and natural cement industries, for which no statistics have been collected. Compared with the previous year there was a gain of $218,618 in the valuation or about seven per cent. The product was distributed among 35 counties of the State with a total of 136 active quarries.

Crushed stone for road metal, concrete, etc., represents the largest item in the output. The value of this material was $1,725,203 against $1,590,205 for 1906. The manufacture of lime is second in importance with a product valued at $888,309 in 1907 and $795,348 in 1906. Building stone represented a value of $189,782, as compared with $229,479 in the preceding year. Limestone used as flux in metallurgical processes accounted for $338,127 against $287,816. Other items are: rubble and riprap valued at $14,588 against $32,975; flagging and curbing $13,123 against $8067; and miscellaneous materials, not classified in the returns, valued at $13,315, as compared with $19,939 in the preceding year.

Distributed according to counties in which the limestone was quarried, the largest producer was Erie county which reported an output valued at $516,727, consisting principally of building stone, crushed stone and furnace flux. This county also ranked first in 1906 with a valuation of $525,381. Onondaga county which returned a total of $479,780 was second as in 1906 when its output amounted to $391,457. It manufactures more lime than any other county in the State. The remaining counties which reported a value of over $100,000 each with their respective totals are here given, the figures in parentheses being the corresponding totals for 1906: Dutchess $399,244 ($368,927); Rockland $284,-800 ($242,184); Genesee $283,513 ($227,062); Warren $225,262 ($205,832); Westchester $156,957 ($143,168); Albany $129,220 ($106,800); and Clinton $110,560 ($96,925).

Lime. There were 38 firms that reported an output last year of limestone (including marble) for lime burning, either as a main product or in connection with the quarrying of other materials. The greater portion of the limestone was converted by the companies operating the quarries. In all 18 counties participated in the production. The quantity of lime made was 403,114 short tons valued at $888,309. Onondaga county reported a product of 295,293 short tons, or about 73 per cent of the whole amount.

In the preceding year the output amounted to 313,369 short tons valued at $795,348, of which Onondaga county contributed 208,-250 tons. The importance of the industry in this county is to be ascribed to the operations of the Solvay Process Co. which uses the lime as a reagent in the manufacture of soda products.

The production in the other leading counties for 1907 and 1906 respectively was as follows, in short tons: Warren 45,747 (39,-076); Clinton 14,800 (16,400); Washington, 13,600 (12,000); Lewis 11,251 (9500); Jefferson 6482 (10,450); Westchester 6029 (7353).

It will be noted that the value of the production as above given is considerably less than the commercial price; this is due to the fact that a nominal valuation has been placed upon the portion used as a chemical reagent. Disregarding the quantity thus consumed, the value of the lime made for the market averaged $4.47 a short ton in 1907 and $4.58 a short ton in 1906.

Crushed stone. Limestone is more generally employed in New York for crushing than any other kind of stone. The total production in 1907 amounted to 2,211,102 cubic yards valued at $1,725,203, as compared with 2,194,547 cubic yards valued at $1,590,205 in the preceding year. Of the quantities given, 363,-589 cubic yards in 1907 and 486,750 cubic yards in 1906 were returned as having been used for road metal, though the amounts thus employed probably exceeded these totals, since some firms do not keep any records as to the disposal of their product.

The leading counties in the production of crushed stone, with their outputs in cubic yards, are as follows, the figures for 1906 being in parentheses: Dutchess 426,744 (400,177); Rockland 390,368 (373,387); Genesee 344,160 (323,128); Erie 250,720 (289,110); Albany 203,000 (150,000); Westchester 132,566 (105,441); and Onondaga 103,546 (92,950).

Building stone. The use of the local limestones for building purposes shows little or no tendency toward expansion, notwithstanding the important increases in the other materials supplied by the quarries. The value of the building limestone, rough and dressed, produced in 1907 was $189,782 as compared with a value of $229,479 in 1906. Erie county has the largest quarries of building stone, its output amounting in value to $114,351 as compared with $118,806 in the preceding year. The remaining counties are small producers. The output each year is supplemented by large quantities of limestone that are brought in from other states.

Furnace flux. The metallurgical industries of the State consume limestone as a flux in smelting operations. The largest users are the iron blast furnaces located in Buffalo and vicinity. The supply for this district is obtained from the outcrop of the Onondaga limestone in western New York and the adjacent part of the province of Ontario. The principal New York quarries are located at Clarence and Gunnville, Erie co., and at North Leroy, Genesee co. Blast furnace flux for the Adirondack iron furnaces is obtained at West Chazy, Clinton co., and near Port Henry, Essex co. It is also quarried at Oriskany Falls, Oneida co., for the furnace at Franklin Springs. A small output of the Gouverneur marble is shipped to Ohio for flux. The production of limestone classed as flux in the returns amounted to 563,684 long tons in 1907 valued at $338,127. In the preceding year the production was 400,002 long tons valued at $287,816.

Production of limestone by counties in 1906

COUNTY	CRUSHED STONE	LIME MADE	FURNACE FLUX	BUILDING STONE	OTHER USES	TOTAL
Albany	$96 200	$9 600	....	$500	$500	$106 800
Cayuga	23 098	....	$300	11 000	3 000	37 398
Clinton	8 350	61 500	15 900	7 175	4 000	96 925
Dutchess	368 927	....	....	....	....	368 927
Erie	222 384	375	172 550	118 806	11 266	525 381
Fulton	6 963	9 200	....	....	....	16 163
Genesee	142 342	14 000	69 650	1 070	....	227 062
Greene	1 785	....	186	24 500	15 500	41 971
Herkimer	4 000	6 300	....	810	....	11 110
Jefferson	4 875	42 250	....	6 053	499	53 677
Lewis	635	47 000	....	824	1 025	49 484
Madison	20 184	....	....	90	1 320	21 594
Monroe	52 295	....	....	7 564	547	60 406
Montgomery	55 235	....	....	4 116	1 297	60 648
Niagara	2 400	40	....	3 425	10 716	16 581
Oneida	32 000	....	12 600	15 000	....	59 600
Onondaga	63 986	313 500	3 420	8 976	1 575	391 457
Rockland	242 184	....	....	....	....	242 184
St Lawrence	....	9 040	3 311	800	911	14 062
Saratoga	13 000	....	....	3 000	....	16 000
Schoharie	21 073	300	....	10 825	7 875	40 073
Seneca	3 301	800	100	2 025	100	6 326
Warren	13 347	190 665	....	1 370	450	205 832
Washington	36 000	48 000	....	....	400	84 400
Westchester	105 441	36 766	711	250	....	143 168
*a*Other counties	50 200	6 012	9 088	1 300	....	66 600
Total	$1 590 205	$795 348	$287 816	$229 479	$60 981	$2 963 829

a Includes Columbia, Essex, Ontario, Orange, Rensselaer, Schenectady, Ulster, Wayne and Yates counties.

Production of limestone by counties in 1907

COUNTY	CRUSHED STONE	LIME MADE	FURNACE FLUX	BUILDING STONE	OTHER USES	TOTAL
Albany	$126 920	$2 000	....	$300	....	$129 220
Cayuga	32 578	400	$560	7 000	$13 050	53 588
Clinton	25 200	62 000	19 200	3 150	1 010	110 560
Dutchess	399 244	....	....	....	....	399 244
Erie	194 144	300	202 845	114 351	5 087	516 727
Fulton	9 141	11 637	....	....	....	20 778
Genesee	200 150	....	82 863	500	....	283 513
Greene	5 475	350	....	5 500	500	11 825
Herkimer	450	5 750	....	75	....	6 275
Jefferson	422	30 871	....	6 067	4 312	41 672
Lewis	475	55 255	....	604	758	57 092
Madison	45 000	....	5 000	....	....	50 000
Monroe	30 908	....	....	6 410	537	37 855
Montgomery	35 000	....	....	6 677	1 038	42 715
Niagara	30 123	500	....	1 920	8 250	40 793
Oneida	27 213	....	7 980	....	....	35 193
Onondaga	63 885	399 996	895	11 404	3 600	479 780
Ontario	3 433	....	....	808	678	4 919
Rockland	284 800	....	....	....	....	284 800
St Lawrence	....	10 940	9 843	809	154	21 746
Saratoga	10 000	....	....	2 500	....	12 500
Schoharie	12 051	300	....	18 446	....	30 797
Seneca	1 325	200	....	1 750	400	3 675
Warren	11 200	212 539	....	86	1 437	225 262
Washington	40 000	54 400	....	....	....	94 400
Westchester	132 566	24 116	275	....	....	156 957
*a*Other counties	3 500	16 755	8 666	1 425	215	30 561
Total	$1 725 203	$888 309	$338 127	$189 782	$41 026	$3 182 447

a Includes Columbia, Essex, Orange, Orleans, Schenectady, Ulster and Wayne.

Marble

The granular crystalline limestones and dolomites classed as marble are found in the metamorphosed areas of the Adirondacks and southeastern New York. A few varieties of compact, non-crystalline limestones, such as the black limestone of the Trenton formation occurring at Glens Falls and the fossiliferous Chazy limestone along Lake Champlain, possess ornamental qualities that fit them for special uses and pass as marble in the trade.

The monumental marble is obtained principally in the vicinity of Gouverneur, St Lawrence co., where a large quarry and polishing industry has been established for many years. The stone has a coarse crystalline texture, a color varying from white to mottled white and gray, often quite dark gray, and takes a lustrous polish. As only the best of the quarry material can be used for monumental work, the poorer grades are dressed into blocks for building and construction purposes. There are a few quarries that have been worked specially for building marble.

The quarries of southeastern New York are located in the metamorphic belt extending from Columbia county, through Dutchess and Westchester to Manhattan island. White and light gray marbles are the characteristic products and are sold principally for building purposes. The South Dover Marble Co. owns quarries of white marble at South Dover, Dutchess co., which have furnished material for many buildings in New York and other cities. The marble is generally recognized as one of the best of the kind. It is employed also for interior work. The Waverly Marble Co. with quarries at Tuckahoe, Westchester co., has been a large producer of building marble, which has been used in many notable structures. It is white but coarser grained than the South Dover marble. Among other localities in this region where quarries have been worked are Ossining, Dobbs Ferry, White Plains, Oscawana and Pleasantville, Westchester co., and Greenport, Columbia co. Some of the quarries furnish material for lime making.

The production of marble during the past year amounted to a value of $1,571,936 which is much the largest total that has been reported by the New York State quarries. The value was distributed among the different kinds of marble as follows: building marble, rough and dressed, $1,408,190; monumental marble, rough and dressed, $152,746; other kinds, $11,000. The corresponding total for 1906 was $460,915, and was divided into: building marble, $337,365; monumental, $99,100; other kinds, $24,450. The value of the marble quarried last year in southeastern New York aggregated $1,252,000 against $260,350 in 1906. St Lawrence county reported an output valued at $297,936 against $136,835 in the preceding year. A new producer in this county is John J. Sullivan who has worked the Davidson marble quarry, 2 miles southwest of Gouverneur.

Production of marble

VARIETY	1905	1906	1907
Building marble	$571 810	$337 365	$1 408 190
Monumental	177 557	99 100	152 746
Other kinds	25 190	24 450	11 000
Total	$774 557	$460 915	$1 571 936

Sandstone

Under the head of sandstone are included the sedimentary rocks which consist essentially of quartz grains held together by some cementing substance. Among the varieties, distinguished mainly by textural features, are sandstones proper, conglomerates, grits and quartzites.

The wide distribution of sandstones in the geologic series of New York State, together with their adaptability to many uses, has given them great economic importance, and in value of the annual output they rank second only to limestone among the quarry materials. Nearly all the formations above the Archean contain sandstones at one or more horizons. The kinds chiefly quarried in New York are the Potsdam, Hudson River, Medina and the Devonic sandstones. A few quarries have been opened also in the Shawangunk conglomerate and the Clinton sandstone.

The fine grained evenly bedded strata that occur in the Devonic are popularly known as bluestone, a term first applied to them in Ulster county where they are distinguished by a bluish gray color. The name, however, no longer has its original significance and is here used generally for the sandstones found within the Devonic belt which stretches across the southern part of the State. Much of the bluestone possesses the property of splitting regularly along planes parallel to the bedding which renders the stone specially serviceable for flagging and curbing.

Production of sandstone

The total value of the sandstone quarried in New York last year was $1,998,417, or a little more than that for 1906 which was $1,976,829. The production was made in 35 counties by over 400 individuals and companies.

Classified as to uses the values for 1907 and 1906 (in parentheses) are divided into: building stone, rough, $220,718 ($343,077); building stone, dressed, $305,081 ($267,472); curbing, $599,053 ($553,085); flagging, $452,017 ($438,526); paving blocks, $320,301 ($282,063); crushed stone for roads, $13,799 ($14,677); crushed stone for other purposes, $42,019 ($36,528); rubble, etc., $24,812 ($11,661); all other kinds, $20,617 ($29,740). There was a small decrease in the value of building stone; the other materials held their own or showed small gains.

The following tables give the value of the production distributed among the leading districts of the State.

Production of sandstone in 1906

DISTRICT	BUILDING STONE	CURBING AND FLAGGING	PAVING BLOCKS	CRUSHED STONE	RUBBLE, RIPRAP	ALL OTHER
Bluestone						
Hudson river...	$70 816	$220 961	$14 228	....	....	....
Delaware river..	110 008	572 470	1 350	$700	$1 188	....
Chenango co...	85 576	41 985	....	....	2 678	....
Wyoming co...	234 280	....	....	550	843	$140
Other districts..	12 658	4 247	....	2 770	....	325
Total bluestone.	$513 338	$839 663	$15 578	$4 020	$4 709	$465
Sandstone						
Orleans county.	$50 845	$147 438	$260 878	$225	$552	$25 000
Other districts..	46 366	4 510	5 607	46 960	6 400	4 275
Total sandstone.	$97 211	$151 948	$266 485	$47 185	$6 952	$29 275
Combined total.	$610 549	$991 611	$282 063	$51 205	$11 661	$29 740

Production of sandstone in 1907

DISTRICT	BUILDING STONE	CURBING AND FLAGGING	PAVING BLOCKS	CRUSHED STONE	RUBBLE, RIPRAP	ALL OTHER
Bluestone						
Hudson river...	$60 613	$219 357	$13 925	....	....	....
Delaware river..	66 627	633 600	873	....	$1 528	$800
Chenango co...	62 302	28 380	175	$500	1 029	14 317
Wyoming co...	195 155	659	....	....	955	....
Other districts..	7 123	1 484	2 400	4 125	....	....
Total bluestone.	$391 820	$883 480	$17 373	$4 625	$3 512	$15 117
Sandstone						
Orleans co.....	$85 750	$139 140	$296 928	$15 500	$800	$4 100
Other districts..	48 229	28 450	6 000	35 693	20 500	1 400
Total sandstone.	$133 979	$167 590	$302 928	$51 193	$21 300	$5 500
Combined total.	$525 799	$1 051 070	$320 301	$55 818	$24 812	$20 617

The value of the bluestone quarried in 1907 was $1,315,927, or approximately 65 per cent of the total output; the value of the other sandstone quarried was $682,490 or 35 per cent of the total. Compared with the preceding year, the returns show a falling off in the bluestone trade, due mainly to the smaller output of building stone, the decrease being distributed over all the different districts. There was little change in the values of the other materials from those reported in 1906. The combined total of sandstone quarried on the other hand showed an increase.

The production of bluestone by districts was as follows, the figures for 1906 being in parentheses: Hudson river $293,895 ($306,005); Delaware river $703,428 ($685,716); Wyoming county $196,769 ($235,813); Chenango county $106,703 ($130,239); other districts $15,132 ($20,000). In the Hudson river district of Albany, Greene and Ulster counties, about 65 per cent of the output in 1907 was sold as flagstone and curbstone and about 21 per cent as building stone. In the Delaware river district including Sullivan, Delaware and Broome counties, the value of the flagstone and curbstone sold amounted to about 88 per cent and the building stone to 11 per cent. In Chenango county about 60 per cent of the entire product was marketed as building stone, while in Wyoming county practically the whole output consisted of that material.

The production of Medina sandstone in Orleans county last year was valued at $542,218, as compared with $484,938, the value of the output in 1906. This stone has come into wide use for street work owing to its durability and even wear, and is also an attractive building material. The quarries at Albion, Medina, Holley, etc., are large and well equipped.

Trap

The term trap is commonly applied to the dark fine grained igneous rocks occurring as dikes or sheetlike intrusions. The variety known as diabase, composed essentially of plagioclase feldspar and pyroxene in small interlocking crystals, is the most common in New York State. The dikes are well distributed throughout the eastern Adirondacks, particularly in Clinton and Essex counties, but they are usually too small to be workable. The dikes near Greenfield, Saratoga co., and at Little Falls, Herkimer co., are exceptional in size for that region, having a thickness of 200 feet or more. By far the largest occurrence in the State is that on the west side of the Hudson river, south of Haverstraw, which forms the remarkable scenic feature known as the Palisades. The southern end of this intrusion is found on Staten Island where it extends southwest from Port Richmond.

The principal use of trap is for crushed stone for roadmaking and concrete. It possesses qualities of strength and durability which place it first among the varieties of stone used for these purposes. The somber color and the difficulty of dressing the stone limits its employment for building work. It is used to some extent for paving blocks.

Rockland county produces most of the trap at the present time. The quarries are at Rockland lake, Mt Joy, Haverstraw and Nyack and are worked in connection with crushing plants. The stone is supplied to the cities and towns along the river, New York affording the largest market. The output of the county had a value of $874,527 in 1907 as compared with $780,703 in the preceding year.

The quarries at Port Richmond, Richmond co., were the only ones worked in the southeastern part of the State, aside from those mentioned.

The remainder of the output came from Greenfield and Northumberland, Saratoga co., and Fort Ann, Washington co.

The aggregate value of the production last year was $941,627, as compared with a value of $847,403 in 1906. Crushed stone was the chief item in the total and amounted to 982,454 cubic yards, valued at $939,027 against 851,293 cubic yards valued at $780,103 in the preceding year. A total of 362,904 cubic yards with a value of $349,485 was reported as sold for road material, but the actual quantity thus used was probably somewhat greater.

Production of trap

MATERIAL	1906		1907	
	Cubic yards	Value	Cubic yards	Value
Crushed stone	851 293	$780 103	982 454	$939 027
Paving blocks, etc	....	67 300	....	2 600
Total	....	$847 403	....	$941 627

TALC

The talc industry of St Lawrence county experienced a prosperous year, with demand and prices above the average for some time past. The production showed a small falling off and amounted to 59,000 short tons valued at $501,500, as compared with 64,200 tons valued at $541,600 in 1906. The figures for both quantity and value of output are based on ground talc in marketable form. The average selling price for the year was $8.50 per ton in carload lots at Gouverneur, which is the usual shipping point for all the mines. The following table gives the annual production and value for the period 1896–1907, the figures previous to 1904 being taken from the *Mineral Resources.*

Production of talc in New York

YEAR	SHORT TONS	VALUE	VALUE PER TON
1896	46 089	$399 443	$8 67
1897	57 009	396 936	6 96
1898	54 356	411 430	7 57
1899	54 655	438 150	8 02
1900	63 500	499 500	7 87
1901	62 200	483 600	6 99
1902	71 100	615 350	8 65
1903	60 230	421 600	7 ..
1904	65 000	455 000	7 ..
1905	67 000	519 250	7 75
1906	64 200	541 600	8 43
1907	59 000	501 500	8 50

The smaller output in 1907 is traceable to curtailment of milling facilities incurred by the destruction by fire of the Hailesboro mill in the preceding year; the mill, one of the original four belonging to the International Pulp Co., was the largest in the district. The company immediately added to the capacity of the Dodgeville mill which it took over from the United States Talc Co., and also started the construction of a new mill at Hailesboro. The latter is planned for a nominal capacity of 100 tons ground talc a day, or 25 tons more than the capacity of the old mill; it was practically completed at the end of the year.

By acquiring the property of the Union Talc Co., the International Pulp Co. has further strengthened its position as a producer. The former has been the largest of the independent companies since its organization in 1900. It owned three mines and produced a superior grade of talc.

The Ontario Talc Co. increased its mining capacity during the year by opening the Potter mine on the Van Namee farm, 1½ miles below Fullerville, from which 15 tons of talc a day were taken. The company is planning the construction of a new mill to be located at Gouverneur.

A talc deposit in the vicinity of Natural Bridge, Lewis co., has attracted some attention recently, though nothing more than a little exploration has been done thus far at the locality. Specimens of the mineral show an earthy or amorphous texture resembling rather the talc from the southern states than that from St Lawrence county.

The fibrous and foliated talc is marketed mostly among paper manufacturers. The former variety is particularly adapted for filling book and writing papers in which a smooth finish is desirable, and for that purpose is considered superior to kaolin in that it is more readily incorporated with the paper stock and at the same time makes a stronger tissue. The St Lawrence county talc has become a staple article in both the domestic and foreign paper trades. Large quantities are exported to Germany, where it competes with the best German clays. It is also shipped to Austria, Italy, France, Great Britain and other countries. The foliated talc is prepared separately and finds special employment in wall paper manufacture for giving a lustrous finish to the surface, such as was formerly produced by the use of ground mica.

ZINC AND LEAD

The deposits of zinc blende near Edwards and Fowler, St Lawrence co., described in preceding issues of this report, remained idle throughout the past year and as yet no shipments have been made from either locality. Their development so far has given very promising results which will lead, no doubt, to a resumption of operations as soon as the present legal difficulties are removed.

The old lead mines in the towns of Rossie and Macomb, St Lawrence co., have received some attention during the year. The mine near Pierces Corners has been under exploration by O. J. David of Gouverneur. The formation of a company under the title of the St Lawrence Lead Mining & Developing Co. was effected for the purpose of carrying on exploration and mining work in this section.

The mine near Otisville, Orange co., once owned by the Washington Mining Co., has been under development by the Phoenix Lead Co. of Paterson, N. J. The vein is reported to be 6 feet wide. It carries galena and zinc blende. No ore was shipped during 1907.

INDEX

Education Department Bulletin

Published fortnightly by the University of the State of New York

Entered as second-class matter June 24, 1908, at the Post Office at Albany, N. Y., under the act of July 16, 1894

No. 434 ALBANY, N. Y. NOVEMBER 1, 1908

New York State Museum

JOHN M. CLARKE, Director

Museum bulletin 123

IRON ORES OF THE CLINTON FORMATION IN NEW YORK STATE

BY

D. H. NEWLAND

AND

C. A. HARTNAGEL

New York State Education Department
Science Division, August 31, 1908

Hon. Andrew S. Draper LL. D.
Commissioner of Education

DEAR SIR: I have the honor to transmit herewith for publication as a bulletin of the State Museum, a report on the iron ores of central New York, prepared in pursuance of a provision in chapter 578, laws of 1907, "for determining what deposits of iron ore exist within the State of New York and the extent and availability thereof."

The investigations, the results whereof are here given, have been carried on by continuous drilling during the autumn, winter and spring of 1907–8 in a field where but slight effort has heretofore been made to estimate the volume of iron ore available for production. This report conclusively indicates that in the region of central New York there exists a commercial asset in iron of great magnitude and vast importance to the people of this State and the conclusions herewith set forth are in essential accord with the prediction made when it was recommended that the work be undertaken.

These operations have been carried on and the report prepared by D. H. Newland, Assistant State Geologist, and C. A. Hartnagel, Assistant in Economic Geology.

Very respectfully
JOHN M. CLARKE
State Geologist

State of New York
Education Department
COMMISSIONER'S ROOM

Albany, August 31, 1908

This is the report of the State Geologist covering a painstaking investigation of the extent of deposits of iron ore in the State, and having particular reference to the territory, something like one hundred miles in length, extending through the central part of the State, from Oneida and Otsego counties on the east to Wayne county on the west, for which a special appropriation was provided in the annual supply bill of 1907. Having very earnestly recommended the appropriation, I find much satisfaction in the assurance of the Geologist that a conservative estimate, based upon this investigation, of the quantity of iron ore deposited in this region places the amount at six hundred millions of tons. If this estimate is warranted, New York might yet easily become the leading iron state in the Union. Of course, this report is scientific and technical, but surely signifies much; and if it points the way truly, as the experience, attainments and assiduity of Dr Clarke, the State Geologist, warrant me in believing it does, it adds much to the economic resources, and is of much moment to the commercial prosperity of the State. The information it contains should be extended as quickly and as widely as practicable. Publication is approved and I hope it may be expedited.

Commissioner of Education

Education Department Bulletin

Published fortnightly by the University of the State of New York

Entered as second-class matter June 24, 1908, at the Post Office at Albany, N. Y., under the act of July 16, 1894

No. 434 ALBANY, N. Y. NOVEMBER 1, 1908

New York State Museum

JOHN M. CLARKE, Director

Museum bulletin 123

IRON ORES OF THE CLINTON FORMATION IN NEW YORK STATE

BY

D. H. NEWLAND

AND

C. A. HARTNAGEL

INTRODUCTION

The hematites accompanying the belt of Clinton strata in New York State have been worked commercially, though with some interruptions, since the early part of the last century. It is on record that a mining lease was granted in Oneida county as far back as 1797, and a small quantity of ore was shipped from Wayne county during the War of 1812. Regular mining operations were not instituted, probably, until about 1825. A few years later charcoal forges and furnaces had been erected in Wayne, Madison and Oneida counties, as reported by the geologists connected with the Natural History Survey of the State.

The production of Clinton ores has averaged about 75,000 tons for the last few years. In 1907 it was 109,025 tons. The aggregate from the beginning may be placed at from 4,000,000 to 5,000,000 tons, which is approximately the yield obtainable, with the average workable seam, from a square mile of area. Mining has been restricted entirely to the surface portion of the beds, and little or nothing has been done by the mine interests, hitherto, toward exploration outside the limited fields of operations.

By the present investigation it is hoped to anticipate, so far as may be, the need for a practical guide to the development of these deposits. With the aid of a legislative appropriation, specially granted for the purpose, it has been possible to perform a series of exploratory tests with the diamond drill and, from the results thus secured, to gain for the first time a general view of the ore distribution over a considerable section of the Clinton belt. A detailed account of this work is included in the report.

The resources of the Clinton formation, known to exist within easy reach of mining operations, are so extensive that they seem to offer a promise of increased commercial importance for the future. The principal handicap to the use of the ores, hitherto, has been their relatively low iron content — from 35 to 45%. But with the rapidly growing demand made upon other eastern mining fields — which has been reflected by a steady falling off in the quality of the product in most cases — its effect is now much less apparent than formerly and will be subject, doubtless, to further reduction. A factor of considerable importance, also, in this connection is the fluxing nature of the Clinton ores, which counterbalances to an appreciable extent their deficiency of iron when used in the furnace.

Because of the unusual interest which is being manifested in the deposits, it has been deemed best to make the results of the investigation public at an early date. To that end some matters of more remote economic application have received scant attention or have been omitted altogether from the discussion, though they might properly come within the scope of the report. The recent field work and exploration have brought out much that is new concerning Clinton stratigraphy and shown the need for a more thorough study of the New York section, to our knowledge of which little has been added since the reports of Hall and Vanuxem. The relations of the formation to its associates, particularly, are open to inquiry. For the present nothing further can be done than to indicate some important corrections and to record observations on which such restudy may be based.

For cooperation in the preparation of the report it is desired to express grateful acknowledgment to the mining and development enterprises and owners of ore properties, who have always given a ready response to inquiries and have extended many other courtesies during the field and office work. The report has specially benefited by the assistance of Mr Charles A. Borst of Clinton, who

contributed many facts relating to ore localities and mines in Oneida county, and of Mr H. M. Selleck and Mr Freeman Pintler of Ontario, who furnished much information about the ores of Wayne county. The line drawings accompanying the report have been made by Mr H. P. Whitlock.

PREVIOUS STUDIES

The researches of Hall and Vanuxem in connection with the first Geological Survey of New York State have been the source of most of our knowledge concerning the Clinton formation. The descriptions of its bounds and relations, as set forth in their final reports of 1842–43, have undergone no essential amendment to this day and are still standard for the recognition and comparison of the different Clinton occurrences elsewhere.

Previous to their investigations, Amos Eaton had given a brief account of the ores and associated beds in his monograph, *A Geological and Agricultural Survey of the District adjoining the Erie Canal*. Eaton seems to have visited the outcrops along the belt at intervals from Herkimer county to the Niagara river. The hematites are placed in the class of " secondary ferriferous rocks," which are stated to consist principally of slate and sandstone. It is not always possible to recognize the various members referred to by Eaton, though there is little doubt that the class includes parts of the Medina and Rochester formations, as now understood, in addition to the Clinton beds.

Vanuxem, whose field of work was in the central part of the State, first described the Clinton and Niagara representatives under a single group which he called Protean. It was later found that the upper and lower members were of unequal distribution, the latter having their strongest development in the eastern section, while the former were predominant in the west. The group accordingly was subdivided. The name Clinton was given to the lower part, from the village of Clinton, Oneida co., and as a " tribute to one who spared no effort to extend a knowledge of science and to add to its acquisitions." The outcrop of the strata was traced by Vanuxem as far west as Cayuga county.

In the final report by James Hall, covering the western section of the Clinton, the following subdivisions are recognized, in ascending order: 1 Lower green shale; 2 Oolitic or lenticular iron ore; 3 Pentamerus limestone; 4 Second green shale, with second iron ore bed; 5 Upper limestone. The exposures of iron ore existing at the time are recorded in detail by both Hall and Vanuxem whose reports, also, are replete with information relating to the character, thickness and other features of the beds.

The portion of the Clinton belt included in the limits of the Rochester quadrangle, about 13 miles from east to west, has been mapped by C. A. Hartnagel. The map is on the usual scale of the folio sheets (1 mile to the inch) which are in preparation for the whole State. In the report accompanying the map the five subdivisions of Hall are described under the local names: Sodus shale, Furnaceville iron ore, Wolcott limestone, Williamson shale, Irondequoit limestone.

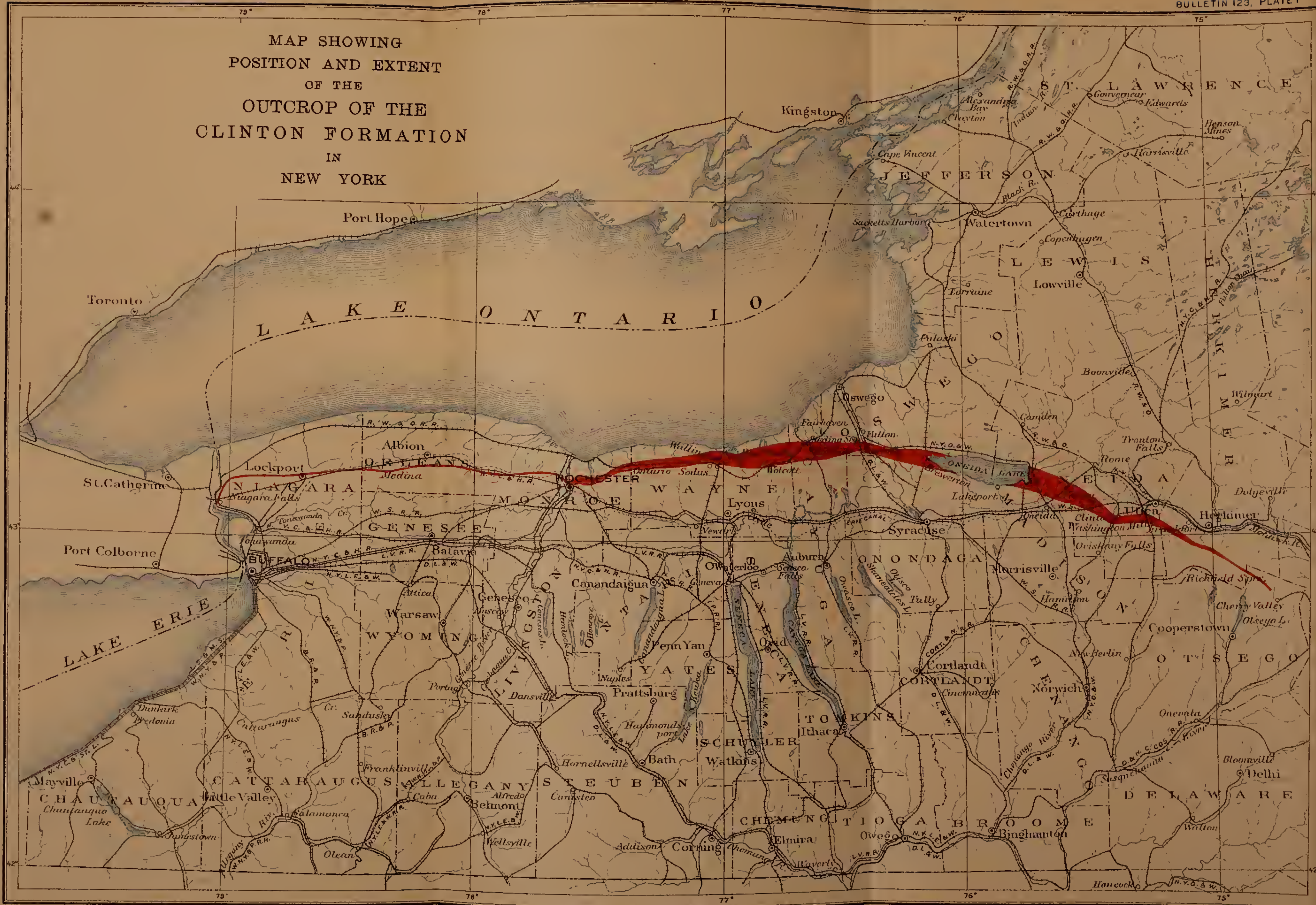
The papers by C. H. Smyth jr, contain an accurate and exhaustive exposition of the origin of the Clinton ores — by far the most satisfactory that has appeared. The evidences Professor Smyth has brought to bear upon the question, from the standpoints of geology and chemistry, must be convincing to any one familiar with the local deposits. For these, at least, the view of secondary replacement which has been advanced by some geologists, may be regarded as completely disproved. A discussion of the subject of origin, with a statement of Professor Smyth's views, is given in a subsequent chapter.

DISTRIBUTION OF THE CLINTON FORMATION

The Clinton strata — comprising shales, limestones, sandstones and interbedded layers of iron ore — are found in a single belt which extends from the eastern central part of the State to the Niagara river and thence for some distance into the Province of Ontario. The length of the belt, included within the limits of the State, is about 225 miles.

On the east the strata can be traced into Otsego county, where they thin out to disappearance, though they were formerly supposed to continue southeasterly into Schoharie and Albany counties. From field observations made recently by one of the writers (C. A. Hartnagel) it would appear that they terminate in the town of Cherry Valley, a short distance east of Salt Springville. This is undoubtedly the limit of their deposition in eastern New York.

West from Otsego county the Clinton belt passes successively through Herkimer, Oneida, Madison, Onondaga, Oswego, Cayuga, Wayne, Monroe, Orleans and Niagara counties; it


MAP SHOWING
POSITION AND EXTENT
OF THE
OUTCROP OF THE
CLINTON FORMATION
IN
NEW YORK
LAKE ONTARIO
LAKE ERIE
Toronto
Port Hope
Kingston
St. Catherines
Port Colborne
Lockport
Albion
Rochester
Buffalo
Batavia
Oswego
Syracuse
Utica
Rome
Watertown
Herkimer
Auburn
Ithaca
Elmira
Corning
Binghamton
Cortland
Norwich
Cooperstown
Oneonta
Delhi
Olean
Jamestown
Mayville
Dunkirk
Canandaigua
Lyons
Sodus
Wolcott
Oneida
Clinton
Richfield Spr.
NIAGARA
ORLEANS
MONROE
WAYNE
GENESEE
WYOMING
LIVINGSTON
ONTARIO
YATES
SENECA
CAYUGA
ONONDAGA
MADISON
ONEIDA
OSWEGO
JEFFERSON
LEWIS
ST. LAWRENCE
HERKIMER
OTSEGO
CHENANGO
CORTLAND
TOMPKINS
SCHUYLER
STEUBEN
CHEMUNG
TIOGA
BROOME
DELAWARE
ALLEGANY
CATTARAUGUS
CHAUTAUQUA

8

se
o1
V
in

R
b
sc
a1
m
n:
W

h:
m
S
p
f:
se
g
tl
v

st
b
t
F
tl

t
p
c
w
i1
S
i1

t
(

crosses the Niagara river at the falls and comes to an end probably in the Province of Ontario. The Clinton areas of Ohio and Wisconsin seem to have been formed in basins separate from the above.

The width of the outcropping strata as shown on the maps ranges up to a maximum of about 5 miles. It is greatest in the central part, in the vicinity of Oneida lake and immediately westward. It diminishes very gradually away from that section, specially to the west, where the strata continue for a long distance with scarcely perceptible changes. The outcrop narrows more quickly toward the east mainly on account of the increasing inclination of the beds in that direction.

The restriction of the Clinton strata to the single belt above delimited is not in accordance with the work of the early geologists, generally accepted until recent years, but it has the support of most convincing evidence. The beds in Schoharie and Albany counties that were formerly supposed to represent the eastern continuation of the belt are now known to be of much later (Salina) age. Likewise the areas in the Skunnemunk and Shawangunk mountains of Sullivan and Orange counties, some 60 miles long altogether, assigned to the Clinton in the early reports, have since been demonstrated to be of post-Clinton development.

TOPOGRAPHIC FEATURES

The Clinton outcrop is seldom traceable by the surface configuration. Physically and structurally united to the beds above and below, the formation has developed few topographic features, by weathering or erosion, that are distinctive.

In the extreme west the Clinton strata are involved in the Niagara escarpment of which they constitute the median portion as exposed in the Niagara gorge. Passing eastward the escarpment become less prominent as a scenic feature and practically disappears in the vicinity of Rochester. The soft shales have been denuded so as to yield a gentle slope from the level of the Lockport limestone at the top down to the Ontario plain that is floored by Medina sandstone. The outcrop of the formation widens out, of course, with the flattening of the topography.

At Rochester the Clinton strata are crossed by the Genesee river which occupies a deep gorge at this point, causing a V-shaped upstream deflection of the outcrop. This is the only place east of the

Niagara gorge where the strata are exposed from the base to the top. Five miles farther east the depression occupied by Irondequoit bay causes another deflection in which the beds are bent in a long loop toward the south.

Beyond Irondequoit bay the basal members of the Clinton spread out northward and cross the "Ridge road," a conspicuous terrace which marks the old shore line of the glacial Lake Iroquois. Their northerly outcropping edge parallels this shore line, about a mile distant, as far as Sodus, Wayne co. Between Sodus and Verona, Oneida co., an embayment of Lake Iroquois extended southward into the Finger Lake region and the entire Clinton between these localities is included within the old lake basin.

In the section from Sodus to the Oswego river, drumlins form a prominent feature of the topography, whereas to the west they are but little developed in the vicinity of the Clinton belt. Their presence conditions the great variation in the amount of overburden encountered in this part, which may reach a thickness of 100 feet or more. They have the usual elongated oval shape, with the main axis parallel to the direction of the ice movement, which was about north and south. They attain an average length of a mile, and some of the more rounded ones are half that in width. Their distribution is irregular, closely set and overlapping at the bases in some places and again spreading out so as to leave an intervening stretch of level country. There are few exposures of the underlying rocks, chiefly along the streams that wind through the connecting depressions.

In the Oneida lake region, the Clinton formation crosses a very flat part of the Iroquois basin. The surface is composed mostly of clays and sands that have been washed over and leveled by wave action. The thickness of these materials is inconsiderable, though few rock outcrops occur.

After entering Oneida county, the trend of the formation, hitherto nearly east and west, bears gradually to the south until it is about 30° south of east. From Verona to Hecla Works, the country is still comparatively level, but loses this character as the Mohawk river is approached, near which the formation becomes involved in the range of hills that limits the valley on the south and merges gradually with the higher ranges of the Helderbergs, so as to present an uninterrupted highland extending eastward into Albany county.

GENERAL GEOLOGY

Stratigraphic relations of the Clinton formation

The Clinton formation falls within the middle division of the Upper Siluric or Ontaric system. At the base of this system, as constituted in New York, lies the Oswegan group which includes the Medina and Oswego sandstones and the Oneida conglomerate. The middle or Niagaran group consists of the Clinton at the base, followed by the Rochester shale and the Lockport and Guelph dolomites. The upper or Cayugan group is made up, in ascending order, of the Salina, Cobleskill, Rondout and Manlius formations. The succession is shown in the following table:

ERA OR SYSTEM	PERIOD OR GROUP	AGE OR STAGE
Ontaric or Upper Siluric	Cayugan	Manlius limestone Rondout waterlime Cobleskill limestone Salina beds
	Niagaran	Guelph dolomite Lockport dolomite Rochester shale Clinton beds
	Oswegan	Medina sandstone, including the Oswego sandstone and Oneida conglomerate

In tracing the Upper Siluric formations across the State it has been found that the higher members have a greater linear extent than the lower ones. This is due to a progressive overlap in sedimentation, whereby each member has had a wider area of deposition than the one immediately preceding. The general relations will be readily understood from the accompanying diagram. It will be observed that there is one exception to the statement above in regard

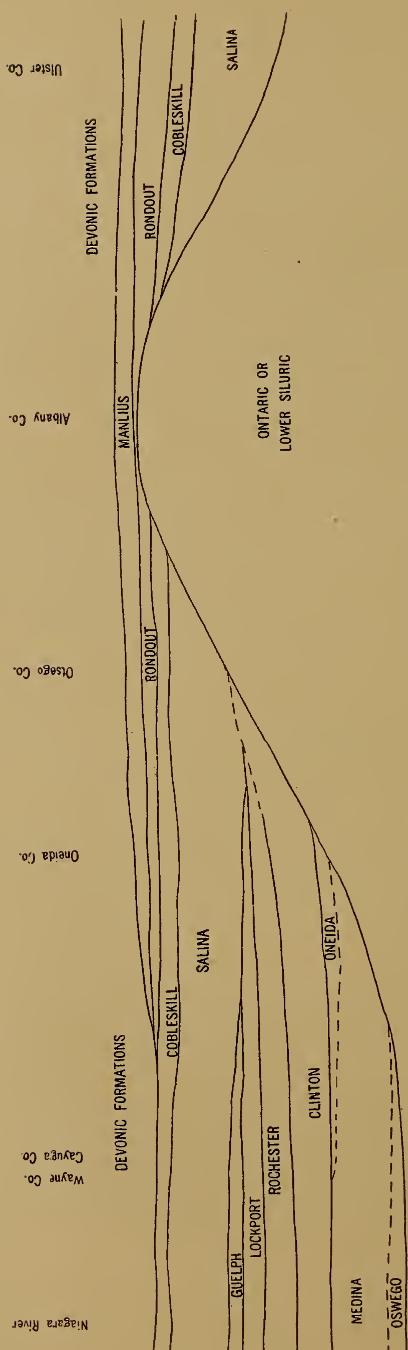


Fig. 1 Diagram showing relative position and linear extent of the Upper Siluric formations in New York State, and their relation to the Lower Siluric and Devonic

to overlapping of the strata, due to a slight uplift which seems to have occurred at the close of the Clinton age. The effect of the uplift is apparent in limiting the transgression of the Niagaran sea to the east, causing the disappearance of the upper members in that direction and bringing the Salina into contact with the Clinton beds.

The whole series of Upper Siluric strata of central and western New York from the Medina up to and including the Niagaran group was laid down in the great mediterranean, known as the Mississippian sea, which came into existence probably during Cambric times. The sea was shut off from the Atlantic basin by a broad barrier that extended along the Appalachian protaxis from New Brunswick through New England, eastern New York and the intervening states to northern Alabama and connected on the north with the continental old-land or Laurentia of Canada. At the opening of Upper Siluric time the barrier had assumed increased proportions through the Taconic revolution. The sediments which had accumulated along the shore of the Appalachian and Canadian regions during Cambric and Lower Siluric times were upraised and folded. Thus, the entire eastern section of New York State became land. Following this uplift the interior sea began to extend its limits so that the Upper Siluric deposits encroached more and more upon the land surface to the east.

With the Cayugan period, sedimentation took place again in southeastern New York. Representatives of this group are found across the State from the Niagara river to Albany county. Here their line of outcrop bends to the south, passing into Ulster county, and thence southwest through Sullivan and Orange counties and into New Jersey in the vicinity of Port Jervis. Disconnected areas, constituting outliers of the main belts, are met with in Orange county, running southwest from the Skunnemunk mountain region. These outliers consist of conglomerate of Salina age (the Shawangunk conglomerate of New York State and the Green Pond conglomerate of New Jersey) followed by a series of sandstones, shales and limestones. Formerly the series was considered to belong to an earlier period of deposition, the conglomerate having been taken for the equivalent of the Oneida in central New York and some of the overlying beds for the Clinton.

The Upper Siluric beds follow each other in conformable arrangement. After the Taconic upheaval sedimentation appears to have been continuous during the whole of the following era. The

Taconic disturbance is most apparent in the eastern part of the State where there exists a strong erosional unconformity between the Lower and the Upper Siluric that is well marked also by basal conglomerates (Oneida, Skunnemunk and Shawangunk); its apparent influence can not be traced farther west than Oswego county, as Vanuxem[1] has noted that no break occurs in the succession from the Lower Siluric to the Oswego sandstone of that section.

The Upper Siluric formations, for the most part, have the characters of shallow water accumulations. In the basal members sandstones and conglomerates prevail and are made up of the coarser quartzose detritus from the wash of the nearby land. Some finer sands and muds were brought down and deposited during Medina time to form the shales which are interbedded with the sandstones, but it was not until Clinton time that they came to be the predominant material. During this and the succeeding Rochester ages silts were accumulated in great thickness, though there were brief periods in the Clinton when they gave way to limestones and in eastern New York to calcareous sandstones. With the beginning of Lockport time the conditions of sedimentation became favorable to the deposition of limestones and these rocks were laid down all through the rest of the Upper Siluric, with one notable interruption represented by the Salina shales. The changes in the character of the sedimentation are to be regarded, doubtless, as reflecting a certain amount of coastal oscillation which produced shallowing or deepening of the waters adapted to the different deposits. It is not necessary to suppose, however, that the shales and limestones required any great depths for their accumulation. On the other hand there are unmistakable evidences that they were laid down for the most part within the littoral reign. The Clinton and many of the overlying limestones are of fragmental character, composed of fossils that were washed up on the old beaches where they were worked over and ground by wave action. Abundant beach markings, such as ripple marks, shrinkage cracks, worm borings and tracks of crustaceans are to be found in the shales.

During Clinton time there seems to have been an approach to the conditions which later in the Salina age led to the extensive deposition of salt and gypsum. These conditions may have been initiated even as early as Medina time. Salt springs are found not infrequently along the outcrop of the Medina sandstones and in such a state of concentration that they were once used commercially for

[1] Geol. N. Y. 3d Dist. 1842. p. 61 *et seq.*

the extraction of salt. Their presence, even if not due to included beds of rock salt, which so far have never been discovered, indicates a high degree of salinity for the waters, that is likely to have been brought about by evaporation in basins shut off from free communication with the sea. The deposition of the Clinton hematites required a similar concentration, as will be explained later in the discussion of their origin.

The existence of shallow waters, sheltered bays and lagoons requisite to the accumulation of deposits like those characteristic of the Clinton formation may be considered as indicative of an extensive coastal plain stretching southward from the ancient land masses — the Laurentian and Adirondack areas. Such a coastal plain had been built up from wash of the lands during the long interval from Potsdam to Medina time. During the Medina age there must have been a gradual sinking of this platform with the progress of sedimentation, and the subsidence continued into Clinton time, though not on the same scale.

As to the northern limits of the shore line during Clinton time, there is little information to be gained from present conditions. Since the uplifting of the strata, they have been continuously subjected to erosion and their outcropping portions worn back until they are now considerably south of the original limits. It seems scarcely probable, however, that the Clinton beds ever extended so far north as to overlap on the crystallines, since this would involve the removal of more than 100 miles of rock on the western end of the belt, between the present line of outcrop and the southern edge of the Canadian Precambric area.

The materials of which the Clinton strata are composed were derived ultimately from the Precambric crystallines. A small portion may have been furnished by the Paleozoic sediments fringing the crystalline areas and previously upraised above sea level. But as these sediments are for the most part low in iron, it is to the Precambric gneisses and schists with their relatively high iron content and extensive iron ore deposits that we must look for the source of the Clinton hematites. The only sedimentary strata of the lower Paleozoic that contain appreciable percentages of iron are the Medina and Potsdam sandstones. The crystalline rocks, on the other hand, uniformly carry several per cent of iron oxids, both free as magnetite and combined in the silicate minerals, and in the Adirondack region they inclose important bodies of magnetite, hematite and pyrite.

The ferruginous minerals were set free from the containing rocks by the processes of weathering and denudation which were operative during a vast time interval. The Adirondack region existed as a land area throughout the latter part of the Precambric and all of the Cambric eras. In the Lower Siluric era it was depressed and encroached upon by the sea, but with the Taconic revolution it was again upraised to remain as a land surface to the present time. The weathering sufficed to break up the ferromagnesian constituents, the iron going into solution, while the magnetite and pyrite were also changed more or less completely into soluble compounds. Very little magnetite and none of the original pyrite are found in the early sediments formed from the decay of the crystallines. While it appears reasonable that the magnetite may have been brought down partly as sand and subsequently altered to hematite, producing the red sandstones of the Potsdam and Medina formations, there is much reason for believing that the Clinton ores were deposited from solution in which the iron existed for the most part as ferrous carbonate but to some extent possibly as sulfate. The conditions under which the ores were formed are set forth more fully in a subsequent chapter.

General structure

The Clinton beds are uniformly inclined toward the south, the direction of slope of the original coastal plain on which they were deposited. Their uplift from sea level seems to have taken place gradually and with little disturbance of their relative position. They are nowhere displaced by faults, apparently, and only in a broad way, as will be explained later, can they be said to show evidences of flexure.

The lowest dips are encountered in the central portion of the belt, in Wayne and Cayuga counties. From the records of the deep wells driven south of the outcrops, it has been possible to determine the dips for this section with great exactitude. Beginning in the central part, along the meridian of middle Wayne county, the strata have an inclination amounting to 820 feet in the 18 miles from the Alloway well to the outcrops on Second creek, or an average of 45 feet to the mile. In the 13 miles from the Clyde well to the line of outcrop due north, as near as it can be located, the aggregate is 640 feet or 49 feet to the mile. Between the well at Seneca Falls and the Wolcott exposures, a distance of 25 miles along the meridian, the average is 48 feet to the mile. From the Auburn well to Sterling Station on a line slightly west of north the mean dip for the 25 miles is 51 feet to the mile.

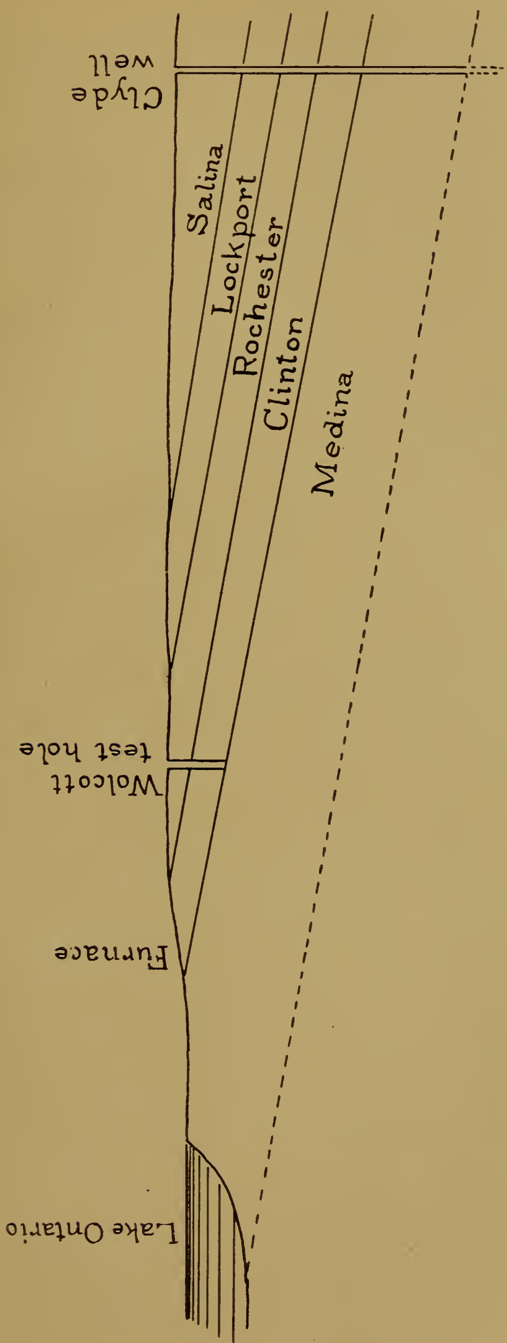


Fig. 2 Ideal section across the Upper Siluric in eastern Wayne county. The actual inclination of the strata is much less than indicated, amounting to about 50 feet to the mile.

In Erie county on the western end of the belt the dip of the Upper Siluric strata has usually been estimated at 50 feet or less to the mile. The Clinton outcrop, however, here lies fully 150 feet higher with respect to sea level than it does in the central part, a circumstance that seems to indicate a higher rate of inclination than the above, when it is further considered that the line of outcrop is somewhat south of its position in Wayne and Cayuga counties. At Rochester the dip has been stated at 80 feet to the mile, in a direction slightly east of south.

On the eastern section of the belt the dips increase progressively from Madison to Herkimer county, while there is likewise a gradual increase of elevation of the outcrop. The average dip, as determined from the Chittenango and Lakeport wells, in Madison county, is 62 feet to the mile over a distance of 8 miles. The dip of the iron ore at Clinton as determined by leveling is 150 feet to the mile. There is little basis for calculation of the dips in the part of the belt beyond Oneida county, but it is to be expected naturally that the beds are more highly inclined as they come more and more within the zone of the Appalachian uplift.

It is in this region that the Clinton outcrop reaches its highest elevation which is about 1400 feet. At Clinton the elevation is about 700 feet. In eastern Wayne county the iron ore bed lies at nearly the level of Lake Ontario which is 246 feet. In Niagara county the northern outcropping edge of the Clinton is found at about 400 feet.

A comparison of the dips given above shows that the uplifting of the beds has been accompanied by a certain amount of warping, the effect of which has been to give the formation as a whole a broad synclinal arrangement, with the depressed portion in the central part near the Wayne-Cayuga county line, where the beds attain their most northerly extent within the State. East of this line the general dip is toward the southwest, becoming more marked as the eastern termination is approached. Between Cayuga and Monroe counties the dip is slightly east of south. West of Monroe county the syncline appears to be interrupted by a minor undulation, indicated by the southwesterly dip of the beds at Niagara Falls.

Details of Clinton stratigraphy

The name Protean originally applied to the Clinton beds by Vanuxem is significant of their extreme variability. They comprise a heterogeneous assemblage of sedimentary types that show little uniformity from place to place. Frequent changes in lithic character, thickness and faunal contents are observable throughout their extent in New York State.

In Niagara county, on the western end of the belt, limestone with a smaller amount of shale constitutes the entire formation. Passing through Orleans into Monroe county where the beds are again well exposed, it is found that the shale predominates over the limestone, a relation which holds true in a general way throughout the remainder of the distance to Herkimer county. In Monroe county the first hematite seam is encountered in outcrop, though it probably begins farther west. In Wayne and Cayuga counties there are important changes with respect to the relative development of the shales above and below the lower or main ore bed, while a second hematite stratum accompanied by limestone makes its appearance. Duplication of the ore seam is a common feature from here to Oneida county. Within the interval included by Oswego, Onondaga and Madison counties the shales attain even greater relative strength, compared with the limestone. Throughout the middle part of the belt, from Wayne to Madison counties, the lower ore bed lies but a few feet above the Medina formation. In Oneida county, however, there is a very appreciable thickening of the basal green shale which causes the ore to lie from 40 to 100 feet over the Medina. Toward eastern Oneida county, the shale becomes quartzose, grading into thinly bedded sandstone with shaly layers.

From Oneida county the stratigraphic bounds of the formation are somewhat indefinite. It is particularly difficult to establish the upper limits, since the extent of the Rochester beds above has not been definitely ascertained. Recent paleontological investigations around Clinton and east of there seem to indicate that the sandstone and shale beds heretofore regarded as upper Clinton may belong to the Rochester. The strata in Herkimer county are closely involved at the base with the Oneida conglomerate and the exact line of demarcation between them has not, as yet, been satisfactorily determined.

The stratigraphic succession along the belt will be shown more in detail by a number of sections that have been prepared from exposures and records of drill borings. The sections are given in order from west to east. Attention may be called here to the records of the test holes recently put down in the portion of the belt from Wayne to Oneida county given in detail in the chapter relating to exploration.

Niagara river. The Clinton strata are exposed within the Niagara gorge all the way from the falls to Lewiston at the north end. They are overlain by 70 feet of Rochester shale and rest upon the "gray band" that forms the uppermost layer of the Medina.[1] Their aggregate thickness is 32 feet.

STRATA	FEET
Bluish gray limestone, somewhat crystalline, fossiliferous.	12
Compact limestone, few fossils, carries iron pyrite in lower portion, the only semblance of the iron ore seams farther east	14
Bright green and olive shale	6

Rochester. Between Niagara river and Rochester, a distance of 75 miles, no complete sections of the Clinton are available. At Rochester the Genesee river cuts through the entire formation, affording one of the best exposures along the entire belt.

STRATA	FEET
Bluish gray limestone (Irondequoit), crystalline, abundant fossils in certain parts	18
Green shale (Williamson) with dark bands containing graptolites and pearly bands near top with *Anoplotheca hemispherica*	24
Hard limestone (Wolcott), silicious, holding *Pentamerus oblongus*, commonly known as Pentamerus limestone	14
Iron ore (Furnaceville), fossil hematite	14 in.
Green shale (Sodus), few fossils	24

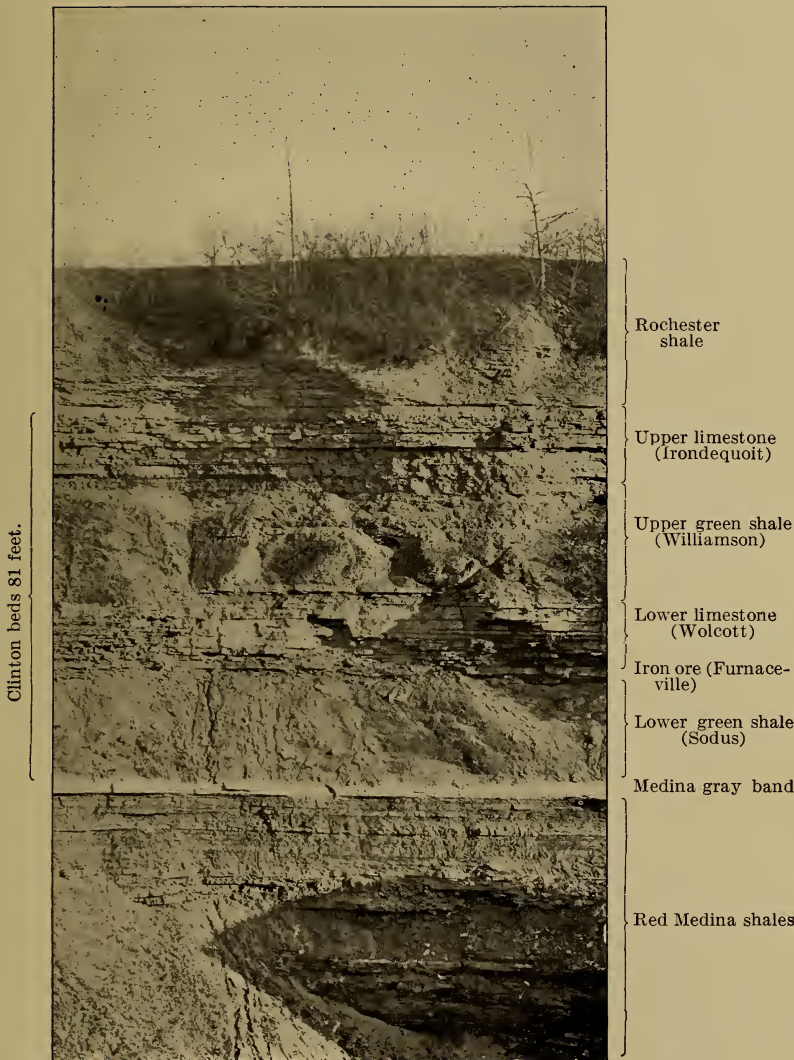
The formation is here 81 feet thick, a gain of 49 feet over the thickness shown at Niagara Falls, mostly represented in the shale members [*see* pl. 2].

Ontario, Wayne co. From the mine workings and drill holes near Ontario, 15 miles northeast of Rochester, the following succession has been established for the lower members of the formation.

STRATA	FEET
Soil and gravel	10±
Shale (Williamson) grading into limestone below	2

[1] For fuller description of the Niagara Falls section, Grabau, N. Y. State Mus. Bul. 45. 1901.

Plate 2



Genesee gorge, Rochester, showing the upper Medina, the Clinton beds and the base of the Rochester shale

STRATA	FEET
Limestone (Wolcott), with abundant Pentamerus......	8
Iron ore, fossil..	22 in.
Green shale (Sodus) compact, calcareous.............	10±
Medina shale	....

Wallington, Wayne co. From the test hole put down at this locality, the following condensed section has been prepared. The full details are given in the part of the present report relating to the recent exploration. The section is introduced here for the purpose of elucidating the stratigraphic relations in this region which have not, heretofore, been satisfactorily explained.

STRATA	FEET
Limestone	10
Dark shale, with graptolites............................	36
Pentamerus limestone..................................	14
Shale, thin bedded, with few fossil varieties............	54
Pentamerus limestone..................................	13
Ore, fossil...	1
Limestone	1
Ore, fossil...	8 in.
Green shale, calcareous.................................	5
Medina shale	2+

The total thickness of the Clinton shown in the hole is 135 feet, an increase of 54 feet over the amount at Rochester.

It will be observed that there are two beds of the Pentamerus limestone, separated by 54 feet of shale. In the early reports this duplication of the limestone was not recognized, which led to a misinterpretation of Clinton stratigraphy in the eastern half of Wayne county. The main or lower ore horizon, indicated by the two seams in the above section, occurs just below the first limestone bed, a position that is constant throughout Wayne county. There is in some places a third ore seam immediately above the upper Pentamerus limestone. This is shown on Second creek, near the entrance to Sodus bay, a little way east of Wallington, a locality referred to by Hall as the Shaker settlement. From study of the Second creek exposure Hall expressed the opinion that the limestone there was identical with the lower Pentamerus and that the iron ore bed found above it was the only one in that locality. It is now certain that there are two ore horizons, the lower being concealed, as its line of outcrop brings it beneath Sodus bay. In the same way Hall identified the ore bed at Wolcott furnace with the seam opened to the east and recently worked at Sterling Station, while they are really two different beds separated by from 75 to 100 feet of shale.

Clyde, Wayne co. A deep well was put down in 1887, in the village of Clyde, about 13 miles south of the Clinton outcrop. The altitude at the mouth of the well is given by Prosser,[1] from whose paper the record has been taken, as 389 feet. The boring was made with a churn drill. The iron ore reported is near the top of the Clinton and represents probably the upper ore horizon.

STRATA	FEET
Gray, green and blue marls (Salina)	152
Red marls (Salina)	156
Blue and green marls (Salina)	32
Dark blue limestone, dolomitic (Lockport)	110
Shaly limestone (Rochester)	225
Shale and limestone, first 15 feet reddish with iron ore (Clinton)	83
Red shale (Medina)	24
Sandstone (Medina)	3

The well was continued into the Hudson River beds, reaching a total depth of 1792 feet.

Alloway, Wayne co. In 1899 a deep boring was made at Alloway, 18 miles south of the Clinton outcrop and 8 miles southwest of the Clyde well at an altitude of 410 feet.[2] The well was started in the Salina and the Niagaran group was reached at 580 feet. No data were obtainable as to the Clinton beds, but they must have been penetrated above 980 feet where the first Medina was found.

Seneca Falls, Cayuga co. A deep well was put down at this place, which is 12 miles southeast of Clyde and 25 miles south of the Clinton outcrop near Wolcott.[3] After penetrating the Salina formation, the Niagaran strata were encountered at 950 feet. The combined thickness of the Clinton, Rochester and Lockport beds, which are not differentiated in the records, is given as 400 feet. The top of the Medina was encountered at 1350 feet. The altitude of the mouth of the well is 385 feet.

---

[1] Am. Geol. 1890. 6: 203.
[2] C. S. Prosser. Am. Geol. 1900. 25: 353.
[3] Prosser. Am. Geol. 1890. 6: 203.

Wolcott, Wayne co. The section of the Clinton at Wolcott, condensed from the record of the recent test hole, is as follows.

STRATA	FEET
Shaly limestone	13
Dark colored shale, with graptolites	44
Ore, fossil	1
Pentamerus limestone	22
Shale	62
Shaly limestone, lower Pentamerus	13
Ore with limestone seam	2
Shale	2+

The drill did not penetrate through the lowest Clinton shale which probably extends 3 or 4 feet below the bottom of the hole. Estimating the thickness of this shale at 6 feet, the Clinton beds aggregate 164 feet, as compared with 135 feet at Wallington.

The upper hematite seam here shown must disappear within a comparatively short distance to the east, since it was not found in the hole at Red Creek. It is present, however, just north of Alton, on Second creek, 10 miles west of Wolcott, but thins out entirely before Wallington is reached. The lower Pentamerus limestone is here quite shaly, containing fewer fossils than farther west. East of Wolcott it is scarcely recognizable. The limestones generally become less important after the belt passes Wayne county. Throughout the eastern part they never form solid masses of any size but are always in thin layers with shale intercalations.

Red Creek, Wayne co. The test hole at this place was drilled to a depth of 178 feet before reaching the ore horizon. The section of the Clinton may not be complete. The greater part of the hole was in shale, with limestone between 86 and 103 feet, representing, perhaps, the upper Pentamerus. About 2 feet of limestone, representing the lower Pentamerus, was found just above the ore. The complete record is given elsewhere.

Auburn, Cayuga co. A deep well was drilled during 1897–98 about 1½ miles north of Auburn. The locality is 24 miles south of the Clinton outcrop at Fair Haven. The strata assigned to the Clinton by Prosser[1] consisted of green noncalcareous shale, 10 feet, and clear green argillaceous shale, 115 feet. Since no samples were inspected from 1290 feet when the drill was in Lockport limestone

[1] Am. Geol. 1900. 25: 157.

to 1380 feet where the green noncalcareous shale was met, it is likely that the top of the Clinton was missed and that the beds are only partly represented in the aggregate of 125 feet above given.

South Granby, Oswego co. A nearly complete section of the Clinton formation was afforded by the test hole put down at South Granby, 15 miles east of Red Creek. An abridged record is given below. The drill started in Rochester shale, which became limey below, grading apparently into the Clinton limestone.

STRATA	FEET
Limestone	1½
Shale, with 4 inches of limestone at 102 feet depth	95
Light colored limestone, with traces of hematite	1
Shale, with 3 inches of iron ore	4
Limestone, basal part shaly	14
Shale, with limestone bands	69
Ore, oolitic	8 in.
Mottled shale	4

The lowest shale was not drilled through, but its base is probably not more than a foot or so below the bottom of the hole. The aggregate thickness is 190 feet.

Brewerton, Onondaga co. The test hole drilled at Brewerton afforded a partial Clinton section of 130 feet.

STRATA	FEET
Olive shale, with 2 inches of fossil ore at 56 feet depth and thin limestone bands at intervals	124
Ore, oolitic	16 in.
Sandstone and shale	5

From outcrops in the vicinity it is judged that the shale above the ore must be at least 150 feet thick. The drill was placed near the lake level and passed through 14 feet of clay before the shale was reached.

Syracuse. Two deep wells were drilled in 1884 near Syracuse. One, known as the Gale well, was put down 3 miles northwest of Syracuse near Onondaga lake and a little way east of the Oswego canal. The altitude at the mouth of the well is given as 435 feet. The record was reported by Dr F. E. Englehardt.[1] The Salina shales were penetrated to a depth of 525 feet, followed by the

[1] Annual Report of the Superintendent of the Onondaga Salt Springs, 1884.

Niagaran strata. Oolitic hematite was encountered at 976 feet and continued, according to the record, till 986 feet. The passage from the Clinton into the Medina strata was taken at 1007 feet depth and according to Prosser's interpretation at 991 feet. On the latter basis the combined thickness of the Clinton, Rochester and Lockport beds amounted to 466 feet. The second well, known as the State well,[1] was drilled a short distance southeast of the Gale well. The record given by Dr Englehardt does not vary essentially from the preceding, so far as the Clinton is concerned. The ore bed was encountered at 995 feet, with an estimated thickness of 5 feet.

Chittenango, Madison co. This is the site of a deep well which was drilled in 1890. The altitude at the top of the well is estimated at 444 feet. Prosser[2] gives the Clinton as beginning at 567 feet depth, with a green argillaceous shale 33 feet thick. Below this is bluish gray shale, 44 feet. Then follows dark gray calcareous material with iron ore, 11 feet, and at the base green argillaceous shale, 235 feet; the lower 10 feet having "a few reddish chips like iron ore."

Lakeport, Madison co. A section from the base to the top of the Clinton formation is afforded by the test hole drilled at Lakeport, on the south shore of Oneida lake, about 6 miles from the eastern end. The hole was started in the basal Lockport, a dolomitic limestone, which was underlain by 22 feet of Rochester shale.

STRATA	FEET
Limestone, with much shale and 6 inches of iron ore at 66 feet depth	17
Shale, with limey bands	227
Ore, fossil, alternating with limestone and shale	2½
Shale, with thin limestone	45
Ore, oolitic	1
Sandstone, shaly at top	2

The thickness of the strata aggregates 295 feet. This is about the maximum for the Clinton in New York State. The main element of the formation, as will be observed, consists of the upper shale, above the ore horizon, which reaches a much greater thickness than in any other portion of the belt. The presence of this great bed of shale affords an explanation for the depression occupied by Oneida

[1] Geol. Soc. Am. Bul. 1892. 4: 102.
[2] Geol. Soc. Am. Bul. 1892. 4: 97.

lake which lies mainly within its area of outcrop, extending east and west along the strike. The more resistent strata of the Oneida and Medina formations border the lake on the north and the contours rise rather rapidly from the shore line, while to the south there is a level stretch several miles wide underlain by the upper Niagaran and Salina beds before the first line of ridges is reached. The basin is the result, thus, of differential weathering and erosion, performed in large part perhaps during glacial times.

Verona, Oneida co. The Clinton strata are well exposed in Verona township, northeast of the city of Oneida. They occupy a strip from 4 to 5 miles wide that is clearly defined by the outcrop of the Oneida conglomerate on the north and the Lockport limestone on the south. The conglomerate occurs in close proximity to the lower Clinton shale. The latter, as shown by the section obtained in the test well at Verona Station, has a thickness of over 35 feet, considerably more than in the sections to the west. It increases still more eastward until at Clinton the thickness is nearly 100 feet.

There is much interest attached to the ore occurrence in this vicinity, since the character of the hematites appears to be quite different from that of the ores exposed around Clinton and in the town of Westmoreland where the next outcrops to the east are found. The main bed is a fossil ore and occupies the same relative horizon in the formation as the Clinton oolitic bed. The presence of a second seam, from 25 to 30 feet above this bed, is evidenced by the excavations made in the village of Verona. This seam consists of lean, limey fossil ore containing crinoid fragments and large-sized brachipods. There appears to be a third ore horizon, still higher up, represented by the seam that comes to the surface on the Donnelly farm, 5 miles northwest of Oneida and is possibly identical with the ore mentioned by Vanuxem[1] as occurring at Joscelin's Corners, between the hamlets of Lakeport and Oneida Lake. Its horizon is shown by the thin band found at 66 feet in the Lakeport hole.

Clinton, Oneida co. Though this is the type locality for the Clinton formation, the stratigraphic relations here are still somewhat indefinite. No sharp line of demarcation can be found between the Clinton and the Oneida-Medina formations below, and the upper limits are equally difficult to determine. A solution of the problem must await further comparison of the fauna with that afforded by the exposures to the west. From a paleontological standpoint, some

[1] Geol. N. Y. 3d Dist. 1842. p. 89.

evidence exists that a part of the upper beds hitherto assigned to the formation may belong to the age of the Rochester shale.

The section at this locality, as given by C. H. Smyth jr,[1] is as follows:

STRATA	FEET
Calcareous sandstone, thin shale layers................	50+
Ore, red flux...........................	6
Calcareous sandstone	6
Blue shale, thin sandstone layers....................	15
Ore, oolitic....................................	2
Shale...	2
Ore, oolitic	1
Blue shale, thin sandstone layers......................	100±

It is manifest that the formation here assumes a lithic character that is quite different from the succession heretofore described. Above the upper calcareous sandstone there is a gap of undetermined extent before the Lockport is reached. In the sections to the east, occurs a heavy gray sandstone, 70 feet thick as a maximum, forming what has been considered the uppermost member of the Clinton.

Herkimer county. The eastern end of the Clinton belt crosses southern Herkimer county into Otsego county. The relations in this region are not well known, and it is impossible as yet to fix accurately the bounds of the formation. The following sections from Hall[2] show the details of the succession so far as established.

Near the boundary of the towns of German Flats and Warren the strata are exposed along Flat creek. This locality is referred to by Hall as Tisdale's mill.

STRATA	FEET
Gray sandstone, upper termination of formation......	60
Shale...	2
Sandstone and shale with iron ore....................	20
Green shale with arenaceous matter, pebbles etc.......	25
Coarse sandstone, with much shaly matter..............	10–15
Green shale with fucoids...........................	?

The Oneida conglomerate below was not observed by Hall, but its presence both here and in the vicinity has been determined by one of the writers (C. A. H.). The ore can not be seen in place, though it occurs as float in the creek bed. It is of oolitic character.

[1] In Kemp's Ore Deposits of the United States. 1895. p. 104.
[2] Palaeontology of New York. 1852. 2:15 *et seq.*

Near Deck, in the town of Little Falls, is the section described by Hall as found at Wick's store in the town of Stark.

STRATA	FEET
Sandstone and conglomerate, uppermost Clinton member....	?
Sandstone, thin bedded, with fucoids, alternating with shale..	?
Red sandstone, cross-bedded..............................	?
White sandstone, with pebbles and green shale...............	?
Conglomerate (Oneida)..................................	?

Montgomery county. The following section is reported by Hall as found at Vanhornesville in the town of Stark.

STRATA	FEET
Red sandstone, coarsely laminated, friable, containing much iron ore but no distinct beds..........................	?
Green shale, fossiliferous................................	?
Red sandstone, cross-bedded..............................	?
Gray sandstone and conglomerate with thin layers of green shale..	?
Conglomerate (Oneida)..................................	?

The locality in the town of Canajoharie mentioned by Hall has not been certainly identified. The highest formation occurring within the present limits of the township is the Hudson river. The section may be the one on Canajoharie creek, in Otsego county, or more likely the section north of Cherry Valley, near Salt Springville, which is approximately at the eastern termination of the Clinton formation. The section is as follows:

STRATA	FEET
Coarse sandstone, with much iron ore.....................	?
Shale..	?
Grayish sandstone, conglomeritic below, darker and laminated above..	?
Conglomerate (Oneida)..................................	?

The total thickness is estimated at less than 50 feet. The presence of the Clinton beds can not be ascertained from the exposures at Cherry Valley, and they may have thinned out entirely. At Sharon Springs, 7 miles farther east, the Salina rests directly upon the Hudson River shales, the whole of the Niagaran and Oswegan groups having disappeared.

EXPLORATION OF THE CLINTON FORMATION

Little or no effort has been made, hitherto, toward the exploration of the Clinton ores outside the limited sections where they are mined. In the stretch from the Oneida-Herkimer county line to the western border of Wayne county, a distance of 120 miles measured along the outcrop, only a small portion is revealed sufficiently by exposure or mining excavations to permit of investigations from the surface. Previous knowledge of this area has been based largely on data secured from the eastern and western extremities; the included interval of nearly 100 miles in which the beds are, for the most part, mantled by glacial drift, has attracted little attention from mining enterprises and its possibilities for ore production remained practically unknown. The mine developments so far made, moreover, are superficial, giving no safe basis for inference as to the changes that may take place in depth.

A recommendation for an appropriation to be used in conducting exploratory operations within the Clinton belt was submitted to the State Legislature last year through the Education Department. The sum of $5000 (one half the amount requested) was allotted for the purpose. With this assistance, it has been possible to put down a number of test holes along the concealed portion of the outcrop and for the first time to establish the position, extent and character of the ore in a general way over many parts of the area. While the original plans called for the drilling of holes at intervals of 4 or 5 miles, east and west, with occasional deeper borings as might be required to explore the continuations of the beds on the dip, they had to be modified materially to meet the limitation in the allowed appropriation. Instead of attempting to carry out the work on a detailed comprehensive scale, which could only have been brought to partial completion under the circumstances, it was considered advisable to cover as much of the territory as possible by placing the holes far apart and restricting them to a single series near the outcrop.

The conditions throughout the Clinton belt, fortunately, are such that they both facilitate exploratory operations with the drill and permit reliable deductions from the obtained data. The ore seams maintain a fairly constant horizon in the series so that there need be little error in estimating the depth at which they will be encountered in most places. This regularity of position is attended by an equal uniformity in their areal development, as might be expected from bedded deposits. The character or thickness of any seam is subject to local variations, of course, but permanent changes take place very gradually as a rule. The volume of ore contained by a given area can thus be ascertained with reasonable accuracy from observations taken at wide intervals, even of several miles under favorable circumstances.

The present exploratory work was performed entirely with a diamond core drill. By this means a core, 1 inch in diameter, representing a section of the rocks and ore penetrated was secured. The cost of drilling has been somewhat greater than if the holes had been put down without attempting to obtain a core, but the increased expense may be considered to be counterbalanced by greater accuracy and detail in the results.[1]

With the meager information to be had from outcrops, the drill cores have served also to clear up many doubtful points regarding Clinton stratigraphy. The succession of rocks has now been established with satisfactory completeness throughout the belt.

The holes to the number of 8 in all were put down between Wallington, Wayne co., and Verona Station, Oneida co. The average interval between successive holes may be stated at about 10 miles. Most of the sites were selected with a view to striking the ore at depths between 100 and 200 feet, a convenient depth for the drill as well as one that permits estimation of a large volume of the deposits. Under normal conditions of dip and surface topography the holes would be from 1 to 3 miles from the outcrop, and their results can thus be accepted with a degree of safety as an average for about twice that width across the dip.

The detailed sections for each drill hole are shown in the tabulations that follow. From their consideration, together with the facts hitherto ascertained, it has been possible to prepare a general survey of the ore distribution throughout the belt.

Wallington, Wayne co. The site of the drill hole is on the farm of Isaac Du Bois about ½ mile west of the trolley station at Wallington, on the west side of Salmon creek and approximately 5 rods north of the highway leading from Wallington to Sodus village. The locality lies 1½ miles north of the outcropping edge of the Lockport dolomite, which is shown in the vicinity of Sodus Center, and 2⅝ miles directly south of the site of the old Sodus iron furnace on Salmon creek, near which the Clinton strata with a thin seam of ore are exposed.

[1] It may be mentioned that the diamond drill proved to be well adapted for the work. Owing to the frequent alternations of hard and soft strata characteristic of the formation, it was thought some difficulty might be encountered in removing a core, but in every case a nearly complete section was obtained. The occasional loss of a part of the core due to grinding of the harder material in the "core barrel" entailed no serious discrepancies in measurements, since a constant check was maintained by observations of the lengths of the drill rods in use and the character of the rock material washed up from below.

SECTION AT WALLINGTON

Strata	From Feet	From Inches	To Feet	To Inches	Character
Soil	0	0	2	6	
Shale	2	6	70	0	Light gray above, becoming darker and more fossiliferous below. Represents basal Rochester.
Limestone	70	0	80	0	Light colored, layers 2 to 16 inches separated by thin shales, 1 to 6 inches. Upper Clinton limestone.
Shale	80	0	88	0	In appearance this shale is similar to the basal Rochester. It is fully as dark and its numerous fossils are evenly distributed through the mass, giving it a variegated appearance.
Shale	88	0	100	0	Similar to above, but with fewer fossils and of a lighter shade.
Shale	100	0	115	8	These dark layers include the graptolite beds with the characteristic form *M. clintonensis*.
Limestone	115	8	130	6	The limestone contains layers of shale 1 to 3 inches thick. Pentamerus is the characteristic fossil of the limestone.
Shale	130	6	133	6	Fossiliferous dark and olive-gray shale with included bands of limestone. Transitional from the limestone above. The division is at point where shale predominates over the limestone.
Shale	133	6	182	0	A uniform purple shale; contains bands of pearly limestone made up of the fossil *Anoplotheca hemispherica*.
Shale	182	0	184	0	The purple shale above changes rather abruptly to this olive-gray shale which passes gradually into the limestone below.
Limestone	184	0	197	6	Characterized by the fossil Pentamerus. The limestone is uniform above. Near the middle is found some flinty material giving the rock a brecciated appearance. Layers of shale in lower part. First trace of ore at 195 feet.
Ore	197	6	198	6	Impure fossil ore.
Limestone	198	6	199	4	Includes some shale.
Ore	199	4	200	0	Fossil ore.
Shale	200	0	205	0	Soft green calcareous shale. The upper 2½ inches is brecciated, arenaceous limestone containing black shale pebbles.
Shale	205	0	207	0	Soft mottled shale of the Medina formation.

The section shows two beds of fossil ore, separated by 10 inches of limestone. The horizon is the same as the main bed at Wolcott and the bed at Ontario Center. While the ore maintains an average thickness for this region, it is hardly of mineable grade, containing as it does seams of unreplaced limestone, besides the heavy parting. A light flow of gas was encountered at 45 feet, in the Rochester shale.

Wolcott, Wayne co. The drill hole was put down on the east bank of Wolcott creek, within the village limits, about 300 yards below the falls. A boring for gas was made some years ago on the other side of the creek and about 20 rods farther north. The hole was started at approximately the same horizon in the Rochester shale as the one at Wallington. The upper ore bed outcrops 1¼ miles directly north, along Wolcott creek, near the site of the old Wolcott furnace.

SECTION AT WOLCOTT

Strata	From Feet	From Inches	To Feet	To Inches	Character
Soil	0	0	5	6	
Shale	5	6	44	0	Dark fossiliferous shales, somewhat lighter near the top where are found some bands of light colored limestone. Rochester shale.
Limestone	44	0	57	0	Considerably mixed with fossiliferous shale. Purest at top and bottom. Cavities in limestone lined with crystals.
Shale	57	0	101	4	Dark shales with graptolites. Includes some lighter colored shale.
Ore	101	4	102	4	Fossil ore.
Limestone	102	4	124	0	Alternating series of limestone and shale. Pentamerus characteristic fossil of the limestone.
Shale	124	0	127	0	Olive-gray shale free from limestone bands.
Shale	127	0	182	0	Purple shale with a number of thin bands of pearly limestone with fossil Anoplotheca hemispherica.
Shale	182	0	186	0	Olive-gray shale. Two inch band of ore at 186.
Limestone and shale	186	0	198	9½	The upper 16 inches is a fossiliferous limestone. Below is a shale with bands of limestone. The lower 3 feet is an impure limestone.
Ore	198	9½	199	0	Fossil ore.
Limestone	199	0	199	4	Impure limestone.
Ore	199	4	200	11	Fossil ore.
Shale	200	11	203	0	Calcareous shale with some very thin seams of limestone. At top is a 2 inch layer with black shale pebbles.

The upper 1 foot seam is the one that was worked in the early days near the furnace on Wolcott creek. The lower beds do not appear in the vicinity; the line of their outcrop must lie between 2 and 3 miles north of Wolcott. They are undoubtedly a continuation of the seam that is exposed in the excavations at Sterling Station and again shown in the hole near Red Creek, between that place and Wolcott. There is thus an area fully 10 miles long, east and west, which is underlain by an unbroken seam from 18 to 36 inches thick. As the holes are nearly 3 miles back from the outcrop, the continuity of the ore on the dip for any distance within easy reach of mining operations may be regarded as certain. The dip of the beds in this section is less than 50 feet to the mile.

The accompanying analyses show the composition of the beds at Wolcott. No. 1, by James Brakes, relates to the upper 1 foot seam and no. 2, by E. Touceda, to the main seam.

	1	2
Fe_2O_3	44.71	44.38
SiO_2	23.98	8.56
TiO_2	.225	....
Al_2O_3	7.26	5.04
MnO	......	tr.
CaO	9.15	13.71
MgO	2.92	7.37
SO_3	.987	.072
P_2O_5	.549	1.58
CO_2	9.6	18.8
H_2O	.26	undet.
	99.641	99.512
Iron	31.3	31.07
Phosphorus	.24	.69

Red Creek, Cayuga co. This test was made on the farm of M. H. Frost, 2 miles northeast of Red Creek, Wayne co., and 3 miles southwest of Sterling Station. The exact location is just north of the highway, beside the small stream that crosses the road east of the house.

SECTION AT RED CREEK

Strata	From		To		Character
	Feet	Inches	Feet	Inches	
Glacial drift.....	0	0	9	0	
Shale...........	9	0	42	0	Shale varies from light to dark, with calcareous layers. Large fossils at 23 feet.
Shale...........	42	0	50	0	Quite uniform, light calcareous shale.
Shale...........	50	0	86	0	Light colored shale above, with dark graptolite layers below. The basal portion includes some thin bands of limestone. At 69 feet is a 3 inch layer with black pebbles.
Limestone.......	86	0	103	0	This division consists of alternating layers of limestone and shales.
Shale...........	103	0	169	4	Purple shale. The upper 10 feet is olive-gray, grading into the purple below. The shale contains many limestone bands up to 6 inches thick.
Ore............	169	4	169	8	Fossil ore.
Limestone.......	169	8	171	8	Gray fossil limestone.
Shale...........	171	8	176	8	Shale shows a purple tinge. Contains some fossil limestone bands.
Limestone.......	176	8	178	0	Gray fossil limestone.
Ore............	178	0	180	6	Fossil ore—2 inches of shaly material near the middle.
Shale...........	180	6	184	0	This is a dark shale with many small "fucoidal" markings, giving it a mottled appearance. Only a few thin bands of limestone present. The upper 3 inches is a breccia.

The test hole shows that the bed exposed at Sterling Station extends thus far in undiminished thickness. There is no noticeable change also in the character of the ore. A sample of the drill core was analyzed by E. Touceda with the following results:

Fe_2O_3..................................	48.7
SiO_2..................................	5.13
Al_2O_3..................................	4.99
MnO..................................	.003
CaO..................................	12.6
MgO..................................	7.75
SO_3..................................	.096
P_2O_5..................................	.477
CO_2..................................	18.35
H_2O..................................	undet.
	98.096

Iron	34.09
Phosphorus	.208

Martville, Cayuga co. The site of this drill hole is on the west bank of Sterling creek about 15 rods below the bridge at Martville, on the property of Dr John Chapman. The locality is 3 miles southeast of Sterling Station and 5 miles northeast of Red Creek.

SECTION AT MARTVILLE

Strata	From Feet	From Inches	To Feet	To Inches	Character
Drift and broken shale	0	0	18	0	
Shale	18	0	83	0	With the exception of a few feet at base, this shale is purple in color. It includes a number of pearly limestone bands, between 33 and 57 feet. A few other light crystalline limestone bands occur at 45 and 54 feet. In thickness the bands of limestone vary from a fraction of an inch up to 6 inches.
Shale and ore	83	0	89	0	One inch of lean ore is followed by 1 foot of shale and limestone. Another inch of lean ore at 84′ 5″, followed below by dark shale with limestone bands.
Limestone	89	0	93	0	Fossiliferous limestone with bands of shale. Below this limestone is the horizon for the main ore bed as encountered in the drillings farther west.
Sandstone and shale	93	0	98	0	Upper few inches brecciated, followed below by greenish shale and sandstone. Below this is a very hard white sandstone, followed by a foot of mottled sandstone. Medina horizon.

This section seems to establish that the ore body which stretches across Wayne county and as far east as Sterling Station, Cayuga co., terminates practically near the latter locality. The excavations made by the Fair Haven Iron Co., at Sterling Station, give some indications of a wedging out of the ore toward the east, though from the evidence here it does not follow that this is anything more than a local condition. The ore bodies are everywhere subject to moderate variations in thickness, but the pinches are usually succeeded in turn by bulges that maintain the average. There is no other locality, so far as has been determined, where a thick bed diminishes in such short distance to a thin seam.

South Granby, Oswego co. The site of this drill hole is on the farm of Alonzo Lutentelly, 1 mile southwest of South Granby, and 1½ miles north of Little Utica, on the west side of the highway leading north from the latter place where it is crossed by a small stream.

SECTION AT SOUTH GRANBY

Strata	From Feet	From Inches	To Feet	To Inches	Character
Sand and gravel	0	0	22	0	
Shale	22	0	39	0	Dark shale, full of fossils—Rochester horizon.
Limestone	39	0	40	6	Impure limestone with fossils.
Shale	40	6	89	0	Shale with a little limestone. At 76 feet is a 1 inch band showing dark pebbles with pyrite.
Shale	89	0	102	0	Shale quite free from limestone bands. At 101 feet there is a thin seam of ore and the shale contains for 4 inches numerous crystals of pyrite. At 102 feet there are 4 inches of limestone with large brachiopods.
Shale	102	0	135	2	Shale with some very dark bands towards the base.
Limestone	135	2	136	1	Light colored limestone with fossils. Near the middle the fossils are replaced by iron ore.
Shale	136	1	138	9	Calcareous shale.
Ore	138	9	139	0	This band of ore is richest below, grading into a highly colored shale above with thin seams of ore.
Shale	139	0	140	0	Shale with band of limestone at the middle.
Limestone	140	0	140	8	Coarse, light colored limestone.
Limestone	140	8	145	3	Coarse, fossil limestone with some shale.
Limestone	145	3	145	6	Lean fossil ore.
Limestone and shale	145	6	154	0	Gray compact limestone and alternations of lighter colored limestone and shale.
Shale	154	0	223	1	Gray shale with bands of limestone. The limestone bands include a number of the pearly layers; also some fine compact bands. None of the bands of limestone are over 6 inches thick.
Ore	223	1	223	9	Oolitic ore with some fossils at base.
Shale	223	9	228	0	Mottled shale with bands of limestone. One inch of shale with pebbles found 2 feet below the ore. Mottled appearance of shale due to organic remains.

The hole is about midway between Sterling Station and the west end of Oneida lake, an interval that seems to be barren of workable deposits. More tests are needed, however, to demonstrate their entire absence, since the distance to the Martville locality is 10 miles and to Brewerton, the next drill site to the east, about 12 miles.

Brewerton, Onondaga co. The drill was set up on the south shore of Oneida river, within the village, about 75 yards west of the bridge. This point is very near the Oswego-Onondaga county border and the south line of the route followed by the new Barge canal.

SECTION AT BREWERTON

Strata	From		To		Character
	Feet	Inches	Feet	Inches	
Clay	0	0	14	0	
Shale	14	0	56	4	Olive-gray shale with many dark bands in the lower part and with few thin bands of limestone. At 19 feet there is a 4 inch band with black pebbles.
Ore	56	4	56	6	Fossil ore, inclosed in shale.
Shale	56	6	79	6	Shale with limestone bands 3 to 4 inches thick found at quite regular intervals. The limestone contains cavities lined with crystals. Traces of ore, as threadlike veinlets, are found in the limestone.
Shale	79	6	138	4	Shale with thin bands of limestone that probably represent the pearly layers. Trace of ore at 133 feet.
Ore	138	4	139	8	Oolitic ore.
Sandstone and shale	139	8	145	0	The layers below the ore are quite variable. The 2 inches immediately below the ore is shale; then follows a sandstone or conglomerate, becoming coarser toward the bottom.

This section is similar to the one at South Granby in showing two ore seams separated by many feet of rock. The absence of limestone is a striking feature and serves to connect this section with the eastern development of the Clinton, as exemplified in Oneida and Madison counties, rather than the western belt. This is further indicated by the oolitic structure of the lower ore seam.

The 16-inch bed is solid ore of uniform character. It will repay further exploration. The site of the hole was chosen purely for convenience, and the chances are very remote that the thickest portion of the bed was encountered by the single test. The discovery is thus of considerable potential importance. The ore was sampled by taking a longitudinal section of the core and an analysis by E. Touceda gave the following percentages.

Fe_2O_3	48.71
SiO_2	9.69
TiO_2	.244
Al_2O_3	3.21
MnO	tr.
CaO	13.8
MgO	4.23
SO_3	.141
P_2O_5	2.38
CO_2	15.45
H_2O (combined)	2.33
	100.185
Iron	34.1
Phosphorus	1.038

Lakeport, Madison co. The site of this drill hole is 1½ miles northeast of Lakeport on the farm of Robert Cowen. The drill was placed near the spring south of the highway, a little more than ¼ mile distant from the shore of Oneida lake.

SECTION AT LAKEPORT

Strata	From Feet	From Inches	To Feet	To Inches	Character
Drift	0	0	7	0	
Limestone	7	0	21	0	This is a dolomitic limestone representing the basal Lockport.
Shale	21	0	50	0	Fossil shale—Rochester horizon.
Limestone	50	0	67	0	Limestone with considerable shale. Six inches of lean fossil ore at 66. Other traces of ore in the limestone.
Shale	67	0	129	0	Alternating layers of dark, light and mottled shales with considerable amount of light fine grained calcareous sandstone.

SECTION AT LAKEPORT (*continued*)

Strata	From Feet	From Inches	To Feet	To Inches	Character
Shale...........	129	0	135	0	This is a shaly limestone with bands of shale. The limestone is fossiliferous and contains several bands of very lean ore, with many crinoid stems.
Shale...........	135	0	152	0	Shale with abundant fossils.
Shale...........	152	0	171	0	Olive-gray shale with fossils—a few thin bands of limestone.
Shale...........	171	0	276	0	Light and dark shale, with few bands of limestone. At 171 feet there is a 4 inch band with black pebbles.
Shale...........	276	0	294	6	Shale with limestone bands, 3 to 4 inches thick. Some of the bands show faint traces of ore.
Ore.............	294	6	295	1	Lean fossil ore.
Shale...........	295	1	295	10½	Gray shale.
Ore.............	295	10½	296	3	Fossil ore.
Limestone......	296	3	296	11	Whitish limestone with 1½ inch of shale at base.
Ore.............	296	11	297	0	Fossil ore.
Shale...........	297	0	328	0	Light and dark shale with thin bands of limestone. Trace of ore at 328 feet.
Shale...........	328	0	335	0	Shales with bands of limestone. Both contain fossils.
Shale...........	335	0	342	3	Soft, very dark shale with a few bands of a lighter color.
Ore.............	342	3	342	10	Oolitic ore, with fragments of bryozoans.
Shale...........	342	10	342	11	This is a dark shale dividing the ore.
Ore.............	342	11	343	3	Coarse grained ore, associated with calcareous sandstone.
Sandstone.......	343	3	345	10	The upper 4 inches is a band of shale with 2 inches at middle of a conglomeratic nature. The basal 6 inches is a white sandstone. The remaining portion contains thin layers of mottled, dark, sandy shale. Some of the sandstone has a reddish tinge showing faint traces of ore.

This hole was intended to test the long stretch between Brewerton and Verona throughout which the Clinton formation is mostly concealed. The results indicate some similarity of conditions in regard to ore deposition with the section at Brewerton and also with that at Clinton, but the oolitic bed is much thinner and the fossil ore is broken by intercalations of limestone and shale. The latter rock reaches its extreme thickness here, the hole showing 227 feet without practical interruption from the base of the limestone which is taken as the uppermost Clinton to the first seam of ore.

Verona, Oneida co. The site of this drill hole is 100 yards west of Verona Station, on the Davis farm, just south of the highway where it is crossed by the creek. It is 2½ miles southwest from the nearest outcrop of the Oneida conglomerate. The Cagwin opening for ore is 1 mile and the Klein opening 1½ miles from this locality.

SECTION AT VERONA STATION

Strata	From Feet	From Inches	To Feet	To Inches	Character
Sand and clay...	0	0	18	0	
Shale...........	18	0	37	2	This is a light colored shale with only a few thin bands of limestone.
Ore............	37	2	38	2	Fossil ore.
Shale...........	38	2	74	0	Shale quite uniform as regards texture. A few thin bands of limestone, up to 2 inches thick.
Sandstone and shale.........	74	0	84	4	These layers are quite variable. Some are made up of light sand in a dark shale matrix. The upper 2 feet is a fine grained calcareous sandstone. A few of the layers contain pebbles.

The object of putting down a hole at this locality, which is only a mile or so distant from old mine workings on the Clinton, was to test for a possible oolitic bed below the fossil ore which alone has been known. The presence of a lower ore horizon would appear probable from comparison of the two sections at Clinton and at Brewerton, east and west respectively of the present locality. In both sections two beds are shown, the lower being oolitic. The fossil nature of the Verona ore indicates relationship with the upper or red flux bed found to the east. The oolitic bed, so far as it can be identified, thus disappears in the interval.

The character of the fossil ore is shown by the following analysis made by E. Touceda on a sample of the ore.

Fe_2O_3	40.92
SiO_2	7.06
TiO_2	tr.
Al_2O_3	11.13
MnO	tr.
CaO	14.68
MgO	3.84
SO_3	.025
P_2O_5	1.02
CO_2	16.3
H_2O (combined)	4.88
	99.855
Iron	28.64
Phosphorus	.445

ORE DISTRIBUTION AND RESOURCES

Over most of the area occupied by the Clinton, the hematite beds contribute an essential feature to the sedimentary succession. They are, indeed, next to the shales, the most persistent element in the formation as represented in the State, having a wider development than either the limestones or sandstones.

Their eastern and western limits are somewhat indefinite, due to the long intervals between exposures; it is a question, also, not of an abrupt termination, but of a gradual thinning to disappearance with the progressive diminution of the formation itself.

At Rochester, the extreme westerly point where the ore is known to be represented, there is a single bed of fossil hematite 14 inches thick. This is very likely a continuation of the bed which stretches across Wayne county and is mined at Ontario Center, 15 miles northeast of Rochester. At any rate the ore shows so moderate a decrease within the interval that its continuity for a considerable distance farther west seems probable. Beyond Rochester there are no good exposures until the Niagara gorge is reached where the ore fails entirely and the whole section of the Clinton is reduced to 40 feet or less.

On the eastern end the hematites can be traced as far as the Oneida-Herkimer county border without any noticeable changes of character. After passing that line their thickness falls off quite rapidly. At the outcrop west of Frankfort hill, in the town of Frankfort, Herkimer co., the oolitic bed measures only 10 inches, which is about one third the amount represented at Clinton, 9 miles west. The red flux bed on the other hand is still fairly well maintained as regards thickness, showing about 40 inches. Following the strike to the southeast across southern Herkimer county, the beds appear to give out within a short distance, for they can not be identified in the outcrops, or else they shade off into a ferruginous sandstone that is much different from the normal ore varieties. In the exposures along the hills south of the Mohawk river, between Frankfort and Herkimer, neither the oolitic nor the red flux bed can be seen, but there are 10 feet or more of deep red sandstone heavily charged with hematite. The latter functions as cement to the quartz grains, but does not encrust them. The iron content of the sandstone may be placed at about 10%. The entire Clinton disappears, so far as surface indications are concerned, near the eastern border of Herkimer county.

The ore seams thus attain their fullest development in respect to thickness within the stretch from eastern Oneida to western Wayne county. Beyond these limits they have little economic importance for the present, at least, and their exploration is not of immediate concern.

The information gained from the test drilling, described elsewhere in this report, serves to show the distribution of the more valuable ore bodies with some precision. It has been found that the ore is mainly gathered into four areas which succeed each other along the outcrop, after longer or shorter intervals that are characterized by thin seams, much below the average, or by their almost complete disappearance. There is a possibility of one or two additional areas being present that have escaped notice by reason of the wide spacing of the holes, but they must be of minor extent compared with the others.

The area which centers about Clinton, Oneida co., has been the principal source of the ore in the past. There are two seams here, an upper of fossil character called the red flux bed and a lower oolitic bed that is sometimes split into two portions by a layer of barren rock. The fossil ore is too lean to be used in the furnace. It attains the notable thickness of 6 feet. The oolitic bed extends through the towns of New Hartford, Kirkland and Westmoreland and is of mineable grade over most of the territory in which it is exposed. It ranges from 20 to 36 inches, with an iron average of 40% or a little more in places. A subordinate area, perhaps connected with this, is found in the town of Verona, where some ore was obtained for the early furnaces. The workings are 7 miles distant from the proximate outcrops in the town of Westmoreland. The bed measures from 12 to 20 inches and is of fossil nature. The oolitic bed is absent from this section.

The test hole at Lakeport, the only one put down in the stretch of 30 miles from Verona Station to the west end of Oneida lake, was unfavorable for the presence of any considerable volume of ore in this vicinity. At Brewerton, 15 miles from Lakeport, a 16-inch bed of oolitic ore was found. This is a new discovery and is nowhere exposed at the surface. That it underlies a considerable area seems quite certain, and it doubtless attains a greater thickness than indicated by the test. Further exploration is needed to ascertain its full value.

After an interval in which the formation crosses the southwestern corner of Oswego county without the appearance of any considerable ore bodies, the third area is encountered in northern Cayuga county, beginning near Sterling Station. The excavations along the outcrop here show from 30 to 36 inches of fossil ore, while within 1 mile to the south the bed is reported to increase to 40 inches. The bed has been proved as far west as Wolcott where the drill encountered 21 inches while an overlying 12-inch seam comes in at this place. The drill hole put down at Red Creek midway between Wolcott and Sterling Station showed the main bed to be 30 inches thick. The two drill tests have demonstrated the extent of the ore to be much greater than hitherto known. All that has been done previously in the way of exploration consisted of shallow open cuts and drill holes on the eastern end, which afforded no satisfactory evidence of the character and volume of the ore to be found to the south and west. The average iron content of the main bed may be placed at about 35% to 38%.

The continuation of the ore bed immediately west from Wolcott has not been prospected. It may be assumed, however, that the main seam thins in this direction, or is broken up by intercalations of limestone, which is in accordance with the results found at Wallington, 10 miles from Wolcott. At about the same distance beyond Wallington, in the town of Ontario, Wayne co., is an area that contains a bed of fossil ore from 18 to 30 inches thick. This seam has been worked for a distance of 5 or 6 miles east and west and explored by the mining companies several miles farther along the outcrop. It diminishes very gradually westward so that at Rochester it is still 14 inches thick. The ore from the surface workings in the town of Ontario averages 40% or slightly more in iron.

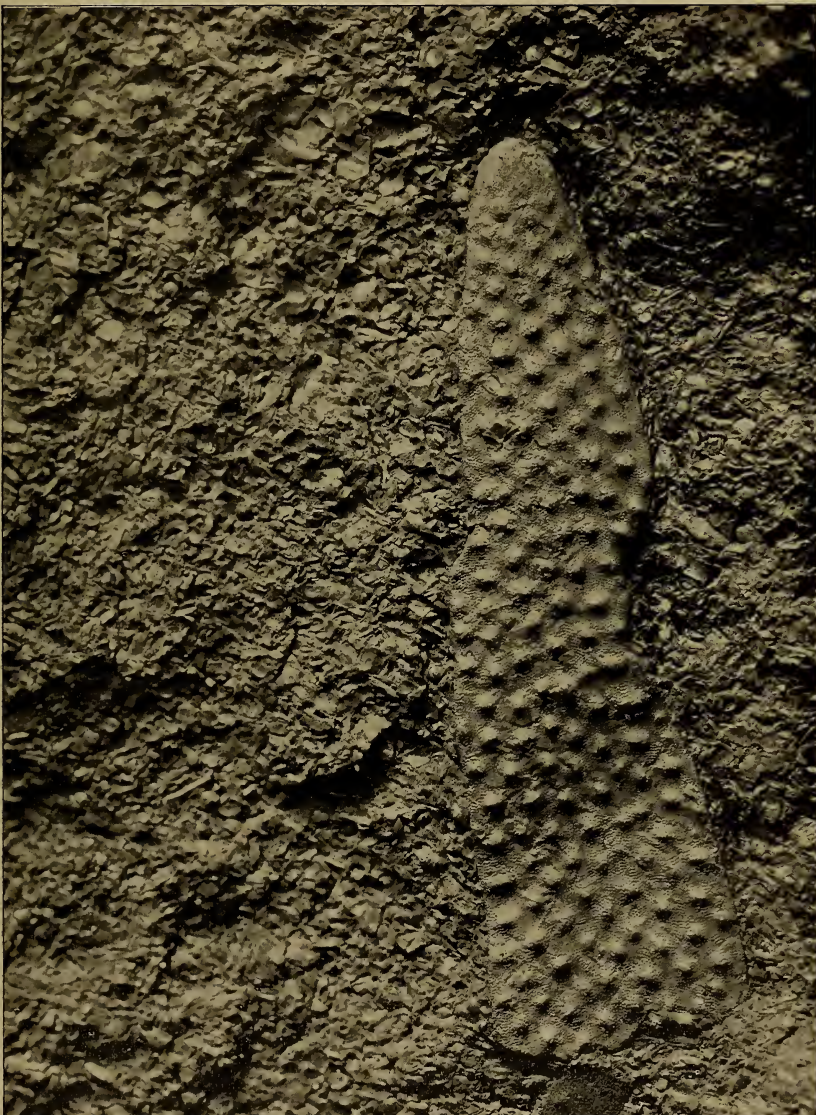
The above outline of the distribution of the hematites is necessarily tentative; it is an effort merely to interpret the data thus far at hand. There are many gaps to be filled in, and much additional information is required concerning the sections even that are best known before an ultimate survey of the conditions is possible. The available evidences suffice, however, to indicate in some measure the possibilities of the Clinton formation as a future source of iron ore.

The volume of ore which is subject to estimate within the areas mentioned is such that it must be considered one of the more important reserves in the present fields of iron mining. A great proportion, of course, will not be subject to profitable extraction for many years to come. But if limitations be put upon the estimate, so as to bring it into relation more or less close with the existing status of the mining industry, the total will still be large.

Thus, to provide a reasonable basis of calculation, we may exclude all ore that is below 18 inches thick or more than 500 feet from the surface, also leaving out of account the beds that are below the average in iron content. Under these restrictions the quantity available in the three principal areas may be placed at approximately 600,000,000 tons.

The larger part of the ore resources available for underground mining is represented by the western areas of Cayuga and Wayne counties. The inclination of the beds in this section is usually less than 50 feet to the mile, while the surface rises very gradually southward; consequently mining could be extended for a long distance (from 5 to 6 miles) on the dip before the depth of the workings would reach 500 feet. That the ore may be expected to hold out for such a distance has been practically demonstrated by the borings at Wolcott and Red Creek which penetrated the beds at points about 3 miles back from the line of outcrop. Its continuity

Plate 3



Fossil ore from Ontario, Wayne co. Slightly enlarged. The large fossil is a bryozoan, Phaenopora constellata.

is also to be inferred from the persistence of the beds along the strike.

In the Oneida county area, on the other hand, though there is a stretch of fully 10 miles east and west in which the beds exceed the minimum thickness stated, the conditions for mining on the dip are generally less favorable. The average width of the area lying within 500 feet from the surface may be placed at 2 miles. The indicated dip is here about 150 feet to the mile.

With large scale operations the cost of ore extraction down to a depth of 500 feet should not be much, if any, over $2 a ton. It would appear that this limit is easily within range of economic mining for the near future, though with the large resources lying near the surface there will be no incentive to extend operations to such a depth for many years to come.

THE ORES

Mineralogy and structural features

The Clinton ores belong to the red, earthy variety of hematite. In some specimens a little specular hematite is present, due to resolution and crystallization after the beds were laid down; siderite or iron carbonate also occurs locally in small amount distributed in fine particles through the mass. The bulk of the ore, however, consists invariably of amorphous hematite, red or brownish red in color and streak. The specific gravity of the ore ranges between the limits of 3.5 and 3.8. For purposes of calculation it may be assumed that a cubic foot weighs 225 pounds.

Compared with the hematites occurring in other surroundings, the Clinton ores may be distinguished by certain structural peculiarities, descriptive of which are the terms oolitic, lenticular, fossil etc., that are applied to them in the various mining districts. These structures are related to the methods of origin and are singularly persistent.

An examination of representative specimens from the New York beds brings out the fact that the hematite forms two kinds of aggregates, each giving a distinctive character to the ores in which it predominates. The one consists of spherical or somewhat flattened grains, quite uniform as to size and having the appearance of being solid hematite. When separated from the matrix and broken, or when observed in thin section, it is usually seen that the grains have a nucleus, generally a minute quartz kernel, about which the hematite is arranged in concentric layers. In each ore particle may be recognized often a number of such layers. Their deposition has taken place at successive intervals while the grains were moved about and in complete contact with the iron-bearing solutions. The formation of oolitic limestone illustrates the general conditions that must have prevailed during the deposition of the ore. The second type of structure found in the Clinton ores is distinguished by the occurrence of the hematite with an organic form, due to its replacement of some calcareous fossil such as a bryozoan, crinoid or brachiopod. The fossils may be wholly replaced, but more commonly a portion of the original lime is retained in the interiors, and in some cases the change has not progressed beyond the outer surfaces, so that practically all steps between fossiliferous limestone and ore may be observed.

The two structures — fossiliferous and oolitic — are not infrequently found together, though in most samples from the New York beds one type so prevails as to lend a fairly uniform appearance to the ore. The oolitic structure is more limited in its development than the other. It characterizes the main bed in the eastern section, notably around Clinton and in the towns of New Hartford and Westmoreland, and is found farther west in the ore at Brewerton and Lakeport. The fossiliferous ore appears at Clinton in the so called flux bed, and forms the single deposit in the town of Verona, Oneida co. The ore mined at Sterling Station, as well as the entire section throughout Cayuga and Wayne counties, belongs to that type.

A curious feature of the oolitic grains, that has been brought out by C. H. Smyth jr, in his studies[1] of the Clinton ores, is the presence of amorphous silica in intimate association with the hematite. Though the silica layers are scarcely discernible in ordinary thin sections, they are easily revealed by subjecting the grains to the action of hydrochloric acid. When the hematite has thus been removed in solution, there remains a perfect cast of the original oolite preserved by the gelatinous, transparent silica. Apparently, the deposition of the silica took place at the same time and from the same solution as the iron.

The individual spherules are usually closely compacted and often coalescent on the borders. They are seldom more than 1 millimeter in diameter. The quartz kernels in their interiors are scarcely half that size as an extreme and range down to particles so minute that

[1] Am. Jour. Sci. 1892. 143: 488. *Also* Zeits. für prak. Geol. Aug. 1894.

Plate 4

Oolitic ore from Clinton, Oneida co.

they are observable only with the aid of the microscope. The kernels sometimes appear to be wholly absent. The quartz has the same character as that found in granitic rocks, showing liquid and gas inclusions, as well as rutile and hematite crystals. Its ultimate source, undoubtedly, is the Precambric crystallines, but the small size of the grains and their well rounded forms indicate long continued abrasion after its release from the rocks.

The texture of the fossiliferous ore varies to some extent with the locality. In the red flux bed as exposed at Clinton, the fossil fragments are coarse and the different forms can be separated and identified without difficulty. In the western part of the State, the beds show much finer texture, while the shell particles have been worn and smoothed until their organic nature is more or less concealed. The smaller fragments are often enveloped by one or more layers of hematite deposited after their replacement in the same way as with the oolitic grains.

The cementing material in both kinds of ore is usually granular calcite. There is considerable variation in the relative proportion of this mineral to the hematite. Local variations may be ascribed to solution of the calcite after the ores were laid down, but it is also to be expected that the conditions of deposition would change from time to time and from place to place. An exceptional type is represented in the eastern section in Herkimer county where there are one or more layers of what is properly a ferruginous sandstone. The fine quartz grains are not coated with hematite to any extent, but the latter fills the interstices as cement. The material is too lean to be classed as an ore.

Chemical character

The Clinton ores show considerable regularity in their chemical composition. Leaving out of consideration the locally occurring beds which are generally too lean or too thin to be workable, the ores throughout the State may be said to average about 40% in metallic iron. They seldom run above 45% or less than 35%. The higher limit is approximated by the oolitic bed in the vicinity of Clinton, where the mines of the Franklin Furnace Co. have returned an average of 44% through a period of several years. The care taken in separating the ore from the inclosing rock and in the removal of shale, sandstone or limestone partings which are often present, is an important factor in determining the yield. According to C. A. Borst, the middle portion of the Clinton oolitic bed can be mined to give

55%, while if the whole bed is taken out without sorting, the average will be about 40%. The fossil ore in the western part of the State runs from 35 or 36% to 44 or 45%.

The following analysis quoted from a paper by A. H. Chester[1] is of interest, as it represents the average from a large number of analyses of Clinton ores from Oneida county.

Fe	44.4
SiO_2	13.09
Al_2O_3	5.99
MnO	.19
CaO	5.85
MgO	2.69
S	.31
P	.53
CO_2	6.08
H_2O	1.45
O in Fe and P	19.71
	100.29

The percentages would indicate that the ores analyzed were chiefly from the oolitic bed, though no mention of localities is made in the paper.

Phosphorus and sulfur are both comparatively high in the Clinton ores. The former is seldom less than .25% and ranges up to more than 1%. Reckoned on the basis of metallic iron, the phosphorus content will average from 1 to 2%. The sulfur is more variable, being found in some ores only in traces and in others running up to .5%. It occurs always in the form of pyrite which seems to be associated rather with the shale partings than intermixed with the hematite. Between the ore and wall rock there is oftentimes a thin seam of pyrite.

Among the other important impurities of the ores are silica, alumina, lime and magnesia. Most of the silica is in the free state as quartz. Its proportion varies from a minimum of 2 or 3% up to 15%, the higher percentages being shown by oolitic ores. In the fossiliferous hematites the average may be placed at about 7 or 8%. The alumina is combined with a part of the silica to

[1] Address delivered before the Utica Mercantile Manufacturing Association, Utica, 1881.

Plate 5

Fossil fragments from the red flux bed. The ore is largely made up of such fragments of bryozoans and crinoid stems which have been partially or wholly replaced by hematite.

Plate 6

Oolitic ore, magnified so as to show quartz nuclei and concentric structure

form clay and amounts to some 2 or 3% as a rule. The lime and magnesia are due to limestone which occurs as a cementing material or as unreplaced fossil fragments. They are in largest quantity in the fossil ores where the carbonates average from 15 to 20%. The oolitic ores carry about 10 or 12% of carbonates as a rule.

Origin of the Clinton ores

The subject of the derivation of the hematites, which are so constant an accompaniment of the Clinton formation, has been repeatedly discussed in the literature relating to the geology of the different fields. There is more than scientific interest involved in the question, since the mode of origin has a bearing upon the distribution of the deposits and its determination is desirable as an aid to exploration. It has become quite evident with the progress of investigations that there is a great degree of uniformity in the character and manner of occurrence of the Clinton ores throughout their extent and that they have been formed in most, if not all, cases under similar conditions.

Of the many principles that are known to govern the accumulation of iron ores in their varied development, it is possible to eliminate all but a few as having no conceivable relation to the Clinton hematites. In fact there are but two explanations which have received the attention of geologists and need to be considered here.

According to the first view, originally advanced by James Hall in his description of the Clinton formation in western New York, the ores were formed in standing water at the same time as the inclosing beds. Hall further expresses the belief that the source of the iron is to be found in the bodies of iron oxids and pyrite contained in the old crystalline rocks. Thermal waters are considered to have been influential in the deposition of the oolitic ore and they may have hastened the decomposition of the pyrite. These conclusions were generally adopted by the early writers.

The alternative explanation, proposed by Shaler for the Clinton ores in Kentucky and favored by some geologists for the whole assemblage of Clinton ores, regards the hematite as a secondary introduction after the formation had been upraised above sea level. The ore beds are considered to be replacements of original limestones, effected by the circulation of ground waters which leached the ferruginous constituents from the overlying strata. This theory of replacement has found its principal advocates among geologists who have worked in the southern fields where the occurrence of rich ores at the surface is at times succeeded by lean, limey ores in depth.

The evidence in support of both views has been traversed very thoroughly by C. H. Smyth jr, in a paper[1] which represents as well the results of long experience and close study of the Clinton ores both in the northern and southern districts. There can be no doubt after an impartial perusal of Professor Smyth's paper that the theory of sedimentary origin is fully substantiated for most of the occurrences. For the ores under present consideration this is the only explanation at all compatible with the conditions.

The stratigraphic features presented by the New York section of the Clinton do not lend themselves to the conception of vertical circulations of ground water such as would be required to dissolve and carry iron from the overlying strata. The ore beds everywhere lie nearly horizontal; their dip is universally toward the south at an angle no greater probably in many places than that given by the contour of the original sea bottom on which they were deposited. At no time in their subsequent history have they been steeply inclined. Moreover, they are overlain by thick shales not readily permeable to water. Underground flowage must necessarily be limited and be dependent for the most part on the cropping out of the more porous strata like the limestone and sandstone layers. Thus, it is directed rather along the bedding planes than across them. Below the ore there is also more or less shale intervening before the top of the sandstone and conglomerate basement is reached.

The existence of limestone above the ore beds has been remarked by Professor Smyth in the paper already quoted. In Cayuga and Wayne counties the fossil hematite is covered directly by limestone and there are one or more layers at varying horizons in the shale. The main ore bed in this part is generally split into two portions by a thin seam of limestone. No noticeable replacement has taken place in the overlying limestones, though this would be the first to be affected by descending iron-bearing solutions. The limestones are fine grained and compact and, where protected by shale, they show little effect of leaching in the mass or of solution along the joint planes.

The ore beds are separated by sharp division planes above and below, with no intervening zone of gradation from ore to rock. This feature is well illustrated in the process of open-cut

[1] Zeits. für prak. Geol. Aug. 1894. *See also* paper in Am. Jour. Sci. 1892. 143:487.

Plate 7

Partial section of the Clinton beds at Clinton, showing red flux bed in upper part

mining, by which the overlying burden is removed over a considerable area before the ore is taken out; the surface of the stratum is extremely regular and smooth, not less so than the surface of the superincumbent limestone.

In their uniformity of character the hematites possess a feature that is consistent only with a sedimentary derivation. This uniformity holds true for the beds near the surface and also with regard to the ores encountered at depths of several hundred feet from the surface. The recent exploration with the diamond drill has shown that there is no notable change of character on the dip for distances of 5 or 6 miles from the outcrop. Deep borings made some years since at Syracuse and Chittenango found the hematite below 600 feet showing it to be of normal composition.[1] The ores hold out to much greater depths than could be expected from the work of underground waters.

Enrichment by solution and redeposition of the iron has not occurred in the New York beds. Whatever variation in iron content there may be is to be regarded as original or as due to weathering on the surface. There are no bodies of soft ores at all comparable to those found in the southern districts. This may be ascribed in large measure perhaps to the effects of the glacial invasion; during the long period previously in which the beds were exposed to atmospheric agencies it seems likely that the ores may have weathered for some distance from the outcrop but were planed off by the ice in its southward advance. Yet, the horizontal disposition of the beds has no doubt retarded disintegration. The chief effect of weathering is the removal of calcite which cements the particles of hematite.

The physical constitution of the hematites has already been described and need not be considered in this connection further than to allude to the almost universal presence of oolitic grains in the ores, even those which are apparently of purely fossiliferous nature. The deposition of iron about a nucleus in layer after layer can scarcely be conceived as taking place elsewhere than in bodies of standing water, with the nucleal grains free to roll about and completely in contact with the ferruginous solutions.

The probable conditions prevailing in Clinton time, bearing

---

[1] C. S. Prosser. The Thickness of the Devonian and Silurian Rocks in Central New York. Geol. Soc. Am. Bul. 4: 91.

upon the formation of the ore beds, have been well stated by Professor Smyth in a paragraph of his paper of which the following is a translation.

By reference to a geological map of the eastern United States, it will be observed that the Clinton beds were deposited in a sea which received the drainage from an extensive area of crystalline rocks. Long continued denundation of these rocks, which are made up in part of iron-bearing silicates and inclose important bodies of magnetite and pyrite, set free large amounts of iron to be carried seaward in solution or suspension. Along the coast of the sea there were in Clinton time extensive swamps and mud flats, evidenced by the frequent surface markings, cracks and tracks of crustaceans and worms found in the shales and sandstones. In other places calcareous fossil fragments accumulated and were rolled about and ground by the waves and finally deposited in shallow water forming shell beaches similar to those of the present day, for example, the coquina on the Florida coast. Most of the iron brought down by land drainage of course would be wasted, but a part would be precipitated to form the ore beds. The precipitation occurred in two ways, thereby giving rise to two ore varieties. Where the waters were collected in partially or completely inclosed basins, the iron was thrown down by slow oxidation and gathered in layer upon layer about the sand grains, thus forming the oolitic ore. The conditions requisite to this method of precipitation obtained apparently over no great areas, so that the oolitic beds are generally of limited extent. Again the ferruginous waters came in contact with the calcareous shell fragments; here the iron was precipitated partly by reaction with the lime carbonate, yet mostly by oxidation, while the lime was carried off in solution by the aid of the carbon dioxid set free. As this process took place while the shells were being rolled about or heaped up in loose aggregates and was chiefly a result of oxidation, the iron took the form of oxid rather than carbonate. It need scarcely be stated that this method of replacement is widely different from the other process of replacement that has been applied to the ores. The progress of the reaction advanced step by step with the accumulation of the fossil fragments. Thus, while the iron is a secondary product as regards the individual particles of ore, it is primary in relation to the ore bed itself. After the ores had thus been collected into loosely aggregated masses of grains and altered fossils, they were compacted into beds and covered by shales, sandstones and limestones. As a result, the grains and fragments rich in iron are frequently surrounded by pure calcite, a circumstance that is far from being opposed to the present theory of ore formation, but rather in line with what one would expect.

Plate 8

View showing small steam shovel and revolving derrick used in removing and loading the ore into the cars. Furnaceville Iron Co., Ontario Center, Wayne co.

The deposition of the iron partly in the form of carbonate is indicated by the fact that the fossil ores quite commonly show a small percentage of this mineral. It is probable, however, that the iron was mostly precipitated as the hydrated oxid. The change from limonite to hematite took place subsequent to the upraising of the beds under the influence of pressure from the overlying strata.

The New York Clinton beds, in common with those of Ohio, Ontario and Wisconsin, were deposited along the northern margin of the interior Mississippian sea, and the ferruginous materials must have been derived largely from the wash of the Precambric land mass on the north and northeast. The New York section has its maximum development in the stretch from Clinton to the west end of Oneida lake where there was apparently an embayment curving around the southwestern border of the Adirondacks. The present outcrop in this part is everywhere within 50 miles at most of the crystalline area. Farther west the beds diminish gradually with the increase of distance from the Adirondack highland, and in the extreme west the materials probably came from the remoter crystalline region of Canada. East of Clinton there is a more rapid thinning of the beds, since the old Appalachian highland that limited the sea in this direction is soon reached. The Pennsylvanian and southern Clinton deposits were laid down on the western shore of the Appalachian highland; their materials were probably gathered from this land mass rather than from the north.

There is an interval of more than 100 miles between the eastern end of the New York belt and the next appearance of the Clinton rocks to the south, which is in central Pennsylvania. It is possible, however, that this gap is due to the overlapping of the higher Upper Siluric members which are represented in eastern New York and pass into Pennsylvania in the vicinity of Port Jervis. A comparison of the faunas of the Clinton in New York and Pennsylvania shows a close relationship that is suggestive of stratigraphic continuity, the buried portion coming to the surface only after it becomes involved in the Appalachian folds.

MINING METHODS

From the beginning of active mining along the Clinton belt, attention has naturally been directed to the northern edge or outcrop of the beds as being the most accessible for development. The conditions are well suited for surface work by stripping or trenching throughout much of the stretch from Herkimer to western Wayne county. In places the ore is encountered directly beneath the soil or at most a few feet of glacial materials, while with its flat dip there is often opportunity to extend the field of operations to considerable distances from the outcrop before the overburden becomes excessive. There is still an abundance of ore that can be removed to advantage by open-cut work.

It is quite recently that mechanical methods of excavation have been introduced, and the greater portion of the product in the past has been won by the crude system of hand labor first employed. With the use of portable steam shovels, the cost of taking out the ore has been so reduced that it is now practicable to strip fully twice as much rock as formerly, notwithstanding the material reduction that has taken place in iron ore prices.

An example of good practice in open-cut excavation is afforded by the recent operations of the Furnaceville Iron Co. at Ontario Center. This company has been engaged in working a strip of land lying to the north of that place and extending for over 4 miles in an east and west line. The plan adopted here consists briefly in opening longitudinal trenches, the first along the northern limits of the property, near the outcrop, and the following ones in parallel order progressively with the removal of the ore from the preceding trench. At the present time about 20 feet of overburden is taken off, while in the first cut some 40 rods to the north the ore lay beneath 6 feet of soil and rock. The trench has a width of 60 feet and until recently two shovels were used in its excavation, each cutting 30 feet or one half the whole width. The shovels loaded into buckets which were hoisted by revolving derricks and dumped on the spoil bank opposite the long face of the trench and just beyond the edge of the ore that was being uncovered. The outer shovel worked somewhat in advance. During the last year the trenching has been done by a single 100-ton shovel which removes the rock for a width of about 45 feet, dumping directly on the spoil bank, and then returns to clear the remainder with the aid of a derrick.[1] The shovels and derricks are mounted to run on tracks

[1] Since the above account was written, the methods have been somewhat modified in that a conveyor has been installed, as shown in the accompanying plates. The conveyor consists of a portable structure, with two skips each of 6 cubic yards capacity which receive the rock material from the steam shovel and carry it up the incline (129 feet long) to the dump. This apparatus increases the efficiency of the steam shovel, at the same time enabling the latter to excavate the trench to the full width of 60 feet without return.

Plate 9

View showing steam shovel and conveyor used to remove the overburden from the ore. Furnaceville Iron Co., Ontario Center, Wayne co.

Plate 10

View of trench after removal of overburden and ore. At the base and to the right is shown the ore bed with overburden above. Furnaceville Iron Co., Ontario Center, Wayne co.

set in the trench. The overburden consists of 10 feet or slightly more of limestone, somewhat shaly toward the top, and about the same thickness of soil and glacial material. It is loosened for the shovels by drilling and blasting. The 6-inch holes made by churn drills, extend into the ore for about 3 inches and are 16 feet apart, the first row being 6 feet from the edge of the trench. A layer of limestone, 15 to 18 inches thick, that remains on the ore has to be removed by hand. The ore is then loosened by blasting, after holes 3 feet apart and extending a few inches into the underlying green argillaceous limestone, have been made by steam drills. A small amount of the limestone sometimes adheres to the ore but is readily removed. The ore is broken by sledges into convenient size for handling, after which it is loaded, by means of a 40-ton steam shovel, into the buckets of a derrick and hoisted into cars for shipment. A spur from the Rome, Watertown & Ogdensburg Railroad extends along the trench on the side opposite the spoil bank; it is moved back from time to time with the advance of operations toward the south.

The Fair Haven Iron Co. has pursued a similar plan in opening the property at Sterling Station. The rock is here mostly shale, so that its excavation presents less difficulty than the limestone farther west. Instead of wasting the material in the abandoned part of the workings, the shovel loads into cars which run out on a track at one end and are dumped to the north of the pit. The shale and soil covering has a thickness of from 10 to 20 feet. The material is loosened by blasting in advance of the shovel in the manner above described.

The mines at Clinton furnish the only examples of underground exploitation of the ores in the State. The long-wall method is employed, the same as used in many coal mines. This method admits of complete extraction of the ore in one operation. It is particularly adapted to comparatively thin deposits that have a flat dip. Entrance to the workings may be had either through a shaft, or, if the seam outcrops anywhere, through an adit driven on the level. By taking advantage of the surface features, it has been possible at Clinton to follow the ore from its outcrop and to make use of the slight inclination of the beds in securing natural drainage. The main entries or gangways are run in an easterly or northeasterly direction across the dip. From these, branches turn off at every 100 feet to the working face, which is kept a short distance ahead of the gangway. As the ore measures 30 inches on the average, approximately 2 feet of the overlying shale is taken down for convenience in working. This material is packed some distance behind the face for roof support, while between the pack and the face wooden posts are placed from 5 to 10 feet apart for further security. As far as possible the posts are removed with the advance of the workings to be again used in the same manner. The bottom of the face is taken out first by drilling diagonally from the top of the ore bed. Upon blasting the lower portion of the ore is loosened and taken out, after which horizontal holes are drilled into the shale and the upper part, including the remainder of the ore bed, is removed. Tracks are laid to the working face and the ore is trammed by hand or by mules to the mine dump outside. The soft character of the Clinton strata is an advantage in this system of working in that it tends to produce a constant and uniform settlement of the ground with the advance of operations. There is thus little or no danger from roof falls. The only drawback seems to be that of occasional creeping of the floor in the gangways which requires attention from time to time.

The few data bearing upon costs that have been obtained would indicate that when the covering does not exceed 20 feet or so the ore can be removed most economically by open cutting. With a 2 foot ore seam, which yields approximately 8000 gross tons to the acre of surface, the cost of stripping and removing the ore under ordinary conditions may be placed at about $1.50 a ton. It has been reported that underground mining has been carried on at Clinton for somewhat less, but here the ore is from 30 to 36 inches thick. Account must be taken also of the expense connected with development wōrk and equipment, which is considerably larger in the case of an underground mine than in surface work.

DESCRIPTION OF ORE LOCALITIES AND MINES

Cayuga county

The outcrop of the fossil ore is encountered near Sterling Station where mining operations were first instituted about 35 years ago and have recently been revived by the Fair Haven Iron Co. Sterling Station lies at the eastern end of the ore belt which stretches across Wayne county. East of this point the ore diminishes rapidly and within a short distance becomes too thin to be workable.

Fair Haven Iron Co. The property of the Fair Haven Iron Co. comprises 280 acres situated just south of Sterling Station

Fig. 3 Sketch map of the Clinton ore belt in Cayuga and eastern Wayne counties. The approximate outcrop of the lower or main ore bed is indicated by the broken line. The map also shows the outcrop of the upper ore seam north of Wolcott and position of the recent test holes. Scale 1 mile to ½ inch

between the Lehigh Valley and New York Central (R. W. & O. branch) railroad lines. The company was organized in 1906. The work done thus far consists in the opening of a trench which begins about 400 yards southwest of the station, near the railroad track, and follows the line of outcrop to the east. The bed is found here beneath 10 to 25 feet of soil and rock. The loose overburden represented by soil and glacial materials varies from 18 inches to 10 feet. A general section involving the ore, made some distance back from the outcrop, with a maximum of covering, is as follows:

MATERIAL	FEET
Soil	10
Shale	55
Limestone	1.5 to 2
Ore	3
Green shaly limestone	5
Medina	10+

The ore as shown in the trench ranges from 30 to 38 inches thick, the average mineable thickness being probably about 30 inches. There is generally a seam of limestone 1 or 2 inches thick in the middle of the ore, while the limestone covering the ore is from 10 to 18 inches thick. Eight feet above the main bed is a thin seam of ore, reaching 4 inches as a maximum. The shale above the ore bed is at times quite compact, but presents no difficulty to excavation after loosening by blasting. It carries one or more layers of limestone which appear at different horizons and are not persistent for any distance, their total thickness amounting to 5 or 6 inches. An analysis of the ore, supplied by Mr W. L. Cumings, showed the following percentages:

Fe_2O_3	49.97
SiO_2	6.01
Al_2O_3	.95
MnO	.47
CaO	13.96
MgO	7.8
SO_3	.11
P_2O_5	.8
CO_2	19.39
H_2O and org	.45
	99.91

Fe	34.98
P	.351
S	.044

The shipments from the property during 1907 are reported to have averaged between 36 and 38% iron.

A spur from the R. W. & O. Railroad extends into the pit from the western end and the ore can be loaded directly on cars for shipment. The rock is run out at the opposite end on a track and dumped on the waste land north of the pit. The excavation has been carried on by means of a 65-ton Marion steam shovel which works down to the limestone capping. The limestone and ore are then removed by drilling and blasting.

Swartout opening. Just west of this property, across the railroad track, is the Swartout opening, which was worked about 35 years ago. The workings are small and the amount of ore taken out could not have amounted to more than a few hundred tons.

Furnaceville Iron Co. A short distance farther west, on the Josiah Gailey farm, ore was mined during the years 1887 and 1888 by the Furnaceville Iron Co. The locality is referred to by Smock[1] who states that the ore occurs in two beds, each about 18 inches thick. It would appear that the two beds are the same as the main bed on the property of the Fair Haven Iron Co. which, as already stated, is divided by a thin seam of limestone. From information obtained locally, the thickness of the ore as mined ranged from 30 to 40 inches. The ore was uncovered by steam shovel. The property is said to be still owned by the Furnaceville Iron Co.

Oneida county

The section of the Clinton belt extending through the towns of New Hartford, Kirkland, Westmoreland and Verona, Oneida co., has afforded most of the ore obtained from the formation in the eastern part of the State. Openings have been made in the ore at intervals all the way from the Oneida-Herkimer county line on the east to Verona Station on the west. Most of the work has been done by open cutting along the outcrop, a method exclusively pursued in the early days of mining, but now abandoned. For some years past operations have been restricted to the properties just

[1] First Report on the Iron Mines and Iron Ore Districts in the State of New York. N. Y. State Mus. Bul. 7. 1889. p. 51.

Plate 11

Entry to the mines of the Franklin Iron Manufacturing Co., Clinton. Red flux bed appears near top, its lower portion being indicated by the iron pipe.

east of Clinton owned by C. A. Borst and the Franklin Iron Manufacturing Co. who obtain the ore entirely by underground mining.

The outcrop of the main ore bed in this region is shown on the map [pl. 12], which reproduces portions of the Oriskany and Utica topographic sheets on the scale of 1 mile to the inch.

The mining industry around Clinton dates back to the beginning of the last century. The first lease for digging ore is said to have been granted in 1797. The Norton mine at the foot of College hill west of Clinton is the site of some of the earliest operations and supplied ore to forges in the vicinity. Charcoal furnaces soon superseded the forges and were operated until the erection of the larger furnaces using anthracite coal. The charcoal plants were located as far away as Taberg and Constantia, while there were others nearer by at Lenox, Walesville, and in the town of Frankfort, Herkimer co. With the opening of the Chenango canal, shipments of ore began to be made to Pennsylvania furnaces. From 1845 to 1850 the Scranton Iron Co. engaged in this business on an extensive scale, shipping the ore from New Hartford and Clinton by boat to Binghamton and then on to Scranton. In 1852 the Franklin Iron Works erected a plant on the site of the present furnace of the Franklin Iron Manufacturing Co., and began operations with an output of 150 tons of pig iron a week. The fuel used was anthracite coal. An additional furnace was built in 1869–70 giving a combined output of about 300 tons a week. The Clinton Iron Co. was organized in 1872 to manufacture iron at Kirkland, just north of Clinton. The furnace was placed in operation in 1872, the ore supply being obtained from Westmoreland. This furnace has been closed down for the last 20 years, while the Franklin furnace has been operated intermittently, depending upon the iron market. Besides the ore used by these furnaces considerable quantities were shipped at one time to Geddes (near Syracuse), Albany and Poughkeepsie. The mining of the Clinton ore for paint manufacture has been carried on by C. A. Borst since 1890. From 5,000 to 10,000 tons are produced each year for that purpose.

Davis opening. This is the most easterly working in Oneida county, being within about a mile of the Herkimer county line. It is also known as the East Hill opening and was once a part of the property owned by the Scranton Iron Co. It was worked for some years by J. G. Egert and afterwards by C. A. Borst. The open-cut excavation extends over several acres beginning a little over a mile east of Washington Mills and extending eastward along the outcrop. The ore is covered by from 6 to 10 feet of soil, with a little shale, and has a thickness of 22 inches as a maximum, diminishing gradually as one proceeds in an easterly direction. At the upper reservoir on Starch Factory creek, across the county line, the bed is only 10 inches thick. The overlying rocks are shown here up to the red flux bed which has a thickness of 40 inches and is exposed over a considerable area. The ore from the Davis mine was shipped to Poughkeepsie and other points. An analysis given by Putnam shows the following percentages:

Iron	43.76
Phosphorus	1.116

Wells and Ellingwood openings. Continuing westward from the Davis mine, the outcrop of the ore bed comes out into the Sauquoit valley and then turns upstream or southward to a point beyond Chadwicks where it crosses the Sauquoit and follows a nearly northerly course to a point about a mile west of Washington Mills. Some ore has been taken out in the valley near Chadwicks, but there are no extensive excavations until the outcrop is encountered along the highway from Washington Mills to Clinton. In this stretch of about 4 miles the surface is quite level, with only a gradual rise to the south, and a large area of the ore bed can be exploited by shallow workings. The outcrop has already been stripped for much of the distance, as there are many places where the only covering is soil and glacial materials.

The Wells, situated in the eastern part of the town of Kirkland about half way between Washington Mills and Clinton, is an open cut extending along the outcrop for several hundred feet. It was once operated by the Franklin Iron Co. It was idle at the time of Smock's report. The property now belongs to C. A. Borst of Clinton. According to the descriptions of Putnam the ore as worked averaged about 21 inches and was covered by 12 to 15 feet of shale and gravel. An analysis of a sample from 400 tons showed the following percentage of iron and phosphorus.

Iron	46.79
Phosphorus	.64

East of the Wells open cut, there is about 1 mile of the outcrop that has not been exploited, while beyond this interval an opening has been made by C. A. Borst over a small area.

The Ellingwood opening adjoins the Wells on the west. An analy-

MAP SHOWING LINE OF OUTCROP OF CLINTON OOLITIC ORE IN PARTS OF ONEIDA AND HERKIMER COUNTIES

sis of the ore made by J. B. Britton and quoted by Putnam gave the following results.

Fe_2O_3	58.2
SiO_2	10.14
S	.51
P_2O_5	2.557
Al_2O_3	3.98
MnO	.2
CaO	6.66
MgO	2.17
H_2O and CO_2	15.14
Undet. and loss	.443
	100.000
Iron	41.05
Phosphorus	1.117

Franklin and Clinton mines. With the sloping of the surface toward the Oriskany valley, the ore beds beyond the Ellingwood opening come out just east of Clinton in a northeast-southwest course at about the 700 foot contour, as shown on the topographic sheet. A large quantity of ore has been removed here by open cutting, the excavations extending nearly a mile on the outcrop, with a width of several hundred feet in places. These workings date back many years. For the last 25 years or more the ore has been mined underground. Altogether an area of about 200 acres has been worked over by mining or stripping, and the ore product must amount to nearly 2,000,000 tons.

The Franklin and Clinton mines are a part of the ore properties owned by the Franklin Iron Manufacturing Co. and have always been operated in connection with the company's furnace at Franklin Springs, 2 miles south of Clinton. They are entered by adit levels that follow the main ore bed in an easterly and southeasterly direction. The advancing long-wall system of mining is employed. From 18 to 24 inches of overlying shale is blasted down with the ore to gain sufficient room for the miners to work. The ore is trammed on cars, holding a little more than a ton, to a loading platform near the mine and is then run over a spur to the Ontario & Western Railroad for shipment to the furnace. Since the rebuilding of the Franklin furnace in 1880 the mines have been intermittently active, producing about 60,000 tons a year when operated. They were closed down last in November 1907, after a campaign of two years.

The exposures of the Clinton strata at this locality have much interest, as indeed they afford one of the best sections of the formation in eastern New York. The following is the succession as given by C. H. Smyth jr.[1]

MATERIAL	FEET
Calcareous sandstone and thin shale	50+
Non-oolitic ore (red flux)	6
Calcareous sandstone	6
Blue shale and thin sandstone	15
Oolitic ore	2
Shale	2
Oolitic ore	1
Blue shale and thin sandstone	100+

The red flux bed reaches its greatest thickness at this point. The oolitic ore alone is mined. The existence of two oolitic beds in the Clinton section has been generally accepted as a normal condition, but this is not the case. There is convincing evidence to show that the lower seam represents nothing more than a split in the main bed due to a thickening locally of the shale or sandstone parting that is nearly everywhere present. There are few places where the two beds are more than a few inches apart. As a rule the ore in this vicinity really measures from 30 to 36 inches, that is the combined thickness of the two beds, and it has been the recent practice to extract the entire oolitic ore without reference to the intervening rock layer.

The composition of the oolitic ore at this locality is shown by the following analyses.

	1	2	3	4	5
Fe_2O_3	69.17	42.97	79.98	63	71.82
SiO_2	11.57	29.72	9.98	12.63	11.34
Al_2O_3	3.92	4.13	2.4	5.45	3.91
MnO	.19	.37	tr.	.15	1.63
CaO	5.8	8.57	1.54	6.2	3.97
MgO	2.27	1.96	.3	2.77	2.21
S	.28	.837	Nil	.23	Nil
P_2O_5	1.726	1.534	1.239	1.5	2.096

[1] J. F. Kemp. Ore Deposits of the United States. 1896. p. 104.

Plate 13

Furnace of the Franklin Iron Manufacturing Co., near Clinton

	1	2	3	4	5
CO_2	4.75	9.47	4.39	6.15	2.47
H_2O	......			2.77	
Loss	......	.439	.171	......	.554
	99.676	100.000	100.000	100.85	100.000
Iron	48.42	30.08	56.37	44.1	50.68
Phosphorus	.754	.67	.541	.65	.915

Analysis no. 1 was made by C. H. Smyth jr. No. 2 relates to the bottom tier of oolitic ore from the Franklin mine; J. B. Britton, analyst. No. 3 is from the same mine, by J. B. Britton. No. 4 is an average analysis of ore from the Franklin and Clinton mines made by A. H. Chester in 1873. No. 5 is from a sample of ore from the Clinton mine, J. B. Britton, analyst. With the exception of no. 1 which is taken from the report by John C. Smock, the analyses are quoted from Putnam's paper in the Report of the Tenth Census.

The variations in the iron percentages shown by the analyses are extreme and may be ascribed to lack of uniformity in taking samples. The ore as roughly mined will run about 40%; the average return during the last period of operations is stated to have been 40.27%. By removing the rock parting the content can be raised to 45%. The median 12 inches or so of the oolitic bed will assay above 50%.

The red flux bed has been analyzed by E. C. Sullivan[1] with the following results:

Fe_2O_3	30.24
SiO_2	8.71
Al_2O_3	3.67
CaO	20.64
MgO	7.84
SO_3	.15
P_2O_5	.75
CO_2	24.78

[1] Eckel, E. C. The Clinton Hematite. Eng. & Min. Jour. May 11, 1905. p 897.

Iron	21.16
Phosphorus	.327

Elliott and Butler, or Borst mines. The properties described in the early reports under the names of the Elliott and Butler openings lie just north of the preceding mines along the east-west outcrop of the Clinton. Since their purchase by C. A. Borst, they have been converted into underground mines. They cover an area of 60 acres. The method of mining is the same as practised by the Franklin Iron Manufacturing Co., but the workings are so laid out that natural drainage is secured. The entry is from the west and the ore is trammed by hand to the stock pile where there are facilities for loading directly on cars for shipment. The mining equipment is exceptionally complete while the underground development is such that a large output can be made. An independent spur connects the mine with the main railroad line. Most of the ore heretofore has been sold for grinding into mortar colors and metallic paint, the output for that purpose being much the largest of any hematite mine in the region. The paint ore is shipped with an average of 45% Fe, the quality being somewhat higher than the run-of-mine, since the sandstone parting is removed by cobbing. An analysis of a sample of the ore is reported by Putnam to have given the following percentages:

Iron	45.73
Phosphorus	.554

The oolitic bed measures about 30 inches, with variations of a few inches above and below the average.

Clinton Mills opening. This open cut, also called the Ferman, is situated 2 miles northwest of the preceding mines, on the opposite side of the Oriskany valley. From the mines east of Clinton village, the ore outcrop runs southwest and, forming an upstream deflection as at Sauquoit, crosses the Oriskany at some distance from the surface in the vicinity of Franklin Springs. Continuing north, on the west side of the valley, the ore is first encountered in exposure within the small glen just south of the road that leads up College hill. One mile further north is the Clinton Mills locality, stated by Smock to have afforded some ore for the Kirkland furnace. An

Plate 14

Mining plant of C. A. Borst, Clinton

acre or more of ground was worked by the open-cut method, the operations dating back to the year 1888. On account of the steep valley slope here the overburden increases rapidly away from the outcrop. The section as given by Smock follows:

Glacial drift	18–30 feet
Greenish gray shale	20 inches
Ore bed	24–30 inches
Floor of ferruginous sandstone.	

The ore bed dips at the rate of 3 feet in 100 feet to the southwest, and drainage is not so readily effected as on the east side of the valley. A peculiar feature is the occurrence of slight offsets which displace the bed as much as 6 inches. The ore has the same general character as the Clinton oolitic bed but contains a greater proportion of shaly material.

Norton opening. This adjoins the Clinton Mills property on the north. It is described by Putnam as under operation at the time of his report. The ore is 21 inches thick, with shale covering. An analysis of a sample from 30 tons of the ore is reported by Putnam to have shown:

Iron	39.88
Phosphorus	.665

Openings in town of Westmoreland. The oolitic bed continues north and west into the town of Westmoreland where it has been worked at different places for the supply of the Kirkland and Taberg furnaces.

One was dug on the Pryer and Laughlin farms, about a mile west of Kirkland, for use in the local furnace. The bed is here 18 inches thick. An analysis, quoted from Putnam, shows the following percentages:

Iron	42.9
Phosphorus	.753

About ¾ of a mile north of the Pryer farm, across the small stream that drains into the Oriskany, are the openings on the Derwin farm and a little south of them, across the stream, the Freibergher opening, all of which were made by the Kirkland Iron Co. The ore from the Derwin farm is about 16 inches thick and somewhat shaly. It was sorted before smelting. A sample of the sorted ore showed:

Iron	40.4
Phosphorus	.693

About ½ mile west from the Derwin farm there are two openings on the adjoining farms of Fred Richer, and a little beyond is another on the Egan farm. The product was partly used in the Taberg furnace. Continuing farther west there are outcrops of the oolitic bed on the farm of Henry Kingsnorth and at Newland's Mills.

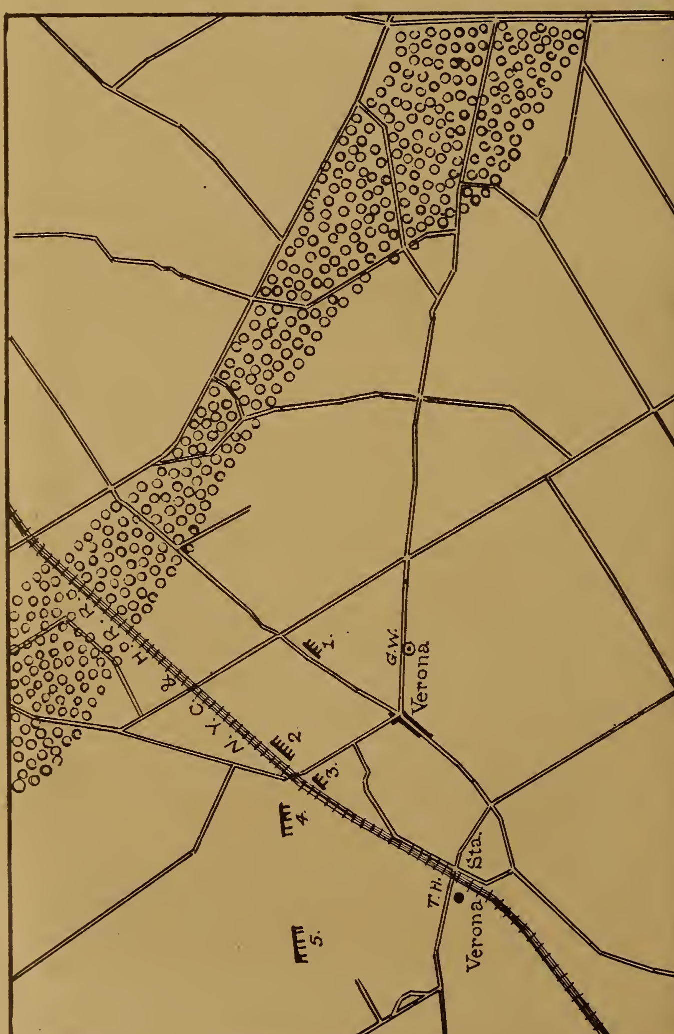


Fig. 4 Sketch map of the district about Verona, Oneida co., showing outcrop of the Oneida conglomerate, openings for ore and position of rece. t test boring. The excavations are numbered as follows: 1. Klein. 2. Stevens, 3. Dann, 4 and 5, Cagwin.

Plate 15

Old blast furnace built by the Kirkland Iron Co. and run upon Clinton ore. Kirkland, Oneida co., 2 miles north of Clinton

Openings in the town of Verona. In the interval of about 6 miles from Hecla works to Verona village the oolitic bed disappears, or at least it is nowhere seen in the exposures. The next openings to the west lie just north of Verona village on the Klein farm. The bed is about 1 foot thick and of fossil character, resembling in appearance the red flux bed around Clinton. It lies beneath 5 or 6 feet of earth. The iron content is low, as shown by the following analysis:

Iron	21.85
Phosphorus	.248

West of Verona village, across the New York Central Railroad, is the Cagwin farm, which is mentioned by Putnam as operated under lease by the Onondaga Iron Co. The ore is 15 to 17 inches thick and richer in iron than the eastern part of the same bed. An analysis showed:

Iron	40.27
Phosphorus	.328

The farms owned by M. Stevens, W. E. Dann and Timothy Smith, near by, have furnished a limited amount of ore in the past. There has been no production of ore in this section for some time. The fossil bed seems to have been discovered at an early date, and was worked in places before 1830. The ore was used mainly in the furnaces at Taberg, Constantia and Lenox, while in later years some ore was shipped to Geddes, near Syracuse.

Wayne county

The belt of Clinton rocks crosses northern Wayne county in an east-west direction. The ore outcrop is encountered in the towns of Wolcott, Huron, Sodus, Williamson and Ontario. The mine workings are entirely of open-cut character, situated on the outcrop or near by, where the maximum covering of soil and rock does not exceed 25 feet. The ore belt, so far as it has been located, is shown on the maps facing pages 56 and 70.

The discovery of the hematites in the county dates back to the opening of the last century. Hall records that ore was dug in the town of Ontario during the War of 1812 and carried to Auburn for grinding into paint. Spafford's *Gazeteer,* published in 1824, refers to active mining operations as carried on in that section for the supply of three local forges and a furnace at Manchester. According to the same authority ore was obtained, also, from the town of Sodus. Hall in 1838 mentioned the existence of workings on the outlet of Salmon creek, town of Sodus, near which a forge was still standing at the time. A furnace had been erected before that date on Bear creek, at the locality now known as Furnaceville, 2 miles north of Ontario village. The furnace was run upon ores taken from the vicinity and continued to operate for many years. About 1869, a new stack having a capacity of 80 tons a day was erected. In the town of Wolcott the manufacture of iron was begun soon after 1820, undoubtedly at the old furnace just north of Wolcott village. The iron after it was converted into castings was hauled to Clyde and shipped to outside points by canal. The last run of iron at this furnace was made in 1869, since which time there has been little or no ore produced in the vicinity. In the town of Ontario mining operations have been carried on more or less steadily from the first discovery.

Openings in the town of Wolcott. The oldest working in this town is that found along the bed of Wolcott creek, 1½ miles north of Wolcott village, near the furnace site. The ore outcrops on both sides of the creek immediately below the soil. It is of fossil character and belongs to the upper ore horizon shown in the record of the test hole put down at Wolcott. It is about 1 foot thick. An analysis quoted from Beck[1] shows the following composition:

Fe_2O_3	51.5
SiO_2	6.0
Al_2O_3	7.5
$CaCO_3$	24.5
$MgCO_3$	7.75
H_2O	2.75
	100.00
Iron	36.05

A second locality, where ore was obtained in the early days, is about 5 miles northeast of Wolcott village, on the course of the little stream called Bear creek. The bed here is 30 inches thick, representing the lower or main seam of ore as developed in this

[1] Mineralogy of New York. 1842. p. 28.

Plate 16

Section of the Clinton beds exposed at Newland's Mills, near Hecla Works, Oneida co. Oolitic ore bed at top, underlain by green shale

region. It has been worked from the outcrop back into the face of a low hill over an area of more than an acre. There has been no work done for the last 40 years. An analysis of the ore is here given.

Fe	38.87
SiO_2	3.45
MnO	.25
S	.018
P	.374

Town of Huron. Hematite is reported to outcrop on lot 339 but has not been worked.

Town of Sodus. There is an old working on Salmon creek, near the mouth, but apparently very little ore has been taken out. Hall states that operations were abandoned before 1838.

Openings in town of Ontario. This township has yielded most of the ore output from the western section of the Clinton belt. The workings extend almost continuously across the whole width of [illegible]wn, between 5 and 6 miles, and for as much as ¼ mile back [illegible] outcrop. The bed passes into the town of Williamson on the [illegible] where it maintains its average thickness for at least 2 miles farther, but has not been opened. The line of workings lies about 3 miles south of Lake Ontario and ½ mile north of the R. W. & O. Railroad tracks. The ore belongs to the fossil variety, averaging about 20 inches thick. It occurs below the Pentamerus limestone, which reaches its maximum in this section of the State.

The Furnaceville Iron Co. owns extensive properties along the ore outcrop from Ontario village westward. At present the strip from Ontario to Ontario Center is under exploitation. The company has been active for many years and its methods of excavation and extraction of the ore have been perfected to a degree rarely seen in such work. At the present time a little more than 20 feet of rock and soil are removed from above the ore bed. The workings are connected by a branch railroad with the main line at Ontario Center. The ore is shipped to Emporium, Pa. Its composition is exhibited by the following analyses, of which no. 1 has been reported by Mr W. L. Cumings and no. 2 has been taken from Putnam's report.

	1	2
Fe	44.12	41.46
SiO_2	11.74	....
Al_2O_3	.48	....

	1	2
CaO	7.34	....
MgO	3.76	....
MnO	tr.	....
P	.494	.578
S	.028	....

In the Report of the Tenth Census, Putnam mentions several properties as under operation and shows their location. The properties in order from east to west include the Bennet, Ontario Furnace Co., Hurly, La Frois, Bundy and Ontario Furnace Co., of which all but the first one were active. The principal holdings of the Ontario Furnace Co. have been taken over by the Furnaceville Iron Co., the former company having gone out of existence. The analyses below are from Putnam and refer to ores from these properties: no. 1, Hurly; no. 2, La Frois; and no. 3, Bundy.

	1	2	3
Fe	40.73	42.25	38.36
P	.531	.481	.471

The Ontario Iron Ore Co. is a new producer in this section and began shipments in 1907. The company owns properties lying east of the Slocum road and a little west of Ontario Center.

The Wayne Iron Ore Co. has properties under development near those of the Furnaceville Iron Co., north of Ontario, and also farther west, near the Wayne-Monroe county line. The holdings near Ontario have been tested with a core drill and the ore bed found to range from 18 to 30 inches thick. The ore on the western properties has an average thickness of 18 inches. A series of 15 analyses from samples of the ore represented by the drill cores and test pits distributed over all parts of these properties shows the following average:

Fe	37.85
P	.646

EDUCATION DEPARTMENT
JOHN M. CLARKE
STATE GEOLOGIST

STATE MUSEUM

BULLETIN 123, PLATE 17

PART OF MACEDON QUADRANGLE

MAP SHOWING LINE OF OUTCROP OF CLINTON FOSSIL ORE THROUGH THE TOWN OF ONTARIO, WAYNE COUNTY

BIBLIOGRAPHY

The following is a list of publications dealing with Clinton ores and their occurrence in New York State. The more important ones have been reviewed in an initial section of this report.

Ashburner, C. A. Petroleum and Natural Gas in New York State. Am. Inst. Min. Eng. Trans. v. 16. 1888.
Includes a number of well sections involving the Clinton formation.

Beck, L. C. Mineralogy of New York. 1842.
Contains brief mention of the ores, with analyses of samples from Wolcott and Rochester.

Chester, Albert H. The Iron Region of Central New York.
An address delivered before the Utica Mercantile and Manufacturing Association, Utica, N. Y., 1891.
Describes the Clinton ores found in Oneida county and advocates the erection of local blast furnaces for their treatment. Gives several chemical analyses.

Conrad, T. A. First Annual Report on the Geological Survey of the Third District of New York. Albany 1840.
Briefly describes the Clinton in western New York.

Eaton, Amos. A Geological and Agricultural Survey of the District Adjoining the Erie Canal in the State of New York. Albany 1829.
First to describe the ores and associated strata.

Eckel, E. C. The Clinton Hematite. Eng. & Min. Jour. v. 79, 1905.
A short account of the fossil and oolitic beds at Clinton, with analyses.

Englehardt, F. E. Annual Report of the Superintendent of the Onondaga Salt Springs, for the year 1884.
Gives detailed sections of two well borings in the vicinity of Syracuse.

Foerste, A. F. On the Clinton Oolitic Iron Ores. Am. Jour. Sci. Ser. 3. v. 41.
Refers to the presence of fossils in the ores and advocates a ɪeplacement process to account for the introduction of the iron.

Hall, James. Second Annual Report of the Fourth Geological District. Albany 1840.

——— Geology of New York, part IV, comprising survey of the Fourth Geological District. Albany 1843.
The best authority on the Clinton stratigraphy in western New York.

——— Palaeontology of New York. v. 2. Albany 1852.
Contains sections of the Clinton strata in Herkimer and Montgomery counties.

Hartnagel, C. A. Geologic Map of the Rochester and Ontario Beach Quadrangles. N. Y. State Mus. Bul. 114. 1907.
Shows the Clinton outcrop within this area and describes the succession of strata found in the Genesee gorge.

——— The Clinton Hematite. N. Y. State Mus. Bul. 112. 1906.
Notes on recent mining developments in the Clinton belt.

Kimball, James P. Genesis of Iron Ores by Isomorphous and Pseudomorphous Replacement of Limestone. Am. Geol. v. 8. 1891.
Advances the replacement hypothesis for the Clinton ores.

Prosser, C. S. The Thickness of the Devonian and Silurian Rocks of Western Central New York. Am. Geol. v. 6. 1900.

Includes well sections through the Clinton formations at Seneca Falls, Clyde and Wolcott.

——— Gas-Well Sections in the Upper Mohawk Valley and Central New York. Am. Geol. v. 25. 1890.

Includes well sections at Auburn, Baldwinsville and Vernon.

——— Section of the Alloway, New York, Well. Am. Geol. v. 25. 1900.

Putnam, B. T. Notes on the Samples of Iron Ore Collected in New York. 10th Census of U. S. v. 15.

Describes mining operations and ore occurrences, with numerous analyses.

Smock, J. C. Report on the Iron Mines and Iron-Ore Districts in the State of New York. N. Y. State Mus. Bul. 7. 1889.

Contains description of the mine workings on the Clinton belt, with some account of the distribution of the ores.

——— Review of the Iron Mining Industry of New York for the Past Decade. Am. Inst. Min. Eng. Trans. v. 17. 1889.

Smyth, C. H. jr. On the Clinton Iron Ore. Am. Jour. Sci. Ser. 3. v. 43. 1892.

Discusses at length the origin of the Clinton hematites.

——— Die Hämatite von Clinton in den östlichen Vereinigten Staaten. Zeits. f. prak. Geologie. August 1894.

A further contribution to the subject of origin, confirming his conclusions as to the original bedded nature of the deposits.

Swank, J. W. The American Iron Industry from its Beginning in 1619 to 1886. Mineral Resources. U. S. Geol. Sur. 1886.

Briefly mentions the Clinton mines.

Vanuxem, Lardner. Third Annual Report of the Geological Survey of the Third District. Albany 1840.

——— Geology of New York, part 3, comprising the survey of the Third Geological District. Albany 1842.

The source of most of our knowledge concerning Clinton stratigraphy in eastern New York.

White, Theodore G. Report on the Relations of the Ordovician and Eo-Silurian Rocks in Portions of Herkimer, Oneida and Lewis Counties. N. Y. State Mus. Rep't 51. v. 1. 1899.

Contains partial Clinton sections in the region south of Utica.

INDEX