GEOLOGICAL SURVEY OF NEW JERSEY

ANNUAL REPORT

OF THE

STATE GEOLOGIST

For the Year 1899

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To His Excellency Foster M. Voorhees, Governor of the State of New Jersey, and ex-officio President of the Board of Managers of the Geological Survey:

SIR—I have the honor to present herewith the Annual Report of the Geological Survey for 1899.

Respectfully submitted,

JOHN C. SMOCK,

STATE GEOLOGIST.

TRENTON, N. J.,
November 29th, 1899.

Administrative Report.

The work of the Geological Survey in 1899 has been done conformably to the plan proposed at the beginning of the year, and the investigations in the several divisions have been in the same general direction as carried forward last year. The survey of the surface formations has been in the charge of Prof. Rollin D. Salisbury, and he has been assisted by G. N. Knapp. The survey of the Paleozoic formations has been begun this year, and Mr. Stuart Weller has had charge of this work. He has had Mr. Kümmel as associate in the study of the structural relations of these rocks of the Paleozoic System. The topographic work of the Survey has been directed by Mr. C. C. Vermeule, who has also given some time to the examination of the forest conditions of the State and the preparation of the report on forestry. Mr. Peter D. Staats has been the field assistant, and J. R. Prince, draughtsman. The record of artesian wells has been continued by Lewis Woolman. Mr. Irving S. Upson has remained in charge of the distribution of the topographic maps, and has acted as disbursing officer to the Survey.

At the summer meeting of the Board of Managers Mr. Henry B. Kümmel was appointed on the staff of the Survey, and since the close of the field season he has had charge of the office work as Assistant State Geologist.

The results and the scope of the investigations and surveys of the several divisions and their relation to the general direction of the work of the Geological Survey and to the economic development of the State are stated in order, under their several heads, in this administrative report.

SURFACE GEOLOGY.

The survey of the surface formations has been directed by Prof. Rollin D. Salisbury. This study of the formations which make the surface of the country is related closely to what is

known as the physical geography or as the physiography, but it includes the investigations which have for their object the nature of the materials, as well as the study of the form or configuration of the surface formations. The physical geography of the State has been described in the last volume published by the Geological Survey.* This report on the physical geography may be considered as the first volume on the geology of the surface. The work of Professor Salisbury has been in progress since 1891, and many of the results of his investigations have been given in the annual reports, besides the volume on the physical geography.† The field work is about done and the preparation of the report on the studies and surveys is in part done. The publication is to be in two parts, one descriptive of the northern part of the State, the other of the southern part. By this plan the distribution will be made to the convenience of localities and will avoid needless excess in sending out the volumes of the Survey. The report on the Surface Geology will cover the descriptions of the sands, gravels, clays, marls and earthy beds, and also of the rock outcrops which make the surface of the State; the relation of these beds to the underlying strata or beds; the history of their origin, or source of materials; their geological age and the correlation with the surface formations of the States of our Middle Atlantic coast; and the value of these facts, as they bear on the origin and nature of the soil, the varieties of trees and the subject of forestry and the occurrence of ores, clays, sands, marls, peat and other crude materials which are of use in the arts. The full discussion of the nature and extent of these surface formations is related closely to the geology of the rocks beneath the surface, or the under geology, and the report will include many facts of the latter division of the general geology of the State. On this account it seems to be desirable to give with the maps of the surface formations those of the underlying formations in the same publication, or at least so much as shall give all the facts of economic importance.

As was stated in the last annual report, the maps which are to accompany this report are to be in sections, or sheets, joining

* Report on the Physical Geography of New Jersey, Vol. IV of the Final Report of the State Geologist, Trenton, 1894.

† Annual Report of State Geologist for 1891, pp. 35-108; 1892, pp. 33-166; 1893, pp 33-328; 1894, pp. 1-149; 1895, pp 1-26; 1896, pp. 1-23; 1897, pp 1-22; 1898, pp. 1-41.

edge to edge and not overlapping as in the old topographic series. The scale, as proposed, is that of the latter series—one inch to one mile—and the sheets are to correspond in form and arrangement to the new maps, of which four sheets are already published. Four of these new and large-scale maps cover the same territory as one of the geological series, but of course on a larger scale. This scheme for the State requires thirty-four sheets, or twice the number of the topographic series. For some parts of the State where there are valuable deposits of ores and minerals and also in the thickly-settled suburban districts, the new topographic series of maps may be used as the base for the exhibition of the geological features and the location and extent of valuable ores and other materials of use. The large-scale maps will be of service in the localities which they show, particularly if they have with the maps descriptive text and notes on the geologic structure. This plan of publication by the United States Geological Survey has proven attractive and of great value and the sales of their geologic folios are large. Some plan of this kind seems to be necessary in order to give all the necessary facts of localities and put them within the reach of all who may want them. In this way every locality would have a particular interest in a particular map or folio, and every one would have, as it were, its own special report and map; and all, taken as a whole and in their geographic order of arrangement, would make an atlas of the State, and the chapters of the geology in detail would give that for the State. The economy in both publication and in distribution is for this plan of sectional maps or folios. The results of the surveys made by Professor Salisbury and his assistants can be put in the hands of the people in the two volumes of this report on the Surface Geology, and within the next fiscal year, or at furthest, two years.

The small-scale maps may illustrate the report sufficiently in detail. The publication of the geological atlas must occupy a longer period, because of the cost of the maps and the time needed for their preparation.

During the year Professor Salisbury has been assisted by . N. Knapp, both in the survey and in the preparation of two as sheets—Newark and Camden—submitted with this report. the northern part of the State Mr. Kümmel did some field-

work late in the season on large-scale maps of local features, and the results of his surveys are to be used in the report on the Surface Geology.

Professor Salisbury's report on the work is here appended. It is a clear and concise summary and statement of plans for the publication of his work in the State.

In connection with the work on the surface formations under the direction of Professor Salisbury, four typical areas were surveyed in detail by Mr. Kümmel, and maps, on a large scale, prepared by the topographical division of the Survey, were used for the delineation of the several surface formations and their characteristic topography. One of these areas is near Hacketts-town, and is a section of the terminal moraine of the last glacial epoch. The map represents the older glacial drift and the terminal moraine, and shows their relative positions and their relation to the older formations, and the soils resulting from the disintegration of these older rocks.

Another area is southwest of Newton, in Sussex county, and embraces a territory of eight square miles. Glacial deposits, unstratified and stratified, are here interlocked with knobs of limestone and slate ridges and the surface is marked by great diversity. The hills of limestone and the patches of till, or unsorted drift, rise as islands above the plains of stratified sand and gravel. The latter are in farms and under cultivation, whereas the rocky ledges of limestone are nearly all wooded. The deep depressions or *kettles* which occur in the gravel plains are characteristic features, and mark the places where blocks and large masses of ice melted at the close of the glacial epoch. The Newton area has been mapped on a scale of 1 inch to 400 feet, and the contour lines have been shown at intervals of 5 feet.

At Ogdensburg, in Sussex county, a large triangular bank of drift, which stretches nearly across the Wallkill valley, was surveyed and mapped on a scale of 1 inch to 200 feet.

The fourth area is a mass of glacial drift in great hills between Hamburg and Franklin Furnace. The map, on a scale of 1 inch to 800 feet and having contour lines 10 feet apart, covers about five square miles. The features of the topography shown by this map are a glacial delta and enormous kames. The lobe

front of the great delta, where it was deposited in water, is in contrast with the hummocky surface back where the gravel was deposited against the irregular ice front. The kames are remarkable for their size, surpassing any known elsewhere in the State.

These four maps of typical areas of glacial formations will make valuable illustrations for Professor Salisbury's report on the Surface Geology, showing in great detail the work of the glacier in depositing the till, or drift under its mass, the terminal moraine at its extreme limit or front, and of the waters in forming deltas, and in modifying the deposits laid down by the glacier.

PALEOZOIC FORMATIONS.

The necessity of a re-survey and of a geological map of the Paleozoic formations of the State has been recognized for a long time. These older rock-formations are found in the valleys of the Highlands and along its borders, both southeast and northwest; in the Kittatinny valley, in the Kittatinny mountain and the valley of the Delaware from Carpenter's Point to Walpack Bend, and in the Green Pond, Copperas and Bearfort mountain ranges. The rocks are in strata, which lie horizontally in places, but are generally upturned at high angles, and are folded and broken by faulting, showing the results of great change in position since they were laid down as sediments in the estuaries or oceans of Paleozoic time. They are conglomerates, sandstones, quartzites, shales, limestones, slates and, in places, they are metamorphosed and sub-crystalline in texture. In his "Final Report," published in 1840, Prof. Henry D. Rogers described these formations as Lower Secondary or Appalachian Rocks. Dr. Kitchell referred to them in his reports in 1854 and 1855. In the "Geology of New Jersey," 1868, the late State Geologist, Professor Cook, described them in detail, so far as their limits, thickness, structural relations of the beds and nature of the rocks were concerned, but little attention was given to the study of the fossilized forms of life in them.* Early in the season Mr. Stuart Weller, of the University of Chicago, was engaged to study these formations, to map their outcrops, and to prepare a report on the

* Geology of New Jersey, 1868, pp. 50-167.

geologic structure and on the paleontologic characters. Mr. Weller was in the field from the first of July to the end of September. He was assisted a part of August and in September by Mr. Kümmel.

The work of the season has been in part a reconnoissance of the Kittatinny valley, and in part a detailed survey of the valley of the upper Delaware. The results of the reconnoissance show the existence of limestones of the Trenton period, lying generally at the margin of the blue magnesian limestone and near the slate rocks; conglomerate beds at the base of these Trenton beds, which contain pebbles of the magnesian limestone, and the presence of fossils (trilobites) in the magnesian limestone beds at Carpentersville, on the Delaware, which indicate their geological age as Cambrian.

The discovery of fossils in the magnesian limestone at Carpentersville is noteworthy, because in all the extent of this formation so little evidence of life has been found that it has been regarded as generally barren of life. The fossils indicate the Cambrian age of the magnesian limestone in part at least, and also of the Hardystonville quartzite. The work of next year in the Kittatinny valley will, in all probability, yield further localities of fossils, and afford evidence as to the age of the whole magnesian limestone series of beds, and the associated conglomerates and quartzites which are at its upper edge and at its base respectively.

The survey of the upper Delaware valley was carried out in detail, and the several formations were traced in their outcrops from the New York line, near Port Jervis, to the Delaware river, at Walpack bend. Some work was done southwest of the Walpack bend and in tracing the extension of these formations in Pennsylvania. The geological structure was studied and a geological map on the base of the topographic survey was drawn, showing the limits of the several formations of limestone, shale, sandstone and slaty rocks.

These formations make the massive ridge which lies between the Delaware river, on the northwest, and the valleys of Flatbrook and Millbrook, which separate it from the main slope of the Kittatinny mountains on the southeast side. The topographic features are marked, and this valley, from one-eighth to

one mile in breadth, is one of them. The drift material in the bottom conceals the adjacent formation at the southeast, but it is almost certainly the Medina sandstone, the rock of the western slope of the Kittatinny mountain. The strata of the ridge dip generally to the northwest and their edges are exposed in the steep southeastern face, so that in crossing over it, in a northwestern direction, the beds are passed over in an ascending order. The large quarry on the Nearpass place, in Montague, affords the best section of the strata, and from near the base of the ridge to its crest. It was the key to the descriptions by Doctor Cook, in the "Geology of New Jersey," but owing to an error in correlating the so-called "ribbon limestone" of this locality with a formation lying upon the water-lime beds at Rondout, on the Hudson, the exact geologic horizon was not interpreted aright. The investigations of Mr. Weller show further that there are more subdivisions than were given in the report in 1868. He has found the following in ascending order from valley of the Flatbrook to the Delaware river:

Poxino Island shale,	Silurian System.
Bossardville limestone,	
Decker Ferry limestone,	
Rondout water limestone,	
Manlius limestone,	Devonian System.
Coeymans limestone,	
New Scotland beds,	
Stormville sandstone,	
Becraft limestone,	
Esopus grits,	
Onondaga limestone,	

These names are from the localities in New York and Pennsylvania where the formations are represented by characteristics which are marked, and hence give the basis for naming them from these typical localities. The fossil species and the order of succession afford the evidence of identification in New Jersey. The readers of the report of 1868 may recognize the "Ribbon limestone" in the Bossardville limestone of Mr. Weller's report; the "peth stone" as the Rondout water-lime. The Lower Pentamerus is now known as the Coeymans limestone and the "Cauda Galla grit" as Esopus grits.

The groups of these formations are in what is known as the Silurian System, which follows the Cambrian, and in the Devonian, which is the next later in geological succession. The slates, conglomerates and sandstones of the Kittatinny mountain belong to the earlier periods of the Silurian; then come the subdivisions of the later Silurian, ending with the water-lime; next the Devonian, which includes the Marcellus shale and the Hamilton rocks, which form the hills across the Delaware in Pennsylvania. The Carboniferous System, including the Coal Measures, follows the Devonian in order of time, and all these are parts of what geologists term Paleozoic time.

From the nature of the rocks and the fossil forms characteristic of them the geologic history is read, and the changes in the relations of the water to land are revealed by the succession of animals whose remains mark the formations. The history is one of rather frequent changes in the conditions of the water and land, and yet they must have been gradual, as is in evidence from the transitional formations, as that of the Rondout water-lime, which was a period of land-locked seas or shut-in seas, and with fresh-water or non-marine forms of life in its waters, following the marine-life conditions of the Decker Ferry formations and succeeded by the epi-continental seas of the Manlius period at the beginning of the Devonian. The Medina sandstone was an earlier epoch of transition.

The changes in the rocks also show, as do those of the fossil forms, altered conditions, the limestones marking the deeper sea deposits, the shales, the sediments off-shore and the sandstones and grits, shore or littoral deposits. All are proof of the great length of time necessary for deposition of these sediments and the changes in the conditions indicated by these differences in rocks and their imbedded forms of life. This report is one of the chapters in the earlier geological history of the State, and in its record of invertebrate life is most interesting because of the abundance and the variety of form. Mr. Weller's studies enable us to recognize the succession of life and afford evidence for the accurate identification of any given horizon. The position of each member in the series is thereby determined and the succession of the strata in any section or part of the ridge is made known.

The value of the map and the report to the economic development of the valley of the Delaware will be in the accurate determination of the place of valuable beds of limestone, both for building purposes and for lime manufacture, and of the water-lime for cement, and of the shales and grits in their relations to the soils and to agriculture and forestry. The contribution to our scientific knowledge and the accurate exposition of the geological structure and the life history of these formations make this first report on the Paleozoic formations of the State suggestive of important results and of value as the survey is continued.

ARTESIAN WELLS.

The record of deep-bored wells in the State has been in the charge of Lewis Woolman, of Philadelphia, who has made reports yearly since 1890. He has visited many of the localities and has collected a large number of specimens of gravels, sands, clays, marls and other earthy materials which have been obtained from these borings. They show the nature of the beds which are passed through in the well-boring, and they make an important addition to the collections made by Mr. Woolman and which have been placed in the Geological Survey Museum. Valuable information has been given by the several well-drilling firms and by their superintendents and foremen about the depth, thickness of the different beds passed through, the nature of the materials, position of the water-bearing beds, flow of water and other facts. The data have been used by Mr. Woolman in his studies on the water-horizons and their relation to the geologic structure of the country, particularly in the southern part of the State, and in the Cretaceous, Tertiary and Post-Tertiary formations. The well-borings of the year confirm the existence of certain well-defined horizons or water-bearing beds which have been described in the Annual Reports for 1897 and 1898, and which have been given names from localities where they have been found in wells. The more open or porous beds, as gravel and sand, are full of water and are water-bearing horizons, whereas the tight and dense materials, as clay and some of the greensand marls, are not water-bearing, but are impervious and prevent the flow of water through them. As is well known in

the greensand-marl districts of the State, there are springs of water issuing from the upper surface or where the top earth or *stripping* rests on the marl beds and not in the marl itself. And at the bottom, when the digging has reached the sandy beds under the marl, the water comes in freely in the pits whence the marl has been taken. The borings for water, as they pass through these dense and tight beds of marl or of clay and strike the more open sands or gravels, give vent to the head of water, and it flows to the surface or nearly up to the top of the well. In some cases there are hard and stony layers, made by a cementation of the sand by oxide of iron, which prevent the rise of the water; in others, a calcareous or lime-cemented bed is the impervious stratum which prevents the passage of the water.

Mr. Woolman has given names to the well-marked water-horizons in the southern part of the State, but it is not necessarily true that they are the sole water-bearing ones. Our knowledge of the geological structure is not yet sufficiently comprehensive in all the details of localities to assume that the classification, as reported, is exclusive of the existence of others. On the contrary, it is almost certain that further study and the data to be had from many localities where there are no bored wells will make it necessary to modify the scheme and to add other horizons. Hence the need of continuing the work of gathering notes of well-borings is urgent, in order to an accurate knowledge of the sources of the well-supply, and not in the southern part of the State only, but in the northern part also, and in the rocky strata of the older formations.

The records of the wells are arranged in the geological order of succession, and under the heads Cretaceous, Miocene and Post-Miocene. Among the notable discoveries shown by the borings are: The existence of the Raritan clays at 45 feet below the surface, and down to 102 feet, in wells southeast of Pedricktown, in Salem county; the *Woodbury-Wenonah* horizon, near Mickleton, in Gloucester county; the Raritan clays, at 290–340 feet, at Colestown, in Burlington county; the red clays (Raritan formation) at East Burlington; the clays in the well at Columbus; the clay marls, at 500–558 feet, at West Asbury Park; the lower water-horizon at Seabright (685–715 feet), and making the third

found in wells there, and the correlation of this horizon with that at 465 feet at Atlantic Highlands, Holmdel at 575 feet, Brookdale at 660–715 feet, and with that of 1,083 feet at Asbury Park. The relation of the wells to the tidal waters near them is shown by the oscillations in a shallow well at Pennsville, in Salem county. The same phenomenon has been observed in the rise and fall of the water in the deep wells on the Atlantic Ocean side of the State.

Mr. Woolman has added several well records from the adjacent country to the southwest, in Pennsylvania and Maryland, and also from Norfolk, Virginia. The League Island wells, southern part of Philadelphia, show clays containing fresh-water diatoms mixed with marine forms, as evidence of an old river which deposited the clays in fresh water and commingled with salt water, as might occur to-day in the lower reaches of the Delaware. They are at 25–38 feet and rest upon gravels which are probably of the Pensauken formation. The records of wells in Maryland show that there is a correspondence between the beds passed through in them and the New Jersey wells. This is true at the Centreville well, where marl beds and characteristic fossils were found in the borings. The Norfolk well found a diatomaceous clay at 640 feet, and at 790 an exogyra was struck. These wells at the southwest indicate the extension of the same beds and the same water-horizons through eastern Maryland and into Virginia as in New Jersey.

In the northern part of the State many wells have been bored in the drift of the surface formations and through them into the underlying rocks, but not with the same degree of success as in the southern part. The varying result of these experiments in the more northern Highlands, and in the crystalline-rocks country has not led to the general use of this system of water-supply, and there are few artesian or deep-bored wells. The same general statement may be made about the limestone and slate rocks of the Highlands valleys and of the sandstones of the mountainous ranges. There are few wells bored in them and they do not give encouragement to the deep boring for water. The limestone, with its cavernous features and its irregular water system, or circulation of water, does not offer much hope for large supplies by means of deep wells. The slate belts may be more promising,

although uncertain. As is well known, the slate-hill country is famous for its numerous springs and its many brooks, and it is to be expected that borings in the slate will ultimately strike water-horizons and make good wells.

The sandstones offer a more inviting field to the well-borer, as they are in places open and coarse-grained and are traversed by systems of joints and fissures open to the circulation of the subterranean waters. In the sandstone of the Newark system of rocks (or the red sandstone of the Triassic age), there are many wells which yield large volumes of water, particularly in the city of Newark and its vicinity, and at Passaic and Paterson. On Bergen Hill and in the trap-rock, a well at Fort Lee, at 875 feet passed through trap-rock and entered a shale, but without getting a satisfactory flow of water. At the Joseph Dixon Crucible Company's works in Jersey City the boring was made through the sandstone and into the crystalline micaceous rocks underlying the sandstone. It is reasonable to believe that there are open and water-bearing horizons in these sandstones, but our scanty data do not show them. Further exploration in well-borings in the Triassic sandstone country is greatly wanted.

TOPOGRAPHIC WORK.

The topographic work has been continued in charge of Mr. C. C. Vermeule, and Mr. P. D. Staats has been his field assistant. The drawings for photo-lithography have been made by Mr. J. R. Prince, and also some photographs of interesting topographic features have been taken by him.

The field work has included the extension of the revision survey about Elizabeth, Plainfield, Rahway and Perth Amboy, in the northern part of the State, and about Woodbury, Medford and Mount Holly, in the southern part.

At the end of the last field season about three hundred square miles had been covered by this revision survey, including the Jersey City, Newark, Paterson, Hackensack and Camden sheets. The first four of these sheets have been printed; the Camden sheet is nearly ready for the engraver. The field work of the present season includes the Elizabeth, Plainfield, Amboy, Woodbury, Mount Holly and Taunton sheets, and an area of about

400 square miles, making a total of 700 square miles which has been covered by the new topographic survey.

The preparation of these sheets for the engraver will be a part of the office work for the coming winter. The importance of the changes in the highways, railway lines, political divisions, etc., which have taken place in the twelve to twenty-one years since the topographical survey was made, is more and more evident as the work progresses, and indicates the necessity of this revision survey.

The scale of the published maps of the new series is one inch for 2,000 feet, or about two and a half times that of the maps of the old series. The larger scale enables us to make the necessary additions and corrections and an advance in the cartography of the State by more accurate delineation and the addition of important details which could not be shown on the one-inch-scale maps. The reproduction by photo-lithography secures the accuracy of the original drawing made under the direction and watchfulness of the topographer of the Survey in the printed maps.

The sheets of the topographical atlas on the one-inch scale are revised from time to time, as new editions are called for to replace the depleted stock. About all that can be done, however, is to add the new steam railroad lines, the more important changes in the town and county boundaries, and the names of new places. A complete revision of these sheets, so as to bring them up to date in all respects, would be impossible, except that they were re-engraved.

Some work has been done in revisiting the areas covered by the forest surveys in the Highlands and in the deforested districts of the Raritan valley. The preparation of the forest map of the northern part of the State has taken some time. Other work in this division has been, as heretofore, the preparation of illustrations for the Annual Report and the collection of material for the continuation of the study of water-supply from wells which was begun last year.

DRAINAGE.

The general drainage laws provide for the improvement and reclamation of the wet lands of the State, both tidal or salt meadows and wet fresh-water lands. "On the application of at least five owners of separate lots of land, included in any tract of land in this State which is subject to overflow from freshets, or which is usually in a low, marshy, boggy or wet condition," the Board of Managers of the Geological Survey is authorized to make surveys of such tract or tracts and to adopt a system of drainage for the same. The plans and surveys are submitted to the Supreme Court, and commissioners to do the work are appointed by the Court. Under these drainage laws the Pequest meadows, in Warren county, have been improved. The Passaic drainage work, which was begun under the provisions of this act, has been suspended, for want of funds, since 1892. The following extract from our last Annual Report is reprinted, as pertinent to the conditions which are bearing on the work: "The importance of the work in its relations to the lands in the upper Passaic valley, subject to overflow, in the improvement of the quality of the water of the Passaic river at Little Falls, and in the betterment of the sanitary conditions of all this part of the State, calls for immediate attention on the part of not only the landholders and residents of the valley, but of all who are interested in the promotion of the public health and the prosperity of the people of the State. It is not merely a local work of improvement, it bears the approval of a department of the State in its plan, and a State-appointed commission is charged with the execution of the plan. The work must be done, but this long delay is unfortunate in leaving thousands of acres of rich meadows to be wasted yearly by floods, in spreading malarial fevers all through the valley, and in fouling the Passaic river water with an enormous mass of decaying vegetable matter.

The State has given all the legislation which has been asked, and the courts have certified to the constitutionality of all the drainage laws which were effective in the case of the Pequest drainage, where conditions were similar to those which prevail in this valley."

RECLAMATION OF THE HACKENSACK AND NEWARK MEADOWS.

Reports on the extent, condition and plan of reclamation of these meadows were published in the Annual Reports for 1896 and 1897.* The subject was referred to in the last administrative report, and attention was called to the fact that 8,700 acres, or nearly one-third of the total area of 27,000 acres, were within the corporate limits of Newark, Jersey City and Elizabeth, and within 10 miles of New York. The improvement of the 4,000 acres in Newark is proposed, and the legislation for doing the work is adequate and comprehensive. The extension of the city over this tract to the deep water of the Staten Island sound will be made possible by the reclamation work. The subject is presented by Mr. Vermeule in a paper appended to this report. The depreciation of values of real estate near the meadows, and the increase which would follow from the reclamation, are strong arguments for the work of improvement. The sanitary benefits commend it not only to the owners of the lands to be drained, but to the residents of the adjacent upland.

FOREST SURVEYS.

The Geological Survey has been engaged in the investigation of the condition and extent of the forests of the State since 1894. The act of the Legislature, approved May 1st, 1894, provided for the survey of the forested lands of the State, to be made by the State Geologist, under the direction of the Board of Managers of the Geological Survey, and assisted by a competent botanist and expert in forestry. The leading objects of this survey of the wooded lands of the State were to ascertain their extent, character and location, and "the advantages as regards timber-supply, water-supply, scenery and climate of the State, which would accrue from the conservation of existing forests" by the establishment of a State forest reservation, and the preparation of a report which should give "an outline of the policy and legislation of other States and countries for the presevation of

* Annual Report of State Geologist for 1896, pp. 287-309; and Annual Report of State Geologist for 1897, pp. 297-315.

forests and their regulation for public ends so far as the same may be applicable to this State."

Reports on the progress of the work and papers on forestry have been published in the annual reports of the Survey.*

Mr. Gifford Pinchot (Chief of the Division of Forestry, U. S. Department of Agriculture) surveyed the southern part of the State, and his report on the subject of "Forest Fires and Wood Production in Southern New Jersey" was published as an appendix to the last annual report of the State Geologist. The same report contains an important paper by Mr. C. C. Vermeule, Topographer of the Survey, entitled "The Pine Belt of Southern New Jersey and Water-Supply."

During the last field season Mr. Vermeule had charge of the work of revising the map of the forests in the Highlands and preparing it for publication. He has given some time to the examination of the questions of forests and water-supply and forests and rain-fall, particularly with reference to the water-sheds of the Highlands, from which district the large supplies for all of the cities of the northeastern part of the State must be obtained. The great importance of the subject of water-supply has suggested the preparation of the forest map of the Highlands. The general condition of the forests of the State also has been studied by Mr. Vermeule, and the results have been given in his report, which is incorporated in the Report on Forestry. Some work has been done by Mr. Staats, under the direction of Mr. Vermeule, in ascertaining the changes in the area of woodland in the valley of the Raritan river, in Somerset and Hunterdon counties.

The question of fires in the forest and the methods of protection, particularly in the southern part of the State, have been studied, and Prof. John Gifford, of the New York College of Forestry, at Cornell University, Ithaca, formerly connected with

*_Annual Report, State Geologist for 1893, pp. 223-286._—Report on Forestry in the Northern Part of the State, by C. C. Vermeule, and Preliminary Report on the Forest Conditions of South Jersey, by John Gifford

Annual Report, State Geologist for 1895, pp. 97-158.—Report on Forestry in Northern New Jersey, by C. C. Vermeule; Report on Forest Fires for season of 1895, by John Gifford; and Notes on the Forests of New Jersey, by Gifford Pinchot.

Annual Report, State Geologist for 1896, pp. 337-365.—Notes Collected during a Visit to the Forests of Holland, Germany, Switzerland and France, by John Gifford.

Annual Report, State Geologist for 1898, pp. 183-193, and Appendix, pp. 1-102.—The Pine Belt of Southern New Jersey and Water-Supply, by C. C. Vermeule; and A Study of Forest Fires and Wood Production, by Gifford Pinchot.

the Survey, has prepared a report on "Silviculture and Forest Protection in Europe and the Relation of European Methods to Conditions in New Jersey." He gives most interesting notes on his observations of the forests in France, Germany, Holland, Belgium and Denmark, and shows the directions in which they are suggestive to the land-owners and managers of woodland in New Jersey, and also some of the points in their management, which are not adapted to conditions as existing here, particularly in the southern part of the State. On the question of forest protection he has reached the conclusion that a system of fire-lanes, or State roads, which may answer the same ends in affording a fighting line or a barrier to the movement of fires, is the most effective and at the same time practicable. He cites the new State road from Camden to Atlantic City as being in effect a fire-lane, across which no forest fires have spread. His report will appear in full in the Report on Forestry.

The legislation of the year on forest protection has consisted of three sections in the general act concerning townships. These sections permit of the raising of money by each township for the necessary expenses attending the work of subduing fires in the woods, the appointment of a fire warden, and the preparation of maps showing the forest lands and the lines of railroad and wagon-roads. The Geological Survey is prepared to furnish maps showing these lines and the forest areas in all the townships of the State. It now remains for the local authorities to put the act in force, in so far as it relates to forest protection, by making an appropriation of money for the work, and by appointing fire wardens. The following extract from this act is here inserted :

CHAPTER 169.

An Act concerning townships [Revision of one thousand eight hundred and ninety-nine].

Approved March 24th, 1899.

BE IT ENACTED *by the Senate and General Assembly of the State of New Jersey:*

* * * * * * * *

FOREST FIRES.

54. In any township where any sum of money shall be raised to defray the expenses of fighting and extinguishing forest fires, it shall be the duty of the township committee, at its next meeting after such sum shall have been ordered raised, to appoint a suitable person, being a resident of said township, to act as fire marshal thereof, and at the same time to determine the amount of compensation per diem to be paid such fire marshal when in the active performance of his duties; upon notice from the person so appointed of the acceptance of the said office the said township committee shall immediately issue to him a certificate of his appointment under their hands; after receiving his certificate of appointment he shall have the power to designate a proper person to act as his deputy in case of his absence or disability from any cause, and the said deputy shall, while engaged in the active duties of the said office, receive the same compensation per diem as his chief.

55. It shall be the duty of said marshal, on being apprised of the existence of any forest fire, either in his own township or in any adjoining township, by which the safety of any property in his own township may be imperiled, to assume absolute direction and control of all operations to be undertaken within the bounds of his own township for the extinguishing or prevention of the spread thereof; he shall have power during the continuance of such fire to appoint as many persons to act as aids in carrying out his instructions as he may deem necessary, and all persons present who may be actively engaged in subduing such fire shall act solely according to his orders and those of his

authorized aids; he shall keep an account of the persons so appointed by him as aids, and of all other persons actively engaged in fighting such fires, together with the time during which they are employed, and in a reasonable time after such fire shall have been extinguished he shall report said account to the township committee, who shall have power to make reasonable compensation for such services out of any moneys that may have been appropriated therefor; if in the judgment of the said marshal a forest fire in an adjoining township shall imperil the safety of any property in his own township, he may, with his aids appointed as aforesaid, and with such other persons as he may employ, render such assistance as he may think necessary for the extinguishment and prevention of the spread of said fire, and any assistance given him in such service shall be reported to, and paid for by, the township committee of his own township in like manner as aforesaid.

56. The township committee may cause to be made an accurate map or maps of such portions of the forest lands of their township as may be subject to damage by fires, with such railroads and public and private roads delineated thereon as they may deem necessary, and shall cause to be made whatever surveys and measurements are necessary for the proper completion of said maps; one copy thereof shall be filed with the township clerk, and so many copies of the same shall be furnished to the fire marshal as the said committee shall deem advisable.

The Geological Survey has indicated in the Report on Forestry and on its forest maps the location and extent of the several large forested districts of the State and their relations to the available water-supply for the use of our cities and towns, and the advantages accruing from the establishment of State forest reservations have been given in this report. The forests in the Highlands are to some extent locally protected by individual owners, who appreciate their value as features of the scenery, as private parks and game preserves, and in some cases for the timber which is produced. The management is in places conservative and in some degree silvicultural. The crop of timber is cut so as to be profitable. That the management generally might be made to follow the methods of scientific silviculture or timber-culture and be more profitable than it is now is

probably correct, but in the absence of trained foresters and under the existing conditions of high taxes and the necessity for income within short time limits, changes of this kind are hardly possible at once. What is needed is a forest experiment station or reservation, which may be the property of the State or an educational institution, where the practicable methods of tree planting or silviculture and of timber-cutting and marketing can be studied by land-owners and managers.

The protection of the timbered hillsides and mountains of the Highlands is necessary to the prevention of too rapid discharge of floods and the transportation of earthy matters from the bared ground. Ultimately a State forest reservation may be desirable as a means of protecting these water-sheds.

The Kittatinny mountain is another woodland belt which may become a desirable reservation in order to prevent forest fires.

The Palisades range is notable for its old timber and the large tracts of woodland, on the Hudson river and so near New York city. Its situation makes it valuable far in excess of the timber as a crop, and the question of preservation is in the adaptation to sites for suburban parks or recreation grounds.

The remaining large area of forest is the pine belt of the southeastern part of the State. It has been over-run by fires and the valuable old timber has been nearly all cut, leaving broad stretches of brush-land and fire-scarred plains, and the value of the whole as timber-producing is so little that a forest reservation for the wood alone would be a source of expense. The water-supply in it is its most important asset.

THE MINING INDUSTRY.

The report on the iron mines of the State has been prepared by Mr. George E. Jenkins. He visited the several mining districts and collected data about the mines—their extent of workings, depth, equipment, nature of ore, statistics of output and names of owner or lessee. This information is given in the report. The statistics of iron ore, shipped from stations in New Jersey over the several railway lines, are given on pages .

The remarkable advance in the price of iron ore and the increasing demand have stimulated the working of the mines

which were in operation last year and during the period of depression in the business, and their output has been larger than it was last year. Many of the mines which had been closed on account of low prices and slack demand for ore have been re-opened. There have been some important changes in management and some new companies have engaged in the business of mining. The inquiry for new localities also has been noted, and many letters have been received at the office of the Survey, asking information about mines and new ore localities. At the end of the year nearly all of the large and historic mines were either being worked or were being re-opened with a view to early production.

The question of concentrating lean ores on a large scale has received close attention, and the concentrating plant at Hibernia has been at work nearly the whole year on the lean refuse from the Hibernia *vein* and on Beach Glen mine ore. The Edison works also have been at work a part of the time.

The total shipments for the year amount to 300,757 tons, an excess of 25,379 tons above the aggregate production for 1898.

The revival in the iron trade and the active demand for iron ore make the report of value and warrant the belief that the iron-mining industry of New Jersey has entered a period of prosperity comparable to any in its history, marked by a substantial character and lacking some of the elements of excessive stimulation which were so evident in 1879, after the depression of 1873–79. The excellence of the ores, the large size of the ore-shoots, the nearness of the mines to the great manufacturing industrial centers and to the great markets, and the location, on or near the great lines of transportation, are conditions favoring the steady continuance of this activity in iron mining.

The operations of the year have been all in the magnetic iron ore and no attempt has been made to re-open the hematite mines.

For descriptive notes on the iron mines of the State reference may be given to the Annual Reports for the year 1890, and succeeding years, as also to the "Geology of New Jersey," 1868, and the earlier annuals.

COPPER MINING.

A short report on some of the copper mines and copper ores of the State has been prepared by Mr. Kümmel. The re-opening of the old Schuyler mine, near Arlington, in Essex county, marks a noteworthy epoch in the history of the oldest copper mine of the State of which there is accurate historical record.*

CHEMICAL WORK.

The chemical investigations and analyses have been made by Prof. William S. Myers, of New Brunswick. They have been examinations of minerals, rocks and ores in order to the determination of the species and, in a few cases, to ascertain the metallic percentages and the value of the specimens for use in the arts. In addition to the regular work of chemical analyses, Professor Myers has made a beginning in the investigation of the amount of chlorine in the natural waters of the State. Samples of water have been collected by the members of the Survey staff, from artesian wells in the southern part of the State, from springs, lakes and rivers, and from the sources of supply of all the large cities of the State. The total solid matters and the amount of chlorine have been determined in these samples, representing the waters of the natural sources of supply. The results are given in the report of Professor Myers. They indicate the decrease in the chlorine content going from the ocean northwest and west, as would be anticipated, as the sources are further from the salt waters of the ocean and the tidal bays and sounds of the coastal part of the State. It is proposed to have a map made to show the amount of the chlorine which marks the natural waters in the several districts of the State.

The usefulness of a chlorine map will be evident in the comparison which it will enable the chemist to make between the normal percentage and that found in any given sample and to decide at once as to the purity of the water. The excess of chlorine will indicate the probable pollution by sewage and sug-

* The earliest mining for copper ore in the State was probably done by the Dutch official authorities in the valley of the Delaware river and in Pahaquarry. The working there was about the middle of the seventeenth century and the mines were connected by the "mines road," with the settlements on the Hudson river at Esopus (now Kingston)

gest further tests. Such a map will be a guide of service to the water-analyst, and afford a safe criterion for judgment as to the purity and healthfulness of the waters which are used for domestic purposes. Massachusetts has a map of this kind and New Jersey has a large part of the data ready for constructing such a map. Another season's work will give enough additional information to allow of its preparation and publication.

GEOLOGICAL ROOMS.

The collections of minerals, rocks, ores, clays, marls and other economic products which occur naturally in the State are arranged in the museum-room in the rear extension building of the State House, and adjacent to the office of the Survey. They are in wall-cases and in table-cases, and, in part, in drawers in drawer-cases. Additions are made by members of the Survey staff collecting in the field in course of geological work, and by the gifts of friends. The mineralogical collection is in the care of Professor A. H. Chester, of New Brunswick, and it attracts the attention of all the visitors to the Museum. Although representative of the species which are found in the State, it lacks the fullness of localities which is desirable in a State collection. All the localities should be represented by specimens, so as to make a complete showing of the occurrence of minerals. Many of the specimens in the exhibition-cases are poor, and unworthy a place in such a collection, and the replacement by good specimens is necessary to a creditable exhibition of the beautiful minerals of New Jersey.

The paleontological collections are shown in part only, and the type specimens of the greensand marl formations are packed in boxes in the basement, for want of room for their proper exhibition.

The collections of the industrial arts are shown in part only because of want of room. An increase in the number of these economic art products would be easy were there space in which to exhibit them. The value of these collections of manufacturing industry by the side of the raw products and materials occurring naturally in the State needs no argument here.

Arrangements for a new and larger collection of the woods of the State have been made, and those which are native in the

southern part have been promised by a friend of the Survey and botanist, Mr. Benjamin Heritage, of Mickleton, Gloucester county.

Several maps of the State have been mounted and hung on the walls near the door. They make an interesting series, historically.

The number of visitors to the museum-room is increasing each year, and the earnest efforts of the enthusiastic Curator of the State Museum have contributed greatly to the general interest in the exhibition and in the appreciation of the collections. Nearly all of the visitors to the State capital visit the museum. The information which is given in this way is, to some extent, educational, but much more could be given, and in an instructive as well as pleasing manner, if there was more space for the proper exhibition of the material now in the collections and additional synoptic and general collections illustrating the general principles of science and art as well as the more special collections of the State. Additional room is proposed in the projected extension of this part of the State House.

LIBRARY.

The books of the library of the Survey are in part arranged in two small wall-cases in the office. Many of the bound volumes and all of the unbound books and pamphlets are stored in boxes in the basement of the State House. The additions are mainly through the exchange of the publications of the Survey with scientific societies and other State and national geological surveys. A few hand-books and works of general reference are bought as needed. The increase during the year has been much larger than in any year of the Survey's history, and has suggested the necessity of a card catalogue, which is being prepared by Mr. Kümmel. On account of the incomplete state of many of the series of reports, in some cases represented by a single volume only, there is urgent necessity for effort to fill these large gaps, and hence additions by exchanges and donations of books are greatly desired. The proposed alteration of the State House and more room will allow of the location of the library in the geological rooms convenient for use.

PUBLICATIONS.

The Annual Report for 1898 and four topographic maps, viz., Newark, Jersey City, Hackensack and Paterson sheets, are the publications of the year.

The work of distributing the publications of the Survey increases from year to year and is recognized as important and valuable in putting the results of the studies and surveys of the workers promptly in the hands of the people of the State, and in libraries and educational institutions generally throughout the United States. The public schools of the State are recipients of the volumes of the series of Reports on the Topography, Geology and Natural History of the State. During the year the distribution of Volume IV, on the Physical Geography of the State, has been completed. The relief map of New Jersey, on the scale of one inch to three miles, which accompanies this volume, has been sent, mounted on rollers, to all the schools. The work has been done by the Department of Public Instruction and by Mr. Herbert N. Morse, of that department. The educational value of the map and of the "Physical Geography" of the State is recognized by the best teachers of geography and is demonstrated by the demand for additional copies in order to have them not only in all the schools of the State, but in several school-rooms in each high-school in the larger towns and cities.

The distribution of the topographical atlas of the State, in sheets, backed and with inset eyelets for hanging on a wall, has been in progress, and many sets of these maps have been sent to the public schools on the order of the superintendent of public instruction. The Geological Survey is the custodian of the stock. A large part of the edition has been distributed, and the purpose of the legislative act has been fulfilled in placing them in the schools throughout the State. The remaining copies will answer the demand for new copies to replace those worn out or out of repair, or which may have been lost.

APPENDIX.

Report on the Surface Formations.

By ROLLIN D. SALISBURY.

The survey of the surface formations has now been extended over the whole State, and the only further field work which will be necessary will be a review of the work in certain portions of the State in advance of the publication of the maps. The study of these formations has been carried to a considerable degree of detail, except in the sandy, pine-covered areas of the southern part of the State. In this unbroken belt the lack of detail was deemed advisable, both because of the lesser importance of the work in this region, and because data for detailed work could not be obtained without great, and what was regarded as unwarranted, expense.

Not only has the work been done in much detail, but it has been done for the most part without established standards, for no such detailed work on the surface formations has been undertaken by any other State survey. The geographic position of New Jersey has perhaps rendered work of this sort especially important, for within its area lies the junction of the Coastal plain with the Piedmont plateau, and the junction of the glaciated area with the unglaciated. This position makes it in some ways a critical and important area in the study of surface formations, for nowhere in geology has there been less satisfactory correlation than in the surface formations of the north and the south, and of the uplands and lowlands.

Many of the results of the survey have been published from time to time in the Annual Reports from 1891 to 1898. It now remains to publish the unified results. These publications will take the form both of maps and of descriptive and interpretative

matter. In the publication of the maps it is thought best not to use the old topographic sheets, which overlap to such an extent as to nearly cover the area of the State twice, but to use a new base of smaller maps which do not overlap. A very considerable saving in the expense of publication will thus be effected, besides providing maps of more convenient size.

It is very desirable that, with the maps showing the surface geology, maps of the sub-surface geology should be issued, so that the relations of the surface and under-geology shall be made clear. Before these latter maps can be issued, some further field work will need to be done, but a good beginning has already been made. The necessary work on the Triassic system has already been done by Dr. Kümmel; work on the Paleozoic systems has been begun by Dr. Kümmel and Mr. Weller, and on the younger systems by Mr. Knapp. The work on these formations should be prosecuted as rapidly as practicable. When it is completed, a new and complete map of the geology of the State will replace the old preliminary map which was made before the topographic survey of the State had given an accurate base for detailed work. The simultaneous publication of these two sets of geological maps will be of great value to the State and to geology in general.

The publication of these maps should be begun as soon as possible and pushed as rapidly as conditions permit, but before the maps for any given area are issued, the topographic base should be revised. This revision, already in progress, is especially necessary in two classes of areas, namely, those where the surface has been greatly changed by culture since the publication of the original topographic maps, and those where the outline of the land has been notably altered by the action of waves and currents, as along the coast from Sandy Hook to Cape May.

The text on the surface geology of the State will appear in two volumes, one on the glaciated area of the north, and one on the area south of the glacial drift. These reports may precede the publication of the full series of maps, but the early sheets of the latter should accompany the reports. It will be the purpose of these reports to set forth the history of the surface of the State in such a manner that it will be intelligible to those who have had no technical education in geology.

Report on Reclamation of Hackensack and Newark Meadows.

By C. C. VERMEULE.

There has been no falling-off of public interest in this projected improvement. The demand for the reports treating of the subject has continued and there is no doubt that they have attained their object by bringing prominently before the people the need of some action, and by concentrating upon the problem the thoughts of many capable minds. The city of Newark has taken up the matter in a way which seems practical and promising of some tangible results. An act of the Legislature was passed last winter which enabled the city to proceed to reclaim the 4,000 acres of tide-marsh within her limits and assess the cost upon the land drained in much the same manner as is done in building sewers and in other municipal improvements. Proceeding under this act the Board of Street and Water Commissioners advertised for plans and proposals, and at the same time the Board of Trade, which has actively promoted such improvement for several years, offered prizes for the best plans which should be submitted. In July several plans were offered in response to the advertisement. The range of prices was large, varying with the plan, but it was evident that a practical plan, which would render the marsh suitable for city occupation, could be carried out at a contract cost not exceeding $300 per acre, an amount which, when compared with the selling price of city lots in Newark, is very small. The plans were first referred to a committee appointed by the Board of Trade and Board of Street and Water Commissioners for a report upon the merits of the plans. This committee has not yet reported. It will report to the Board of Trade and the whole matter will then be referred back to the Board of Street and Water Commissioners for fur-

ther action. If a contract is awarded the work will proceed in the spring.

There is a wide range in the character and cost of the drainage work, according to the uses to which the land is to be put. In the report for 1897 it was estimated that the drainage of the marshes to such an extent as would render them sanitary and adapt them for agricultural purposes—keeping the water-level some three feet below the level of the land—would not exceed $2,500,000 for the entire 27,000 acres, including all expenses of every kind. This is undoubtedly a liberal estimate, and it amounts to $93 per acre. Leaving out cost of land and administrative expenses, the cost, including pumping-plant, was given at $50.75 per acre. This is but one-sixth the cost of drainage for city purposes as ascertained in the case of Newark. The reason for this is found in the more exacting requirements, mainly in the larger quantity of water to be cared for. If the use of the marsh is mainly agricultural, it will continue to absorb water in case of sudden heavy storms, so that the maximum run-off to be taken care of in the pumping-plants will be at a moderate rate. In the report for 1896, page 297, it was estimated that this would in no case exceed 33,000 gallons per acre in 24 hours, or 1,375 gallons hourly, but in the case of Newark the specifications required that the water should be maintained in all parts of the marsh at least six feet below the land surface, and that the pumping-plants and ditches should have a capacity to discharge 900 cubic feet, or 6,750 gallons, per acre hourly. This larger discharge was necessary because, when all the water should be confined to the ditches and the whole area carefully drained, the streets paved and houses built, the discharge of water would be much more sudden and violent. Then, too, there was a large inflow to the marshes from the upland portion of the city. These requirements, while they were all proper and necessary in that case, made deeper and wider ditches necessary, and called for a pumping-plant, for the 4,000 acres of marsh, having an aggregate capacity of 47,700,000 gallons hourly on 10 feet lift, and 3,200 horse-power will be required to operate it.

The accomplishment of this work will enable Newark to occupy a space now needed for her proper growth and development. The southernmost water-front of the city is now only

one mile distant from a channel having a depth of 24 feet out to the ocean. When the meadows have been improved so that the city can reach and occupy this water-front, it will be a simple matter to have this channel extended up to the Newark and New York railroad bridge, so that vessels of 22 feet draft can come up to the wharves at all tides. At present there is only about 10 feet of depth at low tide up to the wharves on the Passaic. It is believed that the opportunity to obtain more space and cheaper land on the improved meadows—with better shipping facilities—would induce many of the factories to withdraw from the residential portions of the city, and that the improved land would become the industrial center, leaving the higher ground west for residence. The appearance and sanitary conditions of the city will be greatly improved if such a change is effected, and there can be no reasonable doubt that the direct gain in taxable property, and the indirect advantages in ridding the city of mosquitoes, improving its sanitary condition, making it accessible to ocean steamships and rendering it more attractive in many respects as a place of residence, would be worth several times the whole cost of the improvement.

In many other cases it would not be necessary or desirable to spend on the first improvement over $100 per acre. Less than this expenditure will drain the land and put it in condition for agriculture or grazing. The moment this is done its value will be greatly enhanced. Drained marsh-lands sell in Nova Scotia for from $150 to $200 per acre for agricultural purposes alone, and in some cases as high as $400, and this is at points where the neighboring improved upland is worth only $50 per acre. The diked meadows of Salem and Cumberland counties, in this State, have always been worth several times as much as the improved upland. As much as 55 bushels of wheat per acre and heavy crops of hay are raised on them. A moderate amount of drained tide-marsh attached to a farm in that vicinity greatly enhances the value of the farm.

Now, bearing in mind that much of the outlying lands of the Hackensack marshes, that is, the lands not immediately adjacent to Newark, Elizabeth or Jersey City, can be bought for from $25 to $100 per acre, that it lies within twenty-five minutes of Broadway, New York, and still nearer Jersey City and Newark,

that consequently it must have, even for agricultural purposes, a greater value than Nova Scotia or South Jersey marsh land, and that in addition to this value it will have a large prospective value for other purposes immediately that it is seen to be dry, healthful and attractive, it seems impossible that it will be worth less than $400 or $500 per acre after, say, about $50 per acre has been spent in dyking and draining it. Therefore, if a private corporation can secure a sufficiently large area to begin operations, and can drain it and put a small portion under cultivation as a demonstration of the capabilities of the soil, the rest could be promptly leased for enough to give a fair return on the investment, and the appreciation in the value of the land in the course of a few years will undoubtedly make the venture very profitable.

If Newark will carry the proposed improvement through to a successful completion, there is little doubt that Elizabeth and Jersey City will find a way to follow her example. This will dispose of the marshes south of Snake Hill. Then if private corporations will take up the improvement of the remainder on the lines suggested above, the whole marsh will be wiped out and the surrounding communities will reap a very great advantage. This is one way in which the improvement may possibly be effected. Another way, and one which would undoubtedly insure a more comprehensive and advantageous improvement in the end, would be the creation of a drainage commission on the lines laid down in the report for 1897. This plan would remove the speculative features and would give stability to, and insure good sanitary and commercial results from, the improvement. Nevertheless, the present trend appears to be in the direction of a municipal and partly a private undertaking, the extent of each enterprise being from 2,000 to 4,000 acres.

We have made some inquiry as to land values on the upland immediately adjacent to the meadows in Hudson and Bergen counties. In Jersey City and West Hoboken a few blocks back from the meadow edge, city lots 25 by 100 feet are worth from $500 to 1,200 each, while close to the meadows they fall to from $100 to $200. There is practically no sale for lots near the meadows for residence purposes. At Rutherford lots are quoted at about the same rates, $1,000, a few blocks back and

$100 near the meadows. At Arlington it is said to be almost impossible to sell lots near the meadow edge while there is a ready sale at good prices up on the ridge. It is everywhere apparent that the meadows seriously injure the immediately adjacent upland property, which is only available for cheap, undesirable improvements. Yet even if we take the low prices of these depreciated upland lots, say $100 per lot, it amounts to $1,200 per acre, and much of the meadow land, especially that near the railroad lines and along the water-front, would be worth much more than this when drained.

We have urged the improvement of these marshes, mainly as a sanitary measure, and to mitigate the mosquito pest. Recent research identifies the mosquito so closely with the spread of malaria that its suppression must be regarded not merely as contributing to the comfort of the neighboring population, but as a sanitary measure as well. The sanitary advantages of the improvement, and the increase in value of all upland real estate east of Orange mountain are of themselves quite a sufficient return for the entire cost of $2,500,000 necessary to put these marshes in a condition suitable for agricultural, horticultural or grazing purposes. While it seems clear that the improvement would yield a sufficient return from the enhanced value of the marsh land, if private capital is not willing to undertake it then it should be accomplished as a public enterprise, on the lines suggested in the report for 1897. The advantages of that plan are that it properly recognizes and respects the rights of the owners of the marsh land by putting a reasonable share of the burden on the shoulders of the surrounding communities, which will reap so large a share of advantage, and it provides for a single and comprehensive control with a minimum of interference with existing municipal governments.

PART I.

Report on Paleozoic Formations

BY

STUART WELLER.

A Preliminary Report on the Stratigraphic Paleontology of Walpack Ridge, in Sussex County, New Jersey.

BY STUART WELLER.

CONTENTS.

INTRODUCTION

The paleozoic rocks of New Jersey fall naturally into three areas. The first of these is situated in the region of Green Pond and Bearfort mountains; the second is the Kittatinny valley, lying between the pre-cambrian highlands on the southeast and the Kittatinny mountain on the northwest, and including some isolated areas of paleozoic rocks within the crystalline area; the third area is the Delaware valley, lying between the crest of the Kittatinny mountain and the Delaware river.

The third area consists of two parallel valleys separated by the Walpack ridge. To the southeast of this ridge, between it and the Kittatinny mountain, is a valley drained in its southern portion by the Flat brook and in its northern portion by the Clove brook. This is essentially a continuous valley whose central portion has been filled with glacial drift, and it will be spoken of hereafter as the Walpack valley throughout its entire length. Along the northwestern foot of the Walpack ridge flows the Delaware river. At the mouth of Flat brook the Delaware makes a great sigmoidal bend known as the Walpack bend, cutting through the Walpack ridge, so that the more southwesterly extension of the ridge is in the State of Pennsylvania. At the north the Clove brook cuts through the ridge near the State line and empties into the Neversink river at Tri-States, New York, near the point where the latter stream joins the Delaware.

The unfossiliferous Medina sandstone covers the whole northwestern slope of the Kittatinny mountain, extending approximately to the middle or even beyond the middle of the Walpack valley, so that the fossiliferous strata of the region are restricted to the Walpack ridge. The strata of this ridge dip, with some local exceptions, more or less steeply to the northwest, so that in passing from the Walpack valley to the Delaware river, younger and younger strata are encountered. The northwestern slope of the ridge usually approximates more or less closely to the dip of the strata, so that the complete section is usually exhibited in passing from the Walpack valley to the crest of the ridge or a little beyond the crest. It is the succes-

sion of the strata in this section, with their included fossil faunas, which will be described in the present report.

Rock exposures are frequent throughout the entire length of the Walpack ridge, and many of the strata are highly fossiliferous. The best section for study, however, is to be found about two miles south of the New York State line, on the farms of John Bigart and Sanford Nearpass, in a quarry known as the old Wm. Nearpass quarry and in the ridges lying beyond. The Nearpass section will be used as a basis for the following descriptions of the faunas, because the actual succession can be worked out in greater detail at this point than anywhere else in the Walpack ridge, although in some cases particular beds are better exposed elsewhere. The continuous rock exposure in the Nearpass quarry bluff is about 150 feet, but between the top of this exposure and the main crest of the ridge there are some 700 feet of strata which are not continuously exposed, but whose hard layers make persistent outcrops.

The formations of the Walpack ridge belong to the Silurian and Devonian systems, and they will be described in succession from the base upward. In general, the formations in New Jersey are continuations, either of those in New York or of those in Pennsylvania, and have been given names by the members of the geological surveys of these two States. For most of the Silurian formations the names used by the Pennsylvania geologists are best adapted to the New Jersey section, while for the Devonian formations the New York names are applicable.

Formations of the Silurian System.

POXINO ISLAND SHALE.

The lowest formation exposed in the Walpack ridge is a buff or greenish calcareous shale, irregularly bedded, in layers one inch or less in thickness. In the bottom of the Nearpass section about one foot of this rock is exposed in an excavation, which has been made in the talus slope at the foot of the bluff. South of Hainesville is another exposure, where a quantity of the material has been excavated for road-making purposes. There are also other exposures south of Walpack Center, but nowhere have fossils of any description been observed.

This formation was first described by I. C. White in his report on Pike and Monroe counties, Pennsylvania,* but he did not observe any outcrops of the formation in New Jersey. These New Jersey exposures, however, have been traced southward by Dr. Kümmel to the type exposure of the formation in Pennsylvania opposite the Poxino island. The base of the formation has not been observed in New Jersey, but in Pennsylvania it is described by White as resting upon a thin limestone formation which in turn rests upon the red Medina sandstone. Only a small part of the entire thickness of the formation is exposed anywhere in New Jersey, but it is described as being at least 200 feet thick in Pennsylvania.

BOSSARDVILLE LIMESTONE.

Lying above the Poxino Island shales is a fine-grained, compact, bluish, banded limestone. It is exposed in the Nearpass section in the excavation already mentioned, where its entire thickness is 12 feet 4 inches. From this point south to Peter's Valley but few outcrops are to be seen, but between Peter's Valley and Flatbrookville there are many excellent exposures. The thickness of the formation is greatly increased to the south, and although no exact measurements could be made, it is at least 100 feet thick below Walpack Center. This formation is unquestionably a northern extension of the limestone designated as the Bossardville limestone by White† in Pennsylvania. It is also the formation which was called the "Ribbon Limestone" by Prof. Cook,‡ and which was erroneously correlated by him with the "Ribbon Limestone" at Rondout, New York, which is the Manlius or "Tentaculite" limestone lying above the water-lime formation. This correlation of the Bossardville limestone was also adopted by White in his Pennsylvania report.

As a matter of fact, the age of the Bossardville limestone is very much greater than that of the Manlius limestone at Rondout, although the two formations are somewhat similar in lithologic characters. The Bossardville limestone itself is entirely barren of fossils, but it is followed by a series of beds which

* 2d Geol. Surv. Penn., Rep. G6, p. 145.
† 2d Geol. Surv. Penn., Rep. G6, p. 141.
‡ Geol. of N. J., p. 156 (1868).

are highly fossiliferous, containing fossils of well-defined Niagaran* age. By reason of this error in correlation, this formation, with the subjacent Poxino Island shale, has in former reports usually been included in the Helderbergian series, and the softer, upper portion of the Medina sandstone has been designated in the Pennsylvania reports as the Clinton red shale,† with apparently no further reason than the belief that the Clinton beds must be represented by the beds immediately beneath the supposed Lower Helderberg.

DECKER FERRY FORMATION.

In his report on Pike and Monroe counties, Pennsylvania, White‡ has described three formations succeeding the Bossardville limestone, which he designates by the name Decker Ferry, from the ferry of this name below Flatbrookville—the Decker Ferry shale, the Decker Ferry sandstone, and the Decker Ferry limestone. The first two of these formations are closely allied, the so-called shale being an alternation of thin sandstone beds with thin beds which are more calcareous, rather than a true shale. These two formations of White will here be included in a single division and will be called the Decker Ferry formation. The Decker Ferry limestone of White is quite distinct, both faunally and lithologically, from the Decker Ferry formation here recognized.

At Flatbrookville and north to Peter's Valley, this entire formation could legitimately be called a sandstone, but with many thin calcareous bands, especially in the lower portion; but north of Peter's Valley the formation rapidly becomes more and more calcareous until in the Nearpass section the whole formation is for the most part limestone, with some thin bands of more or less fissile greenish shale. Only about two feet at the very base of the formation, immediately on top of the Bossardville limestone, show any indication of being arenaceous, and even this is an earthy limestone with a small percentage of siliceous matter, rather than a true sandstone.

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*This term is here used in the sense adopted by Clark and Schuchert in Science, N. S., vol. X, No. 259, pp 874-878, for the period during which the following formations were being deposited in western New York, the Clinton beds, the Rochester shale, the Lockport limestone and the Guelph dolomite. In New Jersey, however, the period is represented by a different set of formations.

†2d Geol. Surv. Penn., Rep. G6, p. 147.

‡2d Geol. Surv. Penn., Rep. G6, pp. 137-141.

In New Jersey the Decker Ferry formation is usually fossiliferous, sometimes highly so, but in many instances the fossils are poorly preserved. At Flatbrookville, at the very base of the formation, there are a few inches of thin alternating beds of fine-grained limestone resembling the Bossardville in its lithologic characters, and of coarser, more crystalline limestone like that above. These beds are individually but a fraction of an inch in thickness, but there is a conspicuous alternation of faunas represented in them. The fine grained layers are often crowded with a rather large, smooth *Leperditia* and contain nothing else, while the more crystalline layers contain the same fossils that occur in the overlying beds.

In the Nearpass section three somewhat distinct life zones may be recognized in this formation, although some species range through its entire thickness. These zones can also be traced to the south, though as yet only the lowest one has been definitely recognized throughout the entire length of the Walpack ridge in New Jersey. These three zones will be named from their more conspicuous species, the *Chonetes jerseyensis* zone, the *Ptilodictya platyphylla* zone and the *Rhynchonella lamellata* zone.

Chonetes jerseyensis zone. In the Nearpass section several distinct beds contain the species of this zone, and they will be described in order from the base up.

I. Highly fossiliferous, earthy, somewhat arenaceous limestone resting upon the Bossardville limestone, 2 feet in thickness. The following species of fossils have been identified:

1. *Zaphrentis* sp. undet.
2. *Monotrypa* cf. *M. undulata* Nich.
3. *Pholidops* sp.
4. *Strophodonta hipartita* (Hall).
5. *Orthothetes* n. sp.
6. *Dalmanella elegantula* (Dal.).

* Although this species cannot be illustrated in this place it has been thought best to apply a name to it, because it is so peculiar and so characteristic of this faunal zone. The species will be illustrated in next year's report.

Chonetes jerseyensis, n. sp. Shell large, often attaining a width of more than 20 mm. Surface marked by coarse, sharply angular plications which increase in numbers towards the margin of the shell. On the brachial valve the plications become coarser toward the hinge-line and are peculiarly curved, the convex side of the curve being toward the hinge-line. The margin of the cardinal area of the pedicle [illegible] five or more oblique spines on each side of the beak.

7. *Chonetes jerseyensis* Weller, n. sp.
8. *Camarotoechia neglecta* (Hall).
9. *Rhynchonella* sp. undet.
10. *Atrypa reticularis* (Linn.).
11. *Reticularia bicostata* (Van.).
12. *Pterinea* sp. undet.
13. *Mytilarca mytiliformis* (Hall).
14. Pelecypods (several undet. sp.).
15. *Straparollus* sp. undet.
16. *Loxonema?* sp. undet.
17. *Orthoceras* sp. undet.
18. Ostracodes (several undet. sp.).
19. *Dalmanites* n. sp.?
20. *Phacops trisulcatus* Hall.

II. Hard blue crystalline limestone with many fossils, but which are not so well preserved as those in the subjacent bed. 14 feet 2 inches.

1. *Favosites* sp. undet.
2. *Monotrypa* cf. *M. undulata* Nich.
3. *Strophcodonta bipartita* (Hall).
4. *Orthothetes* n. sp.
5. *Dalmanella elegantula* (Dal.).
6. *Chonetes jerseyensis* Weller, n. sp.
7. *Camarotoechia neglecta* (Hall).
8. *Rhynchonella* sp. undet.
9. *Atrypa reticularis* (Linn.).
10. *Reticularia bicostata* (Van.).
11. *Cyrtina* sp. undet.
12. *Lichenalia?* sp. undet.
13. *Ptilodictya* sp. undet.
14. *Platyostoma* sp. undet.

III. Fissile shale with limestone bands. No fossils collected. 6 feet 9 inches.

IV. Hard blue crystalline limestone with lithologic characters similar to No. II. Fossils poorly preserved. 8 inches.

V. Shale band. No fossils. 2 inches.

VI. Hard blue crystalline limestone similar to Nos. II and III. 2 inches.

1. *Strophodonta hipartita* (Hall).
2. *Chonetes jerseyensis* Weller, n. sp.
3. *Camarotoechia neglecta* (Hall).
4. Ostracodes sp. undet.

VII. Shale band, no fossils. 2 inches.

These seven beds in the Nearpass quarry section contain the fauna of *Chonetes jerseyensis*. On the next farm south of that upon which the old Nearpass quarry is located, these lower Decker Ferry beds are exposed and the following species have been identified from a bed which is probably a continuation of the lowest bed described above, although it was not observed resting directly upon the Bossardville limestone:

1. *Favosites* sp. undet.
2. *Monotrypa* cf. *M. undulata* Nich.
3. *Strophodonta hipartita* (Hall).
4. *Orthothetes* n. sp.
5. *Dalmanella elegantula* (Dal.).
6. *Chonetes jerseyensis* Weller n. sp.
7. *Camarotoechia neglecta* (Hall).
8. *Rhynchonella* sp. undet.
9. *Atrypa reticularis* (Linn.).
10. *Reticularia hicostata* (Van.).
11. *Leptodesma?* *subplana* (Hall).
12. *Byssonychia?* sp.
13. Pelecypod (undet. sp.).
14. *Platyostoma* sp.
15. *Dalmanites* sp. undet.
16. *Phacops?* sp. undet.

A short distance south of Hainesville, in an outcrop of sandstone near the base of the Decker Ferry formation, the *Chonetes jerseyensis* fauna is represented by the following species:

1. *Monotrypa* cf. *M. undulata* (Nich.).
2. *Strophodonta hipartita* (Hall).
3. *Orthothetes* n. sp.
4. *Chonetes jerseyensis* Weller, n. sp.
5. *Camarotoechia neglecta* (Hall).
6. *Atrypa reticularis* (Linn.).

7. *Reticularia bicostata* (Van.).
8. *Dalmanites* sp. undet.

Below Flatbrookville the lower beds of the Decker Ferry formation are finely exposed, and may be seen resting directly upon the Bossardville limestone. At this locality the beds contain a large amount of arenaceous material, but in the more or less calcareous beds intercalated in the sandstone, fossils are abundant, one of the commonest species being *Chonetes jerseyensis*. The following species have been collected at this point:

1. *Favosites* sp. undet.
2. *Monotrypa* cf. *M. undulata* Nich.
3. *Strophcodonta bipartita* (Hall).
4. *Orthothetes* n. sp.
5. *Dalmanella elegantula* (Dal.).
6. *Chonetes jerseyensis* Weller, n. sp.
7. *Camarotoechia neglecta* (Hall).
8. *Rhynchonella* sp. undet.
9. *Atrypa reticularis* (Linn.).
10. *Reticularia bicostata* (Van.).
11. *Whitfieldella?* sp. undet.
12. Ostracodes (sp. undet.).

As will be seen from an examination of the foregoing lists of species, the *Chonetes jerseyensis* fauna is not a large one, but it remains constant in its characters throughout its entire distribution in New Jersey. Aside from the typical species of the fauna from which it has been named, the species of *Monotrypa* which has been compared with *M. undulata* Nich., is an abundant and characteristic species. It is a coral with fine coralities growing in subhemispherical or depressed convex colonies, and in its general external characters resembles some of the corals of similar form from the Trenton limestone illustrated by Hall in his first volume of New York Paleontology under the name *Chætetes lycoperdon*. The cosmopolitan species *Atrypa reticularis* is another characteristic form. The species is always present and is often exceedingly abundant, and is a gibbous, coarsely ribbed variety. The small rhynchonelloid shell which has been identified as *Camarotocchia neglecta* is one of the most common species of the fauna, often being represented by hundreds of individuals

crowded together. Some of the other species are abundant, but these constitute the most characteristic and the most noticeable members of the fauna.

Ptilodictya platyphylla zone. In the Nearpass section, lying above the strata containing the *Chonetes jerseyensis* fauna, is a conspicuous band of red limestone, 2 feet 6 inches in thickness. The bed contains a quite different assemblage of fossils from those below, the most abundant species being a bryozoan whose leaf-like colonies occur in vast numbers. In breaking the rock this bryozoan invariably splits along its median plane, so that the outer cell-bearing surface has not been observed. The specimens have been compared with the types of the species described by U. P. James* from the Clinton beds of Ohio as *Ptilodictya platyphylla*, and the two seem to be identical. The form described by Foerste† as *Ptilodictya lanceolata* var. *americana*, is probably identical with James' species and with the New Jersey specimens.

The following species have been identified from this red limestone bed in the Nearpass quarry:

1. *Favosites* sp undet.
2. *Monotrypa?* sp. undet.
3. *Vermipora?* sp. undet.
4. *Cladopora* sp. undet.
5. *Strophodonta hipartita* (Hall).
6. *Orthothetes* n. sp.
7. *Leptæna rhomboidalis* (Wilck.).
8. *Orthis flabellites* Foerste.
9. *Dalmanella elegantula* (Dal.).
10. *Rhipidomella hybrida* (Sow.).
11. *Chonetes jerseyensis* Weller, n. sp.
12. *Pentamerus oxalis* Hall?
13. *Camarotœchia neglecta* (Hall).
14. *Rhynchonella* sp. undet.
15. *Meristella tricostalis* (Linn.).
16. *Spirifer crispus* (His.).
17. *Ptilodictya platyphylla* Jas.

* The Paleontologist, No. 1, p. 11 (Jan 1879).
† Geol. Surv. Ohio, Vol. VII, p. 198, pl. 36, figs. 3 a–b

18. *Lichenalia?* sp. undet.
19. Pelecypod (gen. and sp. undet.).
20. *Calymene* sp. undet.

Although several of the species in the above list are also included in the preceding fauna, the assemblage as a whole has quite a different aspect. Among the species common to the two faunas, *Chonetes jerseyensis*, the type species of the preceding fauna will be noticed. In the red limestone, however, but a single, small, imperfect specimen of the species has been observed, so that it is not one of the conspicuous members of the fauna as it had been previously.

Aside from the multitude of specimens of *Ptilodictya*, the following important species make their first appearance: *Orthis flabellites*, *Rhipidomella hybrida*, *Pentamerus ovalis?* and *Spirifer crispus*. The specimens which have been identified provisionally as *P. ovalis* do not agree well with Hall's original illustrations of this species, but resemble rather closely some specimens of *Gypidula galeatus*, but lack entirely the plications of that species.

Of the whole series of beds recognized in the Nearpass section this red limestone is one of the most persistent in passing to the south. On the farm of G. N. Cole, near the Brick House, a ledge of this limestone is finely exposed and its decomposition has given the soil overlying it a deep red color. Again, at a point north of Hainesville the same bed with its *Ptilodictya* fauna was observed, and at one locality between Peter's Valley and Walpack Center, where the Decker Ferry formation has become almost entirely arenaceous, this red bed was observed with sandstone both above and below. This last occurrence shows better than any other the continuity of the highly arenaceous formation at the south with the almost entirely calcareous formation in the Nearpass section. In the extreme southern end of the ridge neither the red limestone nor the *Ptilodictya* fauna have been observed, but sufficiently careful search has not yet been made south of Walpack Center.

Rhynchonella lamellata zone. Succeeding the red limestone in the Nearpass section there is a series of limestone beds with some shale, with a thickness of 21 feet 4 inches, which is characterized by an assemblage of organisms differing in most of its

species from either of the two preceding faunas. One of the most typical species has been described by Hall as *Atrypa lamellata*, but is referred to the genus *Rhynchonella* by Schuchert. For the most part the species in the lower beds of this zone continue to the summit, but in the upper six feet of strata a conspicuous and important coral element is added to the fauna which is not present below, and this upper coral-bearing horizon should perhaps be considered as a distinct subzone. In the lower part of this zone the following species have been identified from the Nearpass quarry:

1. *Cladopora* sp. undet.
2. *Strophodonta hipartita* (Hall).
3. *Orthothetes interstriatus* (Hall)?
4. *Orthothetes* sp. undet.
5. *Leptæna rhomboidalis* (Wilck.).
6. *Dalmanella elegantula* (Dal.).
7. *Rhynchonella lamellata* (Hall).
8. *Rhynchonella* sp. undet.
9. *Spirifer* sp. undet.
10. *Whitfieldella?* sp.
11. *Phænopora?* sp. undet.
12. *Mytilarca mytiliformis* (Hall).
13. *Pterinea* sp. undet.
14. Pelecypod (gen. and sp. undet.).
15. *Fractus pachydermatus* Barrett.

In the bluff one and a half miles below Peter's Valley the Decker Ferry formation is exposed through a thickness of more than eighty feet, although the base of the formation is covered. The major portion of the beds at this point are sandstone, but interstratified with the sandstone there are occasionally thin bands of limestone in which the fossils occur in a sufficiently perfect state of preservation to be identified, and the *Rhynchonella lamellata* fauna has been recognized here. From a thin limestone bed fifty feet above the base of the exposure the following species have been identified:

1. *Strophodonta hipartita* (Hall).
2. *Camarotœchia neglecta* (Hall).
3. *Rhynchonella lamellata* (Hall).

4. *Whitfieldella nucleolata* (Hall).
5. *Phœnopora* sp. undet.

From another thin limestone band seventy-five feet from the base the following species were collected:

1. *Diphyphyllum integumentum* Barrett?
2. *Zaphrentis* sp. undet.
3. *Orthothetes interstriatus* (Hall).
4. *Whitfieldella nucleolata* (Hall).
5. Ostracodes (gen. and sp. undet.).

The bed containing the uppermost of these two small faunas may, perhaps, more nearly correspond with the coral bed at the summit of the *Rhynchonella lamellata* zone in the Nearpass section, but the lower one is probably equivalent to the lower portion of the zone.

The earlier stage of the *Rhynchonella lamellata* fauna, as represented in the Nearpass section, is particularly characterized by the species which has been identified in all these faunas as *Strophcodonta bipartita*. Some beds are composed almost exclusively of the shells of this brachiopod, all the other species being sparsely represented. It is the shell for which Dr. Barrett has proposed the name *Stropheodonta nearpassi*,* but an examination of a large series of specimens, showing both the internal and external characters, seems to indicate that the species is no other than Hall's *S. bipartita*. The specimens frequently exhibit the crenulations of the hinge margin which shows it to be a member of the genus *Stropheodonta* rather than *Strophomena*, where it has usually been placed. Some of the beds in this portion of the zone are highly charged with crinoidal remains, to such an extent, even, that it might sometimes be called a crinoidal limestone. These crinoidal remains, however, are for the most part broken fragments of the stems, and no determinable remains have been observed.

In the upper six feet of the *Rhynchonella lamellata* zone in the Nearpass section, a large number of species are added to those which were present in the lower beds, the most conspicuous additions being among the corals. The coral-bearing bed is separated from the lower fossil-bearing beds by about seven feet of

*Am. Jour. Sci., (3) Vol. XV, p. 372. (1878.)

barren shales, and the two horizons should perhaps be considered as entirely distinct. It has been thought best, however, to include the entire series in one life zone, as the species in the lower beds are practically identical, so far as they go, with those of the coral bed. From the coral bed proper in the Nearpass quarry, the following species have been identified:

1. *Cyathophyllum inequalis* (Hall).
2. *Halysites catenulatus* (Linn.).
3. *Favosites niagarensis* Hall.
4. *Favosites pyriformis* (Hall).
5. *Cladopora seriata* Hall.
6. *Zaphrentis* sp. undet.
7. *Diphyphyllum integumentum* Barrett.
8. *Monotrypa?* sp. undet.
9. *Stromatopora concentrica* Goldf.
10. *Pholidops ovalis* Hall.
11. *Strophodonta bipartita* (Hall).
12. *Orthothetes interstriatus* (Hall).
13. *Leptæna rhomboidalis* (Wilck.).
14. *Pholidostrophia?* sp. undet.
15. *Camarotœchia neglecta* (Hall).
16. *Rhynchonella pisa* H. & W.
17. *Rhynchonella lamellata* (Hall).
18. *Rhynchonella* sp. undet.
19. *Homeospira sobrina* (B. & C.)?
20. *Whitfieldella nucleolata* (Hall).
21. *Spirorbis* sp. undet.
22. *Pterinea* cf. *P. brisa* Hall.
23. Gasteropod (gen. and sp. undet.).
24. *Calymene camerata* Hall.
25. *Proetus pachydermatus* Barrett.
26. Ostracodes (several species undet.).

The bed containing these corals and other fossils is a more or less earthy or shaly, irregularly bedded limestone. The coral masses occur in great numbers, and the disintegration of the rock leaves the harder coral colonies of several species abundantly strewn over the surface of the exposure. The bed has not been recognized continuously throughout the entire length of the Walpack ridge in New Jersey, the southernmost exposure where

the corals occur abundantly being a short distance south of Hainesville. The uppermost of the two limestone bands already mentioned in the bluff below Peter's Valley may belong to this horizon, although the fauna represented is small. Of the five species recognized, two are corals and the *Diphyphyllum integumentum* has not elsewhere been recognized outside of the coral bed.

Correlation of the faunas of the Decker Ferry formation. From the three faunal zones recognized in the Decker Ferry formation, thirty-one species of fossils have been identified specifi-

LIST OF SPECIES IDENTIFIED FROM THE THREE FAUNAL ZONES INCLUDED IN THE DECKER FERRY FORMATION.	Zone of C. jerseyensis.	Zone of P. platyphylla.	Zone of R. lamellata.	Coralline L. S. of New York.	Clinton beds of New York.	Clinton beds of Ohio and Ind.	Rochester shale.	Lockport limestone.	Waldron shale.	Niagara of the West.
1. *Cyathophyllum inequalis*,	.	.	×	×						
2. *Halysites catenulatus*,	.	.	×	×	×	.	.	×	.	×
3. *Favosites niagarensis*,	.	.	×	×	.	.	.	×	.	×
4. *Favosites pyriformis*,	.	.	×	.	.	.	×	×		
5. *Monotrypa cf. M. undulata*,	×									
6. *Cladopora seriata*,	.	.	×	.	.	.	×	×		
7. *Diphyphyllum integumentum*,	.	.	×							
8. *Stromatopora concentrica*,	.	.	×	×	.	.	.	×		
9. *Stropheodonta bipartita*,	×	×	×	×						
10. *Leptæna rhomboidalis*,	.	×	×	.	×	×	×	×	×	×
11. *Orthothetes interstriatus*,	.	.	×	×						
12. *Orthis flabellites*,	.	×	.	.	.	×	×	.	.	×
13. *Dalmanella elegantula*,	×	×	×	.	×	×	×	.	×	×
14. *Rhipidomella hybrida*,	.	×	.	.	.	×	×	.	×	×
15. *Chonetes jerseyensis*,	×	×								
16. *Pentamerus ovalis?*	.	×	.	.	×					
17. *Camarotoechia neglecta*,	×	×	×	.	×	×	×			
18. *Rhynchonella lamellata*,	.	.	×	×						
19. *Rhynchonella pisa*,	.	.	×	.	.	.		.	.	×
20. *Atrypa reticularis*,	×	×	.	.	×	.	×	×	×	×
21. *Reticularia bicostata*,	×	.	.	.	.	.	.	×		
22. *Spirifer crispus*,	.	×	.	×	.	.	×	.	×	×
23. *Homeospira sobrina?*	.	.	×	.	.	.	.	.	×	
24. *Whitfieldella nucleolata*,	.	.	×	×						
25. *Pholidops ovalis*,	.	.	×	.	.	.	.	.	×	
26. *Ptilodictya platyphylla*,	.	×	.	.	.	×				
27. *Mytilarca mytiliformis*,	×	.	×	.	×	×				
28. *Leptodesma? subplana*,	×	.	.	.		.	×			
29. *Prœtus pachydermatus*,	.	.	×							
30. *Calymene camerata*,	.	.	×	×						
31. *Phacops trisulcatus?*	×	.	.	.	×	×				

cally with more or less certainty. In the accompanying table an attempt has been made to tabulate the geologic and geographic dis-

tribution of these species. The species are for the most part more or less well-known Niagaran forms, the larger number of them being present elsewhere in beds of post-Clinton age. A single species, *Pentamerus oralis*, and that one very doubtfully identified, occurs elsewhere only in the Clinton beds of New York. Three species, *Ptilodictya platyphylla*, *Mytilarca mytiliformis*, and *Phacops trisulcatus* have been elsewhere recorded, either from the Clinton beds of Ohio and Indiana, or from both the Clinton of New York and Ohio-Indiana. Even these three species may be considered as somewhat doubtful. No microscopic examination has been made for the purpose of comparing the specimens of *Ptilodictya* from New Jersey and Ohio, and the cell-bearing surface has not been observed in the New Jersey specimens, the identification being made solely upon the general form of the colony—characters which are not sufficiently marked for the satisfactory determination of bryozoa. The *Mytilarca mytiliformis* may be indentical with that species of *Mytilarca* originally described as *Imbonychia acutirostra* from the Niagara linestone of Wisconsin. *Phacops trisulcatus* is an insufficiently known trilobite, and the New Jersey specimens so identified are simply detached pygidia, which may easily belong to some other species. Aside from the four species mentioned, there are several others which occur in Clinton beds elsewhere, but all of them are also present in post-Clinton faunas.

Twenty of the species recorded have never been noted in any Clinton fauna, and all but three of these are more or less well known in various post-Clinton faunas. The three exceptions are, two species, *Chonetes jerseyensis* and *Prætus pachydermatus*, which have been described from these beds in New Jersey, and the species of *Monotrypa*, which has been compared with an Ordovician species, *M. undulata*, and which will also probably prove to be an undescribed species. All the species which have been identified with absolute certainty are members of post-Clinton faunas. The evidence afforded by the fossils, therefore, indicates that the age of the Decker Ferry formation is the same as the Rochester shale and Lockport limestone of Clarke and Schuchert,* or as the Niagara formation of most authors.

* Science, N. S., Vol. 10, No. 253, pp. 574-578. (Dec., 1899.)

In the uppermost faunal zone recognized in the Decker Ferry formation, there is an assemblage of species which indicates the equivalence of this portion of the formation and the Coralline limestone of Schoharie, New York. Especially is this true of the upper six feet or the coral-bearing horizon of the formation. The species which especially ally this zone with the Coralline limestone are *Cyathophyllum inequalis*, *Strophcodonta bipartita*, *Orthothetes interstrialis*, *Rhynchonella lamellata*, *Whitfieldella nucleolata* and *Calymene camerata*. There are, however, in the Coralline limestone at its typical locality, Schoharie, New York, many large gasteropods and some cephalopods which are conspicuously absent in New Jersey.

In his description of the Coralline limestone, Hall* expresses the opinion that the formation represents the entire Niagaran series of other localities, but its occurence in New Jersey would indicate that it represents only the last stage of that epoch.

In the official reports on the Walpack ridge in New Jersey, published by the geological surveys of both New Jersey and Pennsylvania, no strata of either Clinton or Niagara age have been recognized. They have been recognized, however, in the Nearpass section by Dr. S. T. Barrett,† a local geologist of Port Jervis, New York, and to him credit is due for the first announcement of the presence of strata in the New Jersey section referable to the Coralline limestone of eastern New York. Although the presence of the Coralline limestone fauna was recognized by Dr. Barrett, he did not in either of his papers strictly define the limits of the zone bearing it, leaving the reader of his papers to infer that it included a large portion or all of the beds here referred to the Decker Ferry formation. Strictly speaking, only the six-foot coral bed can be referred with certainty to the Coralline limestone. This coral bed was fully recognized by Prof. Cook,‡ but because of his erroneous correlation of the "ribbon limestone" of New Jersey with the Manlius or "Tentaculite" limestone of New York, he failed to recognize the identity of this coral bed with the Coralline limestone.

* Pal. N. Y., Vol. II, p. 321.
† Ann. N. Y. Acad. Sci., Vol. 1, pp. 121-124 (1878). Am. Jour. Sci. (3), Vol. 15, pp. 370-372 (1878).
‡ Geol. of N. J., p. 159 (1868).

Correlation of the Bossardville limestone and the Poxino Island shale. With the correlation of the fossiliferous Decker Ferry formation and the Rochester shale and Lockport limestone of Clarke and Schuchert, or the Niagara formation of most authors, and with the probable continuity of the red sandstone of the Kittatinny mountain with the Medina sandstone of New York, the Bossardville limestone and the Poxino Island shale are left as the representatives of the intermediate Clinton beds of the New York section, and although these two formations have as yet yielded no fossil remains, they will for the present be so correlated.

RONDOUT WATER-LIME FORMATION.

In the Nearpass section the coral bed at the summit of the Decker Ferry formation is followed by 56 feet of strata which may be referred to the Water-lime formation. These strata are very diverse in character, consisting of many alternating beds of shales and limestones of varying characters. The following section is an attempt to subdivide this series of strata, but in many instances the subdivisions might be made still smaller.

1.	Hard blue limestone with bands of shale,	4 ft.
2.	Earthy shales, with bands of limestone,	3 ft. 9 in.
3.	Fine grained dark limestone,	6 ft 4 in.
4.	Thick bedded calcareous shale,	1 ft. 6 in.
5	Hard blue limestone filled with Ostracodes and Stromatopora,	2 ft. 3 in.
6	Fissile buff or greenish shale,	5 ft. 3 in
7.	Dense, fine-grained, compact limestone, bluish on freshly fractured surfaces, but buff or yellowish upon the weathered surface,	5 ft
8.	Fissile gray shales, sometimes much crumpled by pressure,	15 ft.
9.	Bluish black limestone,	13 ft.
		56 ft 1 in.

The most conspicuous member of this series of strata is bed No. 7. This is the "Peth Stone"* of Prof. Cook's report, and is the southern extension of the cement rock which is so extensively quarried at Rosendale and Rondout, New York. This bed in New Jersey possesses the same lithologic characters as the cement beds at Rondout, and has the same stratigraphic position. During a visit to Rondout in company with Prof. J. C. Smock

* Geol. N. J., p. 159 (1868).

and Dr. H. B. Kümmel, the Coralline limestone, with some of the same corals as are found in New Jersey, was observed underlying the cement rock, while above it was the Manlius or "Tentaculite" limestone containing the same *Spirifer vanuxemi* fauna that is present in the same formation overlying the Water-lime formation in the Nearpass section. The chief and only difference between the Water-lime formation at Rondout and in the Nearpass section, is the much greater development of the cement bed in the former locality at the expense of the accessory beds of shales and limestones which are so well exhibited in the Nearpass section.

In passing southward from the Nearpass quarry, the Water-lime formation diminishes in thickness until at the Walpack bend of the Delaware river, on the Pennsylvania side near Decker's Ferry, only the "peth stone" with an underlying bed of fine-grained blue limestone is present, both together being not more than 20 or 25 feet in thickness. This blue limestone underlying the "peth stone" is White's* Decker Ferry limestone already mentioned on a previous page.

The fauna of the Water-lime formation is a peculiar one, being constituted almost exclusively of ostracodes. The successive beds in the Nearpass section were examined closely for these small organisms, and each separate bed was found to contain its own peculiar forms, many of which probably belong to undescribed species. Associated with the ostracodes in some of the beds there are immense numbers of stromatoporoids. In the lowermost bed of the whole formation, in a thin limestone band, two specimens of pelecypods were found associated with the ostracodes.

The real significance of these ostracode faunas is not entirely clear, but they must certainly indicate some important physical change. In the Decker Ferry formation we find a prolific fauna of such organisms as usually occur under typical marine conditions, brachiopods, corals, trilobites, pelecypods, etc., containing also a goodly number of individual ostracodes. With no apparent break in the stratigraphic succession, this well-defined marine fauna is followed by a whole series of faunas consisting of almost no other organisms than ostracodes. At the present

* 2d Geol. Surv. Penn., Rep. G6, p. 137

time ostracodes are inhabitants of both fresh and salt water, while the brachiopods and corals are exclusively marine in their habitat, and the trilobites, though extinct at the present time, are believed also to have been wholly marine organisms. If at the close of the Niagaran epoch in the interior of North America, marine conditions were followed by fresh-water or non-marine conditions, the extinction of the marine types of life such as the brachiopods, corals and trilobites would be accounted for, as well as the persistence of the non-marine ostracodes. With the return of marine conditions the marine types of life would also return, just as they do in the Manlius or "tentaculite" limestone overlying the Water-lime formation in the Nearpass section.

The organic evidence of the non-marine origin of the Water-lime sediments is not confined to the New Jersey area, but wherever the formation is recognized it is characterized by the absence of marine fossils and by the presence of peculiar organic remains, which are believed to be fresh-water or, at least, non-marine forms. The peculiar crustacean or arachnoid genera *Eurypterus* and *Pterygotus*, which are so characteristic of the Water-lime formation in some of its western New York exposures, are nowhere found associated with true marine types of life, but they do occur in other non-marine formations, as, for instance, in Coal Measure strata in Pennsylvania,* associated with the remains of land plants which were in all probability deposited in fresh waters.

The presence of this widespread non-marine formation in the interior of North America is of prime significance. It shows that following the wide-spread interior epicontinental sea of Silurian time†—a sea that had reached from the Appalachian land on the east to beyond the Mississippi river, and from the western extension of the Appalachian land at the south far into the Arctic regions—some readjustment of the earth's crust was accomplished by reason of which the communication between the interior sea and the external ocean was destroyed. During the whole of Silurian time stresses had been accumulating in the earth's crust until a general readjustment became essential. This readjustment is believed to have been universal and not

* 2d Geol. Surv. Penn., Rep. P 3, pp. 23-39.
† Jour. Geol., Vol. VI, p. 697.

local in nature, and the major movements of the earth's crust accompanying it are believed to have been the sinking of the ocean bottoms,* which caused the withdrawal of the waters from the continents.

Following the period of readjustment, the waters confined in the interior by the elevated rim of the continent, became a land-locked sea inhabited by non-marine types of life. In the shallow seas upon the outer borders of the continent which were not drained by the recession of the oceanic waters, and in such moderately deep seas as became shallow by reason of the depression of the ocean level, conditions favorable for the development of shallow-water marine life persisted during this period of readjustment, and in such areas the evolution of marine life continued without interruption. A notable example of such a border province at this time, was in eastern Canada, in the region of the St. Lawrence embayment. Here the shallow-water marine life continued its evolution without the wide-spread extinction caused by the intervention of non-marine conditions such as occurred in the interior of the continent.

This period of readjustment of the earth's crust constitutes a natural geologic time division which is believed to have a world-wide significance. Just as the non-marine deposits of the Medina epoch represent the natural division between the Ordovician and Silurian periods, so these non-marine water-lime beds represent the natural division between the Silurian and Devonian. On the borders of the continents in the "harbors of refuge" where the shallow-water marine conditions were continuous, the conspicuous life-breaks which are so noticeable in the interior of the continents are not present; so in the eastern provinces of Canada there is no such discontinuity between the Silurian and Devonian life as is recognized in the interior.

After the accomplishment of the readjustment of conditions a gradual transgression of the sea upon the continent was initiated. This transgression was caused (1) by the slight settling of the continental borders which may have been forced out of isostatic equilibrium during the period of readjustment; (2) by the landward cutting of the continental border, and (3) by the transporta-

* For a further discussion of this, see "The Ulterior basis of time divisions and the classification of Geologic History," by T. C. Chamberlin. Jour. Geol., Vol VI, pp. 449-462.

tion of materials from the continent and their deposition in the ocean. With the extension of the shallow marine waters towards the interior, a union was at last established between the exterior and interior shallow seas. With the renewal of this connection, the marine, Devonian, interior, epicontinental sea came into existence and the shallow-water marine life again found its way to the interior of the continent, the derivation of this life being from those faunas which had persisted in the shallow waters on the outer borders of the continent during the readjustment period. This re-introduction of marine faunas into the interior initiates the Helderbergian epoch and the Devonian period.

Formations of the Devonian System.

MANLIUS LIMESTONE.

Spirifer vanuxemi zone. Lying upon the Rondout Water-lime formation in the Nearpass section there is a series of 22 feet of thinly-bedded, knotty, dark blue or almost black limestones, referable to the Manlius or "Tentaculite" limestone of the New York section. This is the bed which constitutes the quarry stone, and its outcrop may be traced throughout the entire length of the Walpack ridge in New Jersey by the line of quarries and limekilns, it being the only* limestone of the region suitable for the manufacture of lime.

The fauna of the Manlius limestone is not a large one. Ostracodes still persist, but associated with them are several species and many individuals of brachiopods, gasteropods, and some cephalopods. The fauna represents the first return of marine conditions after the non-marine Water-lime epoch. In the Nearpass quarry, fossils were collected from two horizons in this formation, one near the base and the other near the summit. From the lower zone at this locality the following species have been identified:

1. *Strophodonta varistriata* (Con.).
2. *Spirifer vanuxemi* Hall.

* At Flatbrookville the Bossardville limestone and the calcareous beds of the Decker Ferry formation are occasionally burnt for lime. Near the Delaware Water Gap in Pennsylvania, the Bossardville limestone has been used for years in making lime both for building and agricultural purposes.

3. *Megambonia aviculoidea* Hall?
4. *Holopea antiqua* (Van.).
5. *Tentaculites gyracanthus* (Eaton).
6. Cephalopod (gen. and sp. undet).
7. *Leperditia alta* (Con.).
8. Ostracodes (several species).

From the upper zone at the same locality the following species have been identified:

1. *Strophcodonta varistriata* (Con.).
2. *Cypidula galeata* (Dal.).
3. *Spirifer vanuxemi* Hall.
4. Gasteropods (several species).
5. *Orthoceras*, sp. undet.
6. Ostracodes (several species).

The most conspicuous species in this fauna are *Spirifer vanuxemi* and *Strophcodonta varistriata*, and for the lower beds *Leperditia alta* may be added to these. All the other species are more or less uncommon. In the upper half of the formation there are various thin bands closely crowded with gasteropod shells, but they are so firmly imbedded in the matrix that their characters cannot easily be made out, and as a usual thing they can only be recognized in cross section on the weathered surface of the quarry face. At various localities along the entire length of the Walpack ridge the *Spirifer vanuxemi* fauna of the Manlius limestone was observed, but it will not be necessary to give further lists of species.

There has been, and is at the present time, some diversity of opinion among American geologists and paleontologists as to the proper line of separation between the Silurian and Devonian systems. In the past this line has usually been placed between the Helderberg and Oriskany formations, but more recently Clarke and Schuchert* have become the chief advocates of placing it down so as to include the Helderberg formations in the Devonian. The impracticability of drawing any line of demarcation between two of the major divisions of the geologic time scale at the Helderberg-Oriskany contact horizon, is strongly brought out to any student of the stratigraphic paleontology of

* Science, N. S., Vol. X, pp. 874-878.

eastern New York or New Jersey. There is at this horizon no stratigraphic break, impure shales and cherty limestone beds being continuously represented in the section, and the differentiation of the fossil faunas is no more satisfactory. The faunal break is more conspicuous in New Jersey between the Coeymans limestone and the New Scotland beds than between the summit of the Helderbergian series and the Oriskany beds. The alliance of the Helderbergian faunas is upward to a far greater extent than downward, and in the uppermost faunal zone there is a conspicuous mingling of species which have usually been considered either as characteristic of the Helderberg or of the Oriskany faunas.

Among those opposed to the inclusion of the Helderbergian series in the Devonian, the chief ground of appeal is to the original Silurian system in England as described by Murchison, the contention being made that faunas equivalent to his highest Silurian fauna are present above the Helderberg in America. But even if this contention is true, it should not of necessity establish the Silurian age of the Helderbergian series. In the classification of geologic time into its major subdivisions, it is possible to push the doctrine of priority too far. What the present day geologist is seeking is a natural and satisfactory classification of geologic time, not what was the classification of Murchison or any other of the fathers of geology. With our vastly increased insight into paleontology and stratigraphy, it is unreasonable to hold that the present-day geologist is not able to improve on the classifications of the past. No one should allow his sentimental respect for the labors of the fathers of geology, important as they undoubtedly were, to stand in the path of improvement and progress. It is, of course, best to adopt the earlier classification in so far as it can be adjusted to our more perfect understanding of the facts, but it is not in the line of progress to bind ourselves to the arbitrary limits established long ago for the major divisions of the time scale, when we are now able to establish more natural ones.

In the present report the Helderbergian formations are considered as of Devonian age, but the writer differs from Clarke and Schuchert in his estimate of the Manlius limestone. These authors have placed this formation at the summit of the Silurian,

linking it with the subjacent Water-lime formation as has been the usual custom in the past, rather than with the superjacent formations. The fauna of the Manlius limestone, with its marine types of life, differs conspicuously from that of the Water-lime formation which is characterized by its non-marine life. On the other hand the two most characteristic species of the Manlius limestone fauna, *Spirifer vanuxemi* and *Strophcodonta varistriata* are both present in the *Gypidula galeata* fauna of the superjacent beds, the first one being rarely represented and the second often being abundant in the higher fauna. Then again, *Gypidula galeata*, the most characteristic species of the beds superjacent to the Manlius limestone, is sometimes present in the *Spirifer vanuxemi* fauna. Under these conditions it seems as difficult to draw one of the major division lines of the geologic time scale at the summit of the Manlius limestone as at the summit of the Helderbergian series.

It would seem to be far better for the purposes of a natural classification of geologic time, to consider the non-marine Water-lime formation as the division between the Silurian and Devonian periods, beginning the latter period with the first re-initiation of marine life into the interior of the continent. This non-marine horizon is a widespread one in eastern North America, and it is believed that it will be found to represent a terrestrial period which was more or less world-wide in its distribution. In Europe this non-marine horizon is indicated by the presence of strata in Scotland and on the continent containing a peculiar Eurypterus fauna similar to that in the American Water-lime formation, but the symmetrical continental development of Europe was far less perfect than that of North America, and there are in England no marine beds corresponding to our Helderbergian series.

It is believed that a complete elucidation of the earth's history will show an alternation of terrestrial and marine conditions upon the continental platforms, and that these alternations will be found to be more or less world-wide in their distribution. These alternations, then, will form a basis for a natural classification of geologic time, as has been suggested by Chamberlin.* If this hypothesis shall prove to be tenable, it will be seen that the paleontologic record of the continental interior will usually

* Jour. Geol., Vol. VI, p. 449.

exhibit an alternation of marine and non-marine faunas, the terrestrial periods being represented either by sediments with non-marine life or by no sedimentation at all. On the continental borders, however, marine conditions will have been continuous and no such great life-breaks may be looked for.

In North America this contrast between the interior and border provinces is strikingly brought out, both in the Ordovico-Silurian and the Siluro-Devonian transitions. In the first instance we have the continuity of life in the Anticosti formation of eastern Canada, while the Medina formation, probably non-marine in origin, fills the interval in the continental interior.* In the same border province there is a continuity of Silurian and Devonian life, while in the interior the transitional terrestrial period is indicated by the Salina and Water-lime formations with non-marine life.

COEYMANS LIMESTONE.

Gypidula galeata zone. At the top of the bluff in the Nearpass quarry, lying upon the Manlius limestone and scarcely separable from it stratigraphically, are other limestone beds which gradually assume a coarser texture and often become more or less cherty. This formation is what has usually been known as the "Lower Pentamerus limestone," but for which Clarke and Schuchert† have recently proposed the more satisfactory name Coeymans limestone. This formation differs from the Manlius limestone not only in texture and other lithologic characters, but also in containing a far more prolific fossil fauna. The most characteristic species of the fauna is *Gypidula galeata*, a species formerly included in the genus *Pentamerus*, hence the older name of the formation.

In the Nearpass section the thickness of this formation has been estimated at 40 feet, though only the lower beds are here actually exposed. There are in the formation as it is exhibited in the various outcrops in the area under discussion, several more or less distinct sub-zones of the *Gypidula galeata* fauna. All of these sub-zones contain the type species of the formation, but not

* See "The Silurian Basin Interpreted on the Epicontinental Basis," by Stuart Weller, Jour. Geol., Vol. VI, pp 633-657

† Science, N. S., Vol. X, pp 874-878.

all of them contain it in the same relative numerical abundance. Only the lowermost of these sub-faunas has been traced with any degree of continuity through the entire length of the Walpack ridge, and even this one has not as yet been so clearly recognized in the extreme southern portion of the area as it has at the north.

The fauna of the basal portion of the *Gypidula galeata* zone is characterized by its large number of corals of the genus *Favosites*, and by the genus *Stromatopora*. It is really a southern extension of the coral bed, recognized at the base of the same formation in New York. Near the top of the Nearpass bluff this bed may be easily traced by the large number of Favosites which have become conspicuous in the weathered surface. In the Nearpass quarry the following species have been identified from the Favosites bed:

1. *Favosites helderbergiæ* Hall.
2. *Favosites sphericus* Hall.
3. *Stromatopora concentrica* Goldf.
4. *Strophcodonta varistriata* (Con.).
5. *Strophcodonta beckei* Hall.
6. *Strophonella punctulifera* (Con.).
7. *Dalmanella perelegans* Hall.
8. *Gypidula galeata* (Dal.).
9. *Rhynchonella semiplicata* (Con.).
10. *Rhynchonella transversa* Hall.
11. *Uncinulus mutabilis* Hall.
12. *Atrypa reticularis* (Linn.).
13. *Spirifer octocostatus* Hall.?
14. *Meristella lævis* (Van.)?
15. *Lichenalia torta* Hall.
16. *Ptilodictya?* sp. undet.
17. *Pterinea* cf. *P. textilis* (Hall).
18. *Capulus* sp. undet.
19. *Dalmanites* sp. undet.
20. *Phacops* sp. undet.

At Peter's Valley the Coeymans limestone is well exposed in the hillside above the large spring one-half mile northeast of the village, and again in the hillside above the school-house.

The coral bed is not so well exposed in this locality, but *Gypidula galeata* is remarkably abundant, it being represented by hundreds of individuals, while most of the other species present are more or less rare. The following species have been identified from Peter's Valley above the large spring:

1. *Zaphrentis* sp. undet.
2. *Strophcodonta varistriata* (Con.).
3. *Strophonella punctulifera* (Con.).
4. *Dalmanella perelegans* Hall.?
5. *Gypidula galeata* (Dal.).
6. *Rhynchonella semiplicata* (Con.).
7. *Uncinulus mutabilis* Hall.
8. *Lissopleura æquivalvis* (Hall).
9. *Atrypa reticularis* (Linn.).
10. *Spirifer vanuxemi* Hall.
11. *Meristella lævis* (Van.)? small form.
12. *Rhynchospira formosa* Hall.
13. *Lichenalia torta* Hall.
14. *Conocardium* sp. undet.
15. *Megambonia?* sp. undet.
16. *Tentaculites* sp. undet.
17. *Dalmanites* sp. undet.
18. Ostracodes (several species).

At Flatbrookville the Coeymans limestone is well developed, and in a bed lying near the top of the formation the species collected were the following:

1. *Strophcodonta varistriata* (Con.).
2. *Strophcodonta beckei* Hall.
3. *Strophonella punctulifera* (Con.).
4. *Orthothetes woolworthanus* Hall.
5. *Schizophoria multistriata* Hall.
6. *Gypidula galeata* (Dal.).
7. *Rhynchonella semiplicata* (Con.).
8. *Uncinulus mutabilis* Hall.
9. *Uncinulus pyramidatus* Hall.
10. *Atrypa reticularis* (Linn.).
11. *Spirifer octocostatus* Hall.?
12. *Cyrtina dalmani* (Hall).

13. *Meristella lævis* (Van.)? small form.
14. *Rhynchospira formosa* Hall.
15. *Lichenalia torta* Hall.
16. *Fenestella?* sp. undet.
17. *Pterinea* sp. undet.
18. *Tentaculites* sp. undet.
19. *Dalmanites* sp. undet.
20. *Phacops* sp. undet.

At a single locality, north of Hainesville, a fauna was collected which is believed to have come from the very summit of the Coeymans limestone. The particular variety of *Gypidula galeata* which is present in the lower portion of the formation is not abundant in this locality, although it is rarely represented. Most of the specimens of this species which do occur here have a more pronounced fold and sinus which is marked by coarser plications, the sides of the shell being nearly smooth. The following species have been identified from this locality:

1. *Zaphrentis roemeri* E. & H.?
2. *Favosites helderbergiæ* Hall.
3. Coral (gen. and sp. undet.).
4. *Gypidula galeata* (Dal.).
5. *Rhynchonella semiplicata* (Con.).
6. *Rhynchonella* sp. undet.
7. *Uncinulus pyramidatus* Hall.
8. *Atrypa reticularis* (Linn.).
9. *Spirifer octocostatus* Hall.
10. *Spirifer concinnus* Hall.
11. *Cyrtina dalmani* Hall.
12. *Nucleospira* cf. *N. concentrica* Hall.
13. *Rhynchospira formosa* Hall.
14. *Meristella lævis* (Van.).
15. *Lichenalia torta* Hall.
16. *Fenestella* sp. undet.
17. *Cornulites* sp. undet.
18. *Pterinea textilis* Hall.?
19. *Rhombopteria* cf. *R. mira* Barr.
20. *Capulus gibbosum* (Hall).
21. *Holopea?* sp. undet.
22. *Murchisonia* sp. undet.

This fauna is quite different in its general composition from any of those in the lower beds of the Coeymans limestone, one of its most conspicuous characteristics being the entire absence of the genera *Strophcodonta* and *Strophonella*. In the increased representation of the genus *Spirifer*, the fauna shows its approach towards those of the superjacent New Scotland beds, but on account of the presence of *Gypidula galeata* the beds containing it are included in the Coeymans limestone.

NEW SCOTLAND BEDS.

In New York the Coeymans limestone is followed by a series of beds formerly known as the Catskill or Delthyris Shaly limestone, but for which Clarke and Schuchert* have proposed the name New Scotland beds. This formation contains a wonderfully prolific fauna, especially characterized by the large representation of the genus Spirifer, standing in sharp contrast in this respect to the faunas of the Coeymans limestone. The New Scotland beds are extended into New Jersey, where they are well represented and contain a fauna which is in general identical with that in New York. In New Jersey this fauna as a whole is differentiated into three more or less distinct faunal zones, while in New York, so far as can be determined from the literature, the species constitute one general assemblage of life.

These beds are well exhibited in the Nearpass section, although they are not exposed at any point in the quarry bluff. At this locality three distinct beds are recognized in the formation as a whole, a cherty limestone at the base and another at the summit, with a shale bed between. These three beds have been recognized throughout a large part of the area under discussion, but they have not been so clearly differentiated at the extreme southern end of the ridge as at the north.

Each of the three beds of this formation is characterized by some species which are more or less restricted to it, and these somewhat distinct faunal zones will be spoken of as the *Spirifer perlamellosus* zone, the *Spirifer macropleurus* zone, and the *Spirifer cyclopterus* zone, from that species of Spirifer which is most characteristic of each.

* Science, N. S., Vol. X, pp. 874-878.

Toward the southern part of the Walpack ridge in New Jersey there is intercalated between the Coeymans limestone and the New Scotland beds a sandstone formation which continues southwestward into Pennsylvania, where it becomes conglomeratic in places. To this formation White* has given the name Stormville conglomerate. At Flatbrookville this sandstone seems to replace the lower cherty limestone member of the New Scotland beds. A few notes upon this formation will be added after the discussion of the New Scotland beds.

Spirifer perlamellosus zone. The lowest member of the New Scotland beds is an impure cherty limestone, some beds of which in certain localities are constituted almost entirely of chert. The commonest species of *Spirifer* which has been found in this bed is *S. perlamellosus*, and from this species the faunal zone has been named. This species, however, is not restricted to this horizon alone, as it also occurs in the superjacent shale beds.

In the Nearpass section this bed is for the most part covered with drift, but just above the quarry of Mr. Sanford Nearpass a good outcropping ledge is exposed, from which the following species were collected:

1. *Hindia fibrosa* (Roem.).
2. *Streptelasma strictum* Hall.
3. *Lecanocrinus* sp. undesc.
4. *Pholidops ovata* Hall?
5. *Strophcodonta beckei* Hall.
6. *Strophonella punctulifera* (Con.).
7. *Strophonella* sp. undet.
8. *Leptæna rhomboidalis* (Wilck.).
9. *Dalmanella perelegans* Hall.
10. *Rhipidomella oblata* Hall.
11. *Bilobites varicus* (Con.).
12. *Scenidium insigne* Hall.
13. *Uncinulus pyramidatus* Hall.
14. *Eatonia medialis* (Van.).
15. *Spirifer perlamellosus* Hall.
16. *Spirifer cyclopterus* Hall.

* 2d Geol. Surv. Penn., Rep. G6, p 132.

17. *Nucleospira concentrica* Hall.
18. *Meristella laevis* (Van.).
19. *Pterinea* sp., cf. *P. textiles* (Hall).
20. *Platyostoma* sp. undet.
21. *Dalmanites pleuropteryx* (Green). ?
22. *Phacops* sp. undet.

Just below Hainesville there is another good exposure of this bed and from it the following species have been identified:

1. *Hindia fibrosa* (Roem.).
2. *Glossina spatiosa* (Hall). ?
3. *Strophodonta beckei* Hall.
4. *Strophomella punctulifera* (Con.).
5. *Strophomella levenworthana* Hall.
6. *Leptaena rhomboidalis* (Wilck.).
7. *Dalmanella perelegans* Hall.
8. *Dalmanella subcarinata* Hall.
9. *Rhipidomella oblata* Hall.
10. *Rhipidomella eminens* Hall.
11. *Orthothetes woolworthanus* Hall.
12. *Cincinulus vellicatus* Hall.
13. *Eatonia singularis* (Van.).
14. *Eatonia medialis* (Van.).
15. *Spirifer perlamellosus* Hall.
16. *Meristella laevis* (Van.).
17. *Pterinea spinulifera* (Hall).
18. *Pterinea* sp. undet.
19. *Megambonia ovata* Hall. ?
20. *Cypricardinia sublamellosa* Hall. ?
21. *Lovonema attenuata* Hall. ?
22. *Strophostylus gebhardi* (Con.).
23. *Orthoceras* sp. undet.
24. *Phacops logani* Hall.
25. *Dalmanites* sp. undet.

Spirifer macroplaurus zone. The intermediate member of the New Scotland beds is usually a rather soft earthy shale. In most localities this bed is drift-covered, but several good exposures of it have been observed, it seeming to exhibit greater continuity than either the subjacent or superjacent beds of the

formation. This shale is particularly characterized by the presence of *Spirifer macropleurus*, a species which has not yet been observed at any other horizon in New Jersey, and therefore this horizon has been designated as the *Spirifer macropleurus zone.*

In the Nearpass section this shale bed occupies the first hollow beyond the summit of the Nearpass quarry bluff, only a few limited exposures of it being visible. The following species have been collected at this locality:

1. *Streptelasma strictum* Hall.
2. *Strophcodonta beckei* Hall.
3. *Leptæna rhomboidalis* (Wilck.).
4. *Rhipidomella oblata* Hall.
5. *Eatonia medialis* (Van.).
6. *Spirifer macropleurus* (Con.).
7. *Spirifer cyclopterus* Hall.
8. *Spirifer perlamellosus* Hall.
9. *Trematospira multistriata* Hall.
10. *Meristella arcuata* Hall.
11. *Anoplotheca concava* (Hall).
12. *Pterinea communis* (Hall.)
13. *Cypricardinia lamellosa* Hall.
14. *Tentaculites* sp. undet.
15. *Dalmanites* sp. undet.

About a mile and a half south of the Nearpass quarry, in the east side of the ridge, a small excavation has been made in this shale. At this locality fossils are preserved in abundance and the following species have been identified.

1. *Strophcodonta beckei* Hall.
2. *Strophonella punctulifera* (Con.).
3. *Leptæna rhomboidalis* (Wilck.).
4. *Rhipidomella oblata* Hall.
5. *Eatonia medialis* (Van.).
6. *Spirifer macropleurus* (Con.).
7. *Spirifer cyclopterus* Hall.
8. *Spirifer perlamellosus* Hall.
9. *Atrypina imbricata* Hall.
10. *Meristella arcuata* Hall.
11. *Anoplotheca concava* (Hall).

Below Hainesville, lying above the bed from which the fauna of the *Spirifer perlamellosus* zone has already been recorded, this shale bed is well exposed and has furnished the following species:

1. *Strophcodonta beckei* Hall.
2. *Leptæna rhomboidalis* (Wilck.)
3. *Rhipidomella oblata* Hall.
4. *Eatonia medialis* (Van.).
5. *Uncinulus vellicatus* Hall.
6. *Spirifer macropleurus* (Con.).
7. *Spirifer cyclopterus* Hall.
8. *Trematospira multistriata* Hall.
9. *Atrypina imbricata* Hall.
10. *Meristella arcuata* Hall.
11. *Anoplotheca concava* (Hall).

About one mile below Peter's Valley, in the side of the road crossing the ridge, an excavation for road material has been made in this shale. Some of the beds at this locality are fossiliferous and the following species have been identified:

1. *Strophcodonta beckei* Hall.
2. *Leptæna rhomboidalis* (Wilck.).
3. *Rhipidomella oblata* Hall.
4. *Orthostrophia strophomenoides* Hall.
5. *Eatonia medialis* (Van.).
6. *Spirifer macropleurus* (Con.).
7. *Spirifer cyclopterus* Hall.
8. *Spirifer perlamellosus* Hall.
9. *Trematospira multistriata* Hall.
10. *Atrypina imbricata* Hall.
11. *Meristella arcuata* Hall.

At Flatbrookville, just below the village, the *Spirifer macropleurus* bed is exposed, lying directly upon the Stormville sandstone, indicating that at this locality the sandstone has replaced the basal, cherty limestone member of the New Scotland beds. These shale beds at this point are a much tougher and more calcareous rock than at the localities that were examined further

north. The following species of fossils were collected at Flatbrookville:

1. *Streptelasma strictum* Hall.
2. *Stropheodonta beckei* Hall.
3. *Leptæna rhomboidalis* (Wilck.).
4. *Orthostrophia strophomenoides* Hall.
5. *Rhipidomella oblata* Hall.
6. *Eatonia medialis* (Van.).
7. *Spirifer macropleurus* (Con.).
8. *Meristella arcuata* Hall.
9. *Dalmanites* sp. undet.

Spirifer cyclopterus zone. The uppermost member of the New Scotland beds in the Nearpass section, is exposed along the crest of the first low ridge back of the summit of the Nearpass quarry bluff. This bed is an extremely cherty limestone, which makes a rather continuous outcrop because of its power of resistence to the weather. It is often highly fossiliferous, but the fossils are usually so firmly imbedded in the cherty matrix that it is difficult to make satisfactory identifications of the species. This cherty limestone has been observed at several points along the ridge, but the only locality where the fauna has been made out with any degree of satisfaction is in the Nearpass section from which locality the following species have been identified:

1. *Zaphrentis* sp. undet.
2. *Stropheodonta beckei* Hall.
3. *Stropheodonta planulata* Hall.
4. *Strophonella punctulifera* (Con.).
5. *Leptæna rhomboidalis* (Wilck.).
6. *Rhipidomella oblata* Hall.
7. *Uncinulus vellicatus* Hall.
8. *Rhynchotrema formosum* (Hall).
9. *Rhynchonella bialveata* Hall.
10. *Spirifer cyclopterus* Hall.
11. *Meristella lævis* (Van.).
12. *Pterinea textiles* (Hall).
13. *Phacops logani* Hall.
14. *Homalonotus vanuxemi* Hall.
15. *Lichas pustulosus* Hall.

16. *Dalmanites* sp. undet.
17. Ostracodes (several undet. sp.).

Vertical range of species in the New Scotland beds. For the purpose of comparing the faunas of the three members recognized in the New Scotland beds, the following table has been prepared:

LIST OF SPECIES	S. perlamellosus zone.	S. macropleurus zone.	S. cyclopterus zone.
Hindia fibrosa,	×		
Streptelasma strictum,	×	×	
Lecanocrinus sp. undet.,	×		
Pholidops ovatus,	×		
Glossina spatiosa,	×		
Stropheodonta beckei,	×	×	×
Stropheodonta plannlata,			×
Strophonella punctulifera,	×	×	×
Strophonella leconzworthana,	×		
Leptæna rhomboidalis,	×	×	×
Dalmanella perelegans,	×		
Dalmanella subcarinata,	×		
Rhipidomella oblata,	×	×	×
Rhipidomella eminens,	×		
Bilobites caricus,	×		
Scenidium insigne,	×		
Orthothetes woolcotthanus,	×		
Orthostrophia strophomenoides,		×	
Uncinulus pyramidatus,	×		
Uncinulus cultratus,	×	×	×
Rhynchotrema formosa,			×
Rhynchonella halvcata,			×
Eatonia medialis,	×	×	
Eatonia singularis,	×		
Atrypina imbricata,		×	
Spirifer perlamellosus,	×	×	
Spirifer macropleurus,		×	
Spirifer cyclopterus,	×	×	×
Nucleospira concentrica,	×		
Trematospira multistriata,		×	
Meristella laevis,	×		×
Meristella arcuata,		×	
Anoplotheca concava,		×	
Pterinea textilis			×
Pterinea spinulifera,	×		
Pterinea communis,		×	
Megambonia ovata,	×		
Cypricardinia lamellosa,		×	
Cypricardinia sublamellosa,	×		
Lovonema attenuata,	×		
Strophostylus gibbardi,	×		
Dalmanites sp.,	×	×	×
Phacops logani,	×		×
Homalonotus canaveti,			×
Lichas pustulosus,			×

STORMVILLE SANDSTONE.

This formation is present only in the southern half of the area, where it lies immediately above the Coeymans limestone. It makes its first appearance just south of Hainesville, where it occurs as a thin sandy layer in the top of the Coeymans limestone. South of this locality, for some distance, this sandstone is not a conspicuous formation. It is too thin a bed and is too heavily drift-covered to afford noticeable exposures. Below Peter's Valley, however, it becomes more strongly developed and is frequently met with. A good exposure of it may be seen in the side of the road crossing the ridge at Walpack Center. At one locality above Walpack Center this formation contains numerous fossils, but they are all imperfect casts and cannot be identified with any certainty, though most of them appear to be identical with species which occur in the *Spirifer perlamellosus* zone of the New Scotland beds. At Flatbrookville this sandstone occurs, and from the base of the formation specimens of *Gypidula galeata* were collected, while the beds lying above it contain the fauna of the *Spirifer macropleurus* zone, which indicates that at this locality the Stormville sandstone has replaced the lower cherty limestone member of the New Scotland beds.

According to the report on Pike and Monroe counties, Pennsylvania,* the Stormville sandstone becomes more and more a conspicuous formation to the south, and gradually replaces the remaining members of the New Scotland beds and also the superjacent strata until it becomes continuous with the Oriskany sandstone.

BECRAFT LIMESTONE.

Dalmanites dentatus zone. In the Nearpass section the upper cherty members of the New Scotland beds is followed by a series of more or less calcareous shaly beds, at the summit of which are some well-defined beds of limestone filled with fossils. These limestone beds form the crest of the high ridge to the northwest of the Nearpass quarry, and are a southern extension of the beds which form the crest of the ridge in New York

*2d Geol Surv. Penn., Rep. G6, pp. 132, 133.

State east of Tri-States, which has been called "Trilobite ridge" by those who have collected in that region. These upper beds are characterized by the great number of trilobite fragments which are preserved in them, the most abundant species being *Dalmanites dentatus*. The trilobite remains are not restricted to the limestone beds at the summit of the formation, but occur also in the more shaly beds below, although they are nowhere so abundant as in the upper beds.

The fauna of these trilobite beds is somewhat peculiar, being a mingling of Lower Helderberg and Oriskany species, and is perhaps equivalent to the fauna from Becraft Mt., in New York, which has been noticed by Beecher and Clarke* and has been referred by them to the lower Oriskany.

The following species have been identified from the trilobite beds in the crest of the high ridge in the Nearpass section:

1. *Vermipora serpuloides* Hall.
2. *Vermipora? tortuosa* Hall.
3. *Orbiculoidea ampla* Hall.
4. *Lingula* sp. undet.
5. *Strophcodonta hincklaeni* Hall.?
6. *Strophcodonta magnifica* Hall.
7. *Strophcodonta* sp. undet.
8. *Chonostrophia* sp. undet.
9. *Chonostrophia complanata* Hall.?
10. *Leptæna rhomboidalis* (Wilck.).
11. *Dalmanella subcarinata* Hall.
12. *Dalmanella perelegans* Hall.
13. *Rhipidomella discus* Hall.
14. *Rhynchonella* several undet. sp.
15. *Rensselaeria mutabilis* Hall.
16. *Spirifer arrectus* Hall.
17. *Spirifer* sp. undet.
18. *Cyrtina rostrata* Hall.
19. *Meristella princeps* Hall.
20. *Megambonia bellistriata* Hall? (small form).
21. *Megambonia lamellosa* Hall? (small form).
22. *Modiomorpha?* sp. undet.
23. *Pterinea textilis* (Hall).

*Am. Jour. Sci. (3), Vol. XLIV, pp. 410-414.

24. *Pterinea* sp. undet.
25. *Goniophora* sp. undet.
26. *Loxonema* sp. undet.
27. *Strophostylus transversus* Hall?
28. *Capulus* sp. cf. *C. dilatatum* (Hall).
29. *Hyolithes centennialis* Barrett.
30. *Tentaculites acula* Hall.
31. *Tentaculites* sp. undet.
32. *Dalmanites dentatus* Barrett.
33. *Homalonotus vanuxemi* Hall.
34. *Beyrichia* sp. undet.

Aside from the trilobite remains the most abundant and characteristic species of this zone are *Rensselæria mutabilis* and the undetermined species of *Chonostrophia*. The specimens of *Rensselæria* are much larger than those figured by Hall in the Paleontology of New York, volume III, but in volume VIII of the same work larger specimens of the same species have been illustrated which correspond more nearly with the specimens from New Jersey. The species of *Chonostrophia* is probably an undescribed one. It resembles *C. complanata*, but is always smaller and is marked by finer radiating costæ.

These trilobite beds can be traced throughout nearly the entire length of the Walpack ridge in New Jersey, but are less easily distinguished toward the southern part of the region. At Peter's Valley, opposite the residence of Mrs. Coss, the highly fossiliferous calcareous beds at the summit of the formation are well exposed, and the following species have been identified from that locality:

1. *Schizocrania superincreta* Barrett.
2. *Pholidops* sp. undet.
3. *Strophcodonta magnifica* Hall.
4. *Stropheodonta* sp. undet.
5. *Leptæna rhomboidalis* (Wilck.).
6. *Anoplia nucleata* Hall.
7. *Dalmanella subcarinata* Hall.
8. *Chonostrophia* sp. undet.
9. *Rensselæria mutabilis* Hall.
10. *Spirifer arrectus* Hall.

11. *Cyrtina rostrata* Hall.
12. *Meristella princeps* Hall.?
13. *Perinea textilis* (Hall).
14. *Dalmanites dentatus* Barrett.
15. *Leperditia?* sp. undet.

South of Walpack Center these calcareous beds are again exposed and have afforded the following species of fossils:

1. *Dalmanella subcarinata* Hall.
2. *Rhynchonella* sp. undet.
3. *Rensselaeria mutabilis* Hall.
4. *Megambonia bellistriata* Hall? (small form).
5. *Orthoceras* sp. undet.
6. *Dalmanites dentatus* Barrett.
7. *Homalonotus vanuxemi* Hall.

ORISKANY BEDS.

Spirifer arrectus Conr. The Oriskany formation in New Jersey is constituted of two sharply differentiated members, a more or less siliceous limestone which is often somewhat shaly, and a well-defined sandstone. In the northern portion of the district the sandstone is not represented, but near Peter's Valley it makes its first appearance at the top of the formation as a whole, overlying the siliceous limestone beds. The fauna of both the limestone and the sandstone beds is approximately the same, although the fossils in the sandstone are less perfectly preserved and are less abundant.

In the Nearpass section, at a point about one-half mile north of the Nearpass quarry, the following species have been identified from the siliceous limestone:

1. *Strophodonta magnifica* Hall.
2. *Eatonia peculiaris* (Con.).
3. *Spirifer arrectus* Hall.
4. *Cyrtina rostrata* Hall.
5. *Meristella lata* Hall.
6. *Perinea textilis* var. *arenaria* (Hall).
7. *Platyostoma contricosa* Con.
8. *Dalmanites* sp. undet.

On the road leading from Layton to Dingman's Ferry a highly fossiliferous outcrop of the impure, cherty, limestone beds of the Oriskany, is exposed, and has afforded the following species of fossils:

1. *Strophcodonta magnifica* Hall.
2. *Leptæna rhomboidalis* var. *ventricosa* Hall.
3. *Rhipidomella* sp. undet.
4. *Anoplia nucleata* Hall.
5. *Chonostrophia complanata* Hall.
6. *Spirifer arrectus* Hall.
7. *Spirifer arenosus* (Con.).
8. *Cyrtina rostrata* Hall.
9. *Metaplasia pyxidata* Hall.
10. *Anoplotheca flabellites* (Con.).
11. *Meristella lata* Hall.
12. *Pterinea textilis* var. *arenaria* (Hall).
13. *Platyostoma ventricosa* Con.
14. *Dalmanites* sp. undet.

At Peter's Valley, on the hill opposite the residence of Mrs. Coss, weathered masses of the siliceous Oriskany limestone are strewn over the surface, and the hill itself is doubtless constituted of this rock. Some of these loose masses of rock are highly fossiliferous, and the following species have been identified:

1. *Edriocrinus sacculus* Hall.
2. *Strophcodonta magnifica* Hall.
3. *Leptæna rhomboidalis* var. *ventricosa* Hall.
4. *Pholidops ovata* Hall.
5. *Hipparionyx proximus* Van.
6. *Chonostrophia complanata* Hall.
7. *Eatonia peculiaris* (Con.).
8. *Spirifer arrectus* Hall.
9. *Spirifer arenosus* (Con.).
10. *Spirifer tribulis* Hall.
11. *Anoplotheca flabellites* (Con.).
12. *Meristella lata* Hall.
13. *Megambonia bellistriata* Hall.
14. *Platyostoma ventricosa* Con.

15. *Platyceras tortuosum* Hall.
16. *Tentaculites elongatus* Hall.

Near Peter's Valley the sandstone member of the Oriskany formation makes its appearance lying above the siliceous limestone beds, and from this point south its outcrop is more or less continuous. Fossils are poorly preserved in these sandstone beds, but those that have been observed are always identical with species which have been recognized in the calcareous beds below, although not nearly so many species have been collected from the sandstone as from the siliceous limestone beds.

At a locality just below Walpack Center the following species were collected from the Oriskany sandstone:

1. *Leptæna rhomboidalis* var. *ventricosa* Hall.
2. *Spirifer arrectus* Hall.
3. *Anoplotheca flabellites* (Con.).
4. *Meristella lata* Hall.

ESOPUS GRIT.

This is the formation which has usually been known in the past as the "Cauda-galli grit," but for which the members of the New York Geological survey have adopted the name Esopus grit. It is one of the most persistent formations in the region under discussion, and forms the crest of the Walpack ridge throughout the greater part of its entire length. It is a gray or nearly black gritty rock in which cleavage is frequently developed to a high degree. When the cleavage is not too strongly developed, the fucoid "cauda-galli" markings are frequently abundant along the bedding planes, but other fossils are almost entirely absent, a single specimen of *Lingula* from near Flatbrookville being the only one which has been found.

In the report on Pike and Monroe counties, Pennsylvania, I. C. White† mentions the presence of fossil brachiopods, in this formation, but a careful search in New Jersey has failed to bring to light any other than the one specimen already mentioned. It

*13th Ann. Rep. N. Y. State Geol., Vol. I, p. 209; 47th Rep. N. Y. State Museum, p. 403; Science, N. S., Vol. X, No. 253, pp. 874-875.

†2d Geol. Surv. Penn., Rep. G6, p. 122.

is possible that the fossils mentioned by White were from the shaly beds at the base of the superjacent Onondaga limestone, as these beds frequently resemble, in a measure, some of the beds of the Esopus grit, and they are usually more or less fossiliferous.

ONONDAGA LIMESTONE.

The Onondaga limestone lies above the Esopus grit, and covers the greater portion of the northwestern slope of the Walpack ridge. Towards its base this formation is somewhat shaly, and sometimes has a slight resemblance to the upper beds of the Esopus slate. These shaly beds, however, soon pass upward into the limestone. The limestone is a hard, regularly bedded rock, the beds ranging from three inches to a foot in thickness. Some of the beds contain large quantities of chert which gives to their weathered surfaces an extremely rough and jagged appearance.

Fossils are not abundant in this formation, and those that are present are usually too firmly imbedded in the matrix to be satisfactorily studied. Along the river road about three and one-half miles below Tri-States, New York, there are several outcropping ledges of this formation from which the following species of fossils were collected:

1. *Stropheodonta* sp. undet.
2. *Atrypa reticularis* (Linn.).
3. *Loxonema* sp. undet.

In a field west of Peter's Valley there are some good exposures of the Onondaga limestone in which some fossils were observed; but aside from numerous corals too firmly imbedded to be collected and some crinoid stems, the only species recognized was *Leptæna rhomboidalis* (Wilck.).

One of the best fossiliferous localities of the Onondaga limestone which has been observed is along the river road about one and one-half miles southwest of Peter's Valley. From this place the following species have been identified:

1. *Stropheodonta perplana* (Con.).
2. *Rhipidomella vanuxemi* Hall.?

3. *Chonetes arcuatus* Hall.?
4. *Atrypa reticularis* (Linn.)
5. *Reticularia fimbriata* (Con.).
6. *Anoplotheca camilla* (Hall).
7. *Fenestella?* sp. undet.

Another locality where several species of fossils were secured from the Onondago limestone, is along the river road about four miles above Flatbrookville. From this place the following species have been identified:

1. *Zaphrentis* sp. undet.
2. *Lingula* sp. undet.
3. *Leptæna rhomboidalis* (Wilck.).
4. *Orthothetes pandora* (Bill.).
5. *Spirifer varicosus* Hall.?
6. *Anoplotheca camilla* (Hall).
7. *Cupulus* sp. undet.

Along the river bank about two miles north of Flatbrookville the following species were collected:

1. *Anoplotheca acutiplicata* (Con.).
2. *Orthothetes* sp. undet.

In the shaley beds at the base of the Onondaga limestone fossils are sometimes present, and in the side of the river road about one mile north of Flatbrookville several specimens of *Anoplotheca acutiplicata* were collected from this portion of the formation.

Descriptions of Cambrian Trilobites from New Jersey, with Notes on the Age of the Magnesian Limestone Series.

By STUART WELLER.

Cambrian Trilobites have been recognized in New Jersey at two distinct horizons, (1) in the quartzite near Franklin Furnace, between the crystalline pre-cambrian rocks and the blue magnesian limestones, and (2) in the blue magnesian limestone at Carpentersville on the Delaware river about six miles below Phillipsburg.

In the first of these localities, trilobites belonging to the genus *Olenellus* occur in an exceedingly hard, bluish, calcareo-siliceous bed, which has been traced by its weathered fragments on the surface, from Hardistonville on the north to some distance south of Franklin Furnace. This same bed has been noticed again north of Andover. The actual thickness of this fossiliferous bed has not been observed, but it cannot be more than a very few feet. The trilobites can be recognized only in the weathered portion of the rock, from which the calcareous matter has been dissolved. This weathered rock is of a deep brown color, arenaceous and friable, and it splits along the planes where the trilobite tests have been removed by solution during the process of weathering. A careful search in the fresh, unaffected portion of the rock failed to disclose any sign of fossil remains, but that they are really present in abundance is shown by their frequency in the weathered portions.

The Hardistonville Quartzite, as it has been named by Wolff and Brooks* in the region of Franklin Furnace, has been known to contain the remains of trilobites of the genus *Olenellus*, for some time. They were first discovered by Beecher,† who made

*18th Ann. Rep. U. S. G. S., Pt. II, p. 442.
†Ann. Rep. State Geol. N. J. for 1890, p. 49.

an examination of the rocks for fossils in connection with Nason's studies of the white crystalline limestone at Franklin Furnace. Later, Foerste* found numerous fossil localities during his studies with Wolff, for the United States Geological Survey. The accompanying illustrations, however, are the first figures that have been published of these New Jersey specimens of *Olenellus*.

The second locality, in the magnesian limestone at Carpentersville, has not hitherto been recognized; in fact, no trilobites have previously been recorded from this magnesian limestone series in New Jersey. The locality where the fossils occur is in Robinson Brothers' quarry south of the village of Carpentersville. In this quarry the strata dip to the northwest at an angle of from 65° to 70°, with the strike N. 60° E. Most of the fossils were found in the quarried stone at the north end of the quarry, but a careful search located the fossils *in situ* in the upper part of the north end of the quarry, in a bed which, if continued, would pass about ten or twelve feet north of the northernmost of the three kilns by the railroad track. The specimens are apparently all of a single, small and somewhat variable species which is referred to the somewhat doubtfully valid genus *Liostracus*. The only other American species which have been placed in this genus have been described from the middle Cambrian of New Brunswick, and although the species from Carpentersville is not closely allied to any of those previously recognized, it will perhaps be safe to refer the beds containing it to the middle Cambrian.

The Hardistonville quartzite, with its Olenellus fauna, is referable to the lower Cambrian, and similar quartzite having the same position between the magnesian limestone and the crystalline rocks occurs at frequent intervals and is perhaps continuous throughout the whole length of the paleozoic area in New Jersey. Below Carpentersville no actual outcrop of this quartzite was observed between the fossil locality in the magnesian limestone and the crystalline rocks; it may be present, however, covered with drift. The actual position of the fossil bearing bed at Carpentersville, within the limestone series, was not

* Am. Jour. Sci. (3) vol. XLVI, p. 438.

definitely fixed, although it is probably somewhere in the lower third of the entire series.

If the lower portion of the magnesian limestone series be middle Cambrian, as the fossils seem to indicate, the age of the higher beds still remains to be determined. Lying on top of the magnesian limestones at many localities in New Jersey is a thin bed of highly fossiliferous limestone, free from magnesia, whose age as indicated by the fossils is Trenton. This fixes the age of the uppermost magnesian limestone beds as at least pre-Trenton. This Trenton limestone has usually been considered as directly continuous with the subjacent beds, but there is always present in the basal portion of the formation, where it can be observed, a conglomerate bed in which the pebbles are of the subjacent magnesian limestone and the matrix is the purer Trenton limestone. This conglomerate bed is best exposed east of Branchville, but it was also noticed near Belvidere, near Andover, and near Newton. The presence of this conglomerate bed at the base of the Trenton limestone, indicates that there must have been a time hiatus between the deposition of the magnesian and the Trenton limestones. In order to determine the length of this time interval it will be necessary to secure fossils from the uppermost beds of the magnesian limestone. Until such evidence can be secured, however, considering the fact that the only fossils as yet found in the magnesian limestone are of Cambrian age, it seems best to consider the entire series as Cambrian, allowing the lower Ordovician time to be represented by the time interval which elapsed between the deposition of the magnesian and the Trenton limestones. This interpretation must be held as a tentative one, however, subject to corroboration by the discovery of Cambrian fossils in the upper strata of the magnesian limestone.

Description of Species.

Olenellus thompsoni (Hall)?

(Plate I, Figs. 9-10.)

Head, without the genal spines, subsemicircular in outline. Glabella elongate with subparallel sides, depressed convex,

marked by four pairs of furrows of which the anterior pair is situated about two-fifths the length of the glabella from the anterior end and the others arranged about equidistant from each other, the posterior pair usually the most pronounced. The eye-lobes level with the glabella and separated from it by rather broad furrows, their anterior extremities opposite the anterior pair of glabella furrows. Eyes elongate, reaching nearly to the posterior margin of the head, narrowly crescentic in outline. Cheeks sloping away from the glabella and eyes to the lateral and anterior margins, with a gentle convexity at first, but becoming slightly concave near the margin. The margins bordered by a narrow, scarcely elevated rim. The head alone of this species has been observed in New Jersey.

REMARKS.—For a complete discussion of the members of this genus, with bibliography, reference is made to Walcott's Bulletin No. 30, U. S. Geological Survey, and to the 10th Annual Report of the U. S. Geological Survey.

From the head alone it is difficult to identify the species of this genus with entire certainty, but the New Jersey specimens seem to agree most closely with the typical species of the genus, *Olenellus thompsoni*. All the species of *Olenellus* and the allied genera or subgenera *Holmia* and *Mesonacis*, are remarkable because of the apparent absence of facial sutures upon the dorsal side of the head. This characteristic is well shown in the New Jersey specimens. The heads are either complete as in Fig. 10, with no indication whatever of facial sutures, or if the outer portions of the cheeks are detached they are always broken along irregular lines as in Fig. 9, being very different in this respect from trilobites in general, whose detached cheeks are separated from the cranidium along definite lines. Holmes' study of the Scandinavian species, *O. Holmia kjerulfi*, indicates that that species does possess a true facial suture along the doublure on the ventral side of the head. Beecher* has recently made the character of a marginal or ventral facial suture the chief characteristic of the order Hypoparia in his admirable classification of the trilobites, and *Olenellus* and its allies should, on this basis, be included in this order rather than in the order

*Am. Jour Sci. (3), Vol. III, p 181.

Opisthoparia, in the same family with *Paradoxides*. Walcott* suggests a family separation of *Olenellus* and its allies from *Paradoxides* under the family name Mesonacidiæ, but the separation seems to be of even more than family importance. If the Mesonacidiæ be considered as a family of the Hypoparia they differ conspicuously from other members of that order in the remarkable development of their eyes, but these eyes of *Olenellus*, under this interpretation, cannot be considered as analogous to the eyes of other trilobites, which are always borne upon the free cheeks.

Liostracus? jerseyensis n. sp.

(Plate I, Figs. 1–8.)

Species known by the cranidium and pygidium alone. Cranidium, exclusive of the lateral angular extensions of the posterior margin, and the posterior spine of the occipital ring, longitudinally semi-ellipitical in outline. Glabella large and prominent, longer than wide, sub-quadrangular or sub-elliptical in outline, marked by two pairs of faint furrows, of which the anterior pair are transverse in their direction, each one extending to about one-third the width of the glabella, sometimes nearly or quite obsolete; the posterior pair always present, although sometimes nearly obsolete, arching backwards towards the occipital furrow. Occipital ring separated from the glabella by a deep and rather wide occipital furrow, extended posteriorly in a broadly triangular spine which is slightly attenuate towards the extremity. Fixed cheeks somewhat convex, bending downward to the lateral margins; the anterior margin of the head bending upward and forming a rather conspicuous elevated rim in front. Facial sutures slightly curved inward anteriorly and bending outward posteriorly to the posterior margin, their direction being somewhat sigmoidal. No free cheeks have been recognized and the position of the eyes is not definitely shown on the margin of the fixed cheeks, but they are apparently nearly opposite the anterior furrows of the glabella.

Pygidium small, much broader than long, obtusely subangular at the posterior extremity; axis prominent and strongly convex, consisting of five segments, with indications of a sixth

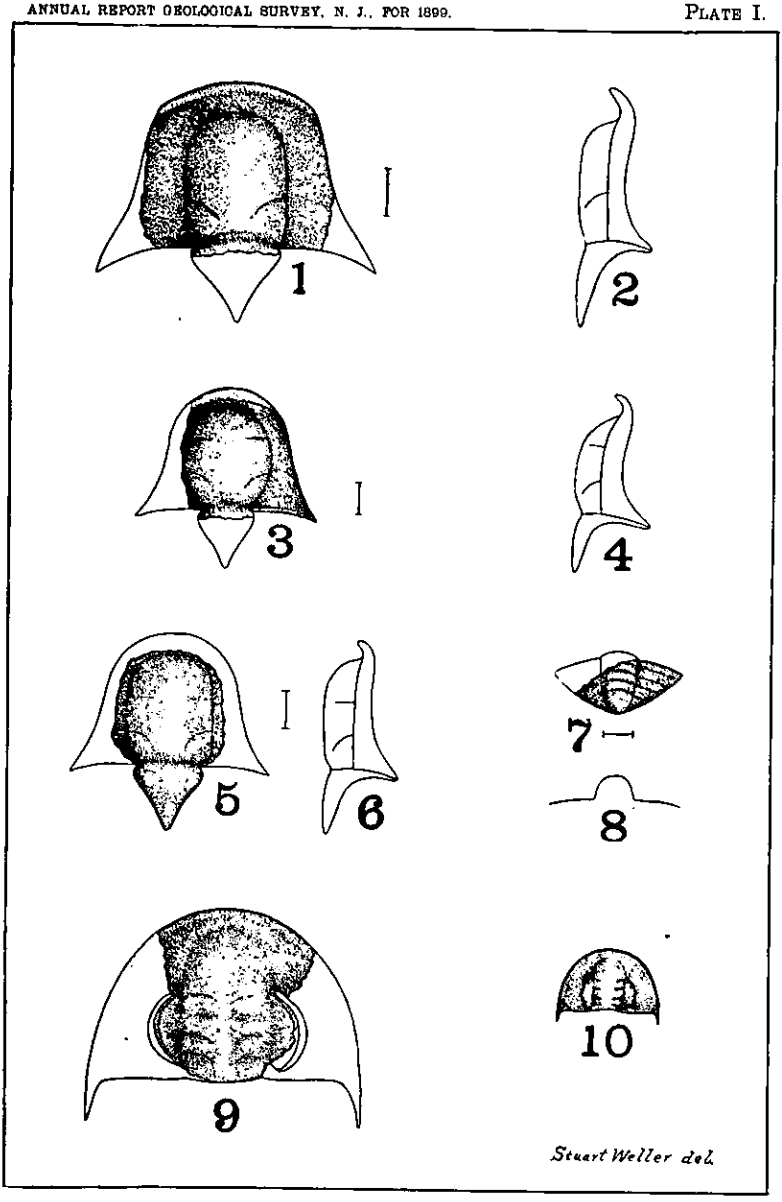
* 10th Ann. Rep. U. S. G. S., p. 635.

one posteriorly, its posterior extremity abruptly rounded and reaching to the posterior margin of the pygidium; pluræ nearly flat, with a slight marginal groove, consisting of five segments.

REMARKS.—The genus *Liostracus* is closely allied to *Ptychoparia*, and has not always been considered as distinct by American paleontologists. In his list of paleozoic fossils Miller* records the following six species of the genus, besides four varieties: *L. aurora* Hartt, *L. linnarsoni* Brög., *L. neglectus* Hartt, *L. onongondianus* Hartt, *L. quadratus* Hartt, and *L. tener* Hartt, all from the Cambrian strata of New Brunswick. Walcott† refers all these species except *linnarsoni*, which he does not notice, to the genus *Ptychoparia*. Matthew,‡ in his studies of the New Brunswick Cambrian faunas, refers *linnarsoni* to *Ptychoparia*, but retains *onongondianus* and *tener* in the genus *Liostracus*, the chief generic characters recognized being the absence of genal spines, the faint glabella furrows, and the small number of segments in the pygidium. If the genus *Liostracus*, based upon the characters enumerated by Matthew, is really valid, then the New Jersey specimens here described should probably be included in it. The presence or absence of genal spines, however, cannot be determined because the free cheeks have not been observed, but the faintness of the glabella furrows is a conspicuous character in all the specimens, and the pygidium contains but few segments.

The specimens referred to this species exhibit considerable variation, especially in the form of the glabella, as is indicated by the accompanying figures, but they do not seem to represent distinct species.

*North Am. Geol. and Pal., p. 535.
†Bull. U. S. Geol. Surv., No. 10.
‡Trans. Roy. Soc. Can., 1887, pp. 133-152.



Cambrian Trilobites.

Explanation of Plate I.

Figs. 1–8. *Liostracus? jerseyensis* n. sp. All enlarged 5 diameters.

Figs. 1–2. Dorsal view and profile in outline, of the largest specimen observed, showing the subquadrangular glabella and the obsolete anterior glabella furrows.

Figs. 3–4. Dorsal view and profile in outline, of a smaller specimen with elliptical glabella and one entire fixed cheek.

Figs. 5–6. Dorsal view and profile in outline, of a specimen retaining the spine of the occipital ring.

Figs. 7–8. Dorsal view and cross-section of a pygidium.

Figs. 9–10. *Olenellus thompsoni* (Hall)? Natural size.

Fig. 9. Imperfect head of the largest individual observed.

Fig. 10. A perfect head of average dimensions.

PART II.

Artesian Wells

By LEWIS WOOLMAN.

Artesian Wells.

OUTLINE.

INTRODUCTION.

I. Wells in Southern New Jersey.

Sec. 1.—Wells in Cretaceous Strata.

At Hancock's Bridge.
At Pennsville. Two wells.
At Perkintown Station. One mile east of.
At Perkintown Station. One and one half miles east of.
At Pedricktown.
At Mickleton. Four miles west of.
At Mickleton. Northeast of.
At Laurel Springs.
At Westville.
At Camden. 17th and Stevens streets.
At Pensauken.
At Colestown.
At Marlton. Northeast of.
At Marlton. Southeast of.
At Milford
At Riverton.
At Burlington. Three wells.
At Smithville.
At Columbus.
At Lakewood. Two wells.
At West Asbury Park.
At Seabright
At Port Monmouth.
At Rumson Bluff.
At Little Silver.
At Babylon, N. Y.
At Woodside, N. Y.
At Kennedyville, Md.
At Centreville, Md.
At Chesapeake Beach, Md.

At Tilghman's Island, Md. } These two wells may draw from horizons
At Taylor's Island, Md. } above the Cretaceous, the one at Taylor's
Island possibly above the Eocene.
At Norfolk, Va. Lambert's Point, north of.
At Norfolk, Va Moore's Bridges, east of.
At Severn River, Va

Sec. 2.—Wells in Miocene Strata.

At Bridgeton.
At Cedarville.
At Greenbank.
At Smith's Landing. County Asylum
At Atlantic City:
At the Traymore.
At the Waldorf-Astoria.
At the Gas Works.
At Ocean City.
At Sea Isle City.
At Mahon River, Del.
At Bowers Beach, Del.
At Madison, Md.
At Delmar, Md.
At Salisbury, Md.
At Pokomoke City, Md. Two records.

Sec. 3.—Wells in Post Miocene, or Surface Strata.

Philadelphia Navy Yard, Pa.
Northfield.
Absecon.
Atlantic City.
Shinnecock Hills, L. I., N. Y.
Sciasconsett, Nantucket Island, Mass.
Laurel, Del.
Seaford, Del.

II. Wells in Northern New Jersey.

Sec. 1.—Bored Wells reported by Stotthoff Bros.

At Huntsville. Two wells.
At Sparta.
At Bernardsville. Three wells.

At Flemington. Two wells.
At Readington.
At Three Bridges.
At Liberty Corners.
At Somerville.
At Goodman's Crossing.
At Maywood. Two wells.
At Trenton.
At Martinsville.
At Union.
At Linden.
At Elizabeth.
At Passaic. Five wells.
At New Dorp, Staten Island, N. Y. Two wells.
At Burdette, N. Y.
At Woodside Long Island N Y.
At Whitestone, Long Island, N. Y.
At Fairfield, Conn.
At Easton, Pa.
At Bethlehem, Pa.
At Rose Glen, Pa.
At Seigfried, Pa.
At Yardley, Pa. Two wells.

Sec. 2.—Bored Wells reported by P. H. & J. Conlan.

At and near Summit. Two locations.
At Newark. Two wells.
At Harrison.
At Kearney.
At West Orange.
At and near Passaic. Five locations
At Pompton.
At Rahway.
At Jersey City.
On Shooter's Island.
In New York City.
At Rockaway, L. I., N. Y.

Sec. 3.—Wells reported by The Joseph Dixon Crucible Co.

At Jersey City. Two wells.

ARTESIAN WELLS.

INTRODUCTION.

We present for this year records and geological data respecting well borings, first in Southern New Jersey and then in Northern New Jersey. With the former we also include some wells at a few points beyond the State, both to the east and to the south. The wells beyond the State are introduced because of the correlation of the beds penetrated by them with the same beds beneath the Southern New Jersey coastal plain.

I. Wells in Southern New Jersey.

The records of wells in Southern New Jersey naturally fall into three heads, under which we treat them in the succeeding pages, viz.:

1. Wells drawing water-supply from Cretaceous strata.
2. Wells drawing water-supply from Miocene strata.
3. Wells drawing water-supply from Post-Miocene or surface strata.

The wells noted to the eastward of the State are on Long Island, with one exception (a well on Nantucket Island), and those to the southward are, with the exception of two wells near Norfolk, Va., on the Delaware–Maryland peninsula, which intervenes between the Delaware and the Chesapeake bays.

The strata penetrated by the wells to the eastward and southward are, in either direction, more or less identical with, and the continuation of, some of the beds on the coastal-plain portion of New Jersey. The data are of value in correlating the various geological subdivisions and their interbedded water-yielding horizons.

Sec. 1.—Wells in Cretaceous Strata.

ARTESIAN WELL AT HANCOCK'S BRIDGE, AT FOGG & HIRES' CANNING FACTORY.

Elevation, 5 (?) feet; diameter, 4½ inches; depth, 58 feet.
Water rises within 5 feet of the surface

Haines Bros. furnish the following record of strata penetrated in a well bored by them at the above location:

Made ground,	5 feet =	5 feet.
Grayish-white sand,	47 " =	52 "
Shells, "6 inches," say,	½ foot.	
Sand,	1½ feet =	54 "
Shells, "10 inches," say,	1 foot =	55 "
Sand, say,	2 feet =	57 "
Shells, "12 inches," say,	1 foot =	58 "

This well was cased to the depth of 52 feet and required no casing below that depth. "An elegant supply of good water" was obtained.

We have included this among Cretaceous wells, but it may possibly draw from a somewhat higher horizon. We are not informed as to the character of the shells noted in the three separate but very close layers near the bottom. If the species were known they would doubtless determine the geological position of the beds.

TWO ARTESIAN WELLS AT PENNSVILLE.

Elevation, 10 feet; diameter of each, 3 inches; depth of each, 33 feet.
Water rises in each well to within 8 feet of the surface.
The water in both wells rises and falls 8 inches with the tides.

At Pennsville, also for Fogg & Hires, Haines Bros. have bored a well to the depth of 33 feet, of which they furnish this record:

Clay,	10 feet =	10 feet.
Grayish sand,	23 " =	33 "

At the same place and for the same firm, Haines Bros. have also bored to the same depth (33 feet) a second well, this time on

land where quite recently the river flowed, that is, since the settlement of the region by the white man. In this well the material is described as "sand all the way down."

In both these wells Haines Bros. note that "the water rises to within eight feet of the surface and also rises and falls *eight* inches with the tides."

These wells are evidently supplied with filtered river water.

ARTESIAN WELL, ONE AND ONE-HALF MILES EAST OF PERKINTOWN STATION, DELAWARE RIVER R. R.

Elevation, 15 (?) feet; diameter, 3 inches; depth, 115 feet.
Water rises to within 14 feet of the surface.

From Haines Bros. we have learned the following respecting a well bored by them for Thomas Berry, on a farm between Auburn and Perkintown Station, the last-named place being on the Delaware River Railroad. The well has a depth of 115 feet and passed through the following strata:

Clay,	8 feet =	8 feet.	?
Marl,	37 " =	45 "	
Black sand mixed with slimy marl,	45 " =	90 "	Matawan
Fine gray sand,	20 " =	110 "	
Coarse sand,	5 " =	115 "	

The water is "clear but irony and there is plenty of it." This well was pumped 1,000 gallons per hour. The supply is probably from the base of the Woodbury–Wenonah water-horizon, as defined in the Annual Report for 1898 and as shown on the Artesian Well Section, Plate III, of that report.

ARTESIAN WELL, ONE MILE EAST OF PERKINTOWN STATION.

Elevation, 10 feet; diameter, 3 inches; depth, 41 feet.
Water rises to within 8 feet of the surface.

Haines Bros. have also drilled a well for George Gaventa about one-half mile west of the last well reported herein, and about one mile east of Perkintown Station. This well was bored to the depth of only 41 feet. Haines Bros. say the material passed through was "pure white sand all the way to the bottom, where

the sand was mixed with coarser sand and gravel," in which some of the pebbles are described as being as large as hens' eggs.

This well furnishes "plenty of clear water" and was tested by pumping 1,200 gallons per hour. The supply may possibly be from the Woodbury-Wenonah water-horizon.

ARTESIAN WELL, THREE-FOURTHS OF A MILE SOUTHEAST OF PEDRICKTOWN.

Elevation, 30 feet; diameter, 2 inches; depth 180 feet.
Water rises to within 30 feet of the surface.

Haines Bros. have furnished the following data, which we copy verbatim, respecting a well bored by them for Ebenezer Sparks at a point about three-fourths of a mile southeast of Pedricktown.

Soil, sand and loam,	2 feet	=	2 feet.	
Blue clay,	4 "	=	6 "	} Age ?
Marl,	39 "	=	45 "	} Matawan.
Iron-stone, 3 inches,				
Gray sand,	8 "	=	53 "	
Sand with white plastic clay,	29 "	=	82 "	} Raritan.
Plastic clay,	20 "	=	102 "	
Sand, water-bearing,	10 "	=	112 "	

The water-supply is just below the base of the clay marl or Matawan division and from the upper part of the plastic clay or Raritan division of the Cretaceous.

Subsequently to the receipt of the above record we have learned that this well was afterward deepened to 180 feet, increasing the amount of water supplied. We are not informed as to character or succession of the material below 112 feet, but the continuation was doubtless within the Raritan beds.

ARTESIAN WELL FOUR MILES WEST OF MICKLETON.

Elevation, 15 (?) feet; diameter, 3 inches; depth, 43 feet
Water rises within 14 feet of the surface.

From Haines Bros. we have obtained the following information respecting a well bored by them for E. G. Miller, on a farm located between Asbury Station and Gibbstown and about four miles west of Mickleton.

Soil,	2 feet	=	2 feet	
Clay,	6 "	=	8 "	
Marl,	12 "	=	20 "	Matawan.
Fine gray sand,	15 "	=	35 "	
Coarse sand,	8 "	=	43 "	

This well was cased to the bottom. The water rises within 14 feet of the surface and is "soft and good." The well was pumped for two days at the rate of 1,200 gallons every hour. The supply is probably drawn from the Woodbury–Wenonah water-horizon.

ARTESIAN WELL, ONE-HALF MILE NORTHEAST OF MICKLETON.

Elevation, 50 feet; diameter, 3 inches; depth, 183 feet
Water rises within 45 feet of the surface.

For Howard Busby, of Philadelphia, Haines Bros. have bored a well, located as noted above, to the depth of 183 feet. Of this they have furnished the following description of strata, which we quote verbatim:

Loam,	3 feet,	=	3 feet.	
Clay,	15 "	=	18 "	
Black marl,	20 "	=	38 "	
Black sand, mixed with slime,	20 "	=	58 "	Matawan
Running marl,	115 "	=	173 "	Clay Marls.
White sand with water,	10 "	=	183 "	

We are informed that "the water rises within 45 feet of the surface," also that it "is soft," and that "there is plenty of it." The source of supply is probably in the Woodbury-Wenonah water-horizon.

ARTESIAN WELL AT LAUREL SPRINGS.

Elevation 80 (?) feet; diameter, 3 inches; depth, 48 feet.
Water rises within 18 feet of the surface.

A well has been put down by A. G. Dunphey for Col. John A. Wiedersheim near Laurel Springs Station, on the Reading Railroad Company's route to Atlantic City.

The well was finished at the depth of 48 feet. The water rises to within about 18 feet of the surface, which has an elevation of about 80 feet.

The water-bearing stratum in which the boring stopped is described as a "pepper-and-salt sand."

ARTESIAN WELL AT WESTVILLE.

Elevation, 14 feet; diameter, 6 inches; depth 241 feet
Water rises within 11 feet of the surface.

In the Annual Report for 1897, page 268, there are noted two wells at this locality, put down to supply the town with water; their depths are respectively 112 and 114 feet. The well now under notice was put down the present year, adjacent to the two former wells, for the supply of the same water-plant, but to a lower horizon.

The former wells (1897) draw from an horizon at the base of the Matawan clay marls; this well draws from a still lower stratum which is quite within the upper portion of the Raritan formation.

Through the courteous co-operation of the American Pipe Co., contractors for the water-plant, and of Jos. W. Pratt, the well-driller, we have been furnished with an unusually liberal supply of the borings, at frequent intervals, from which we compile the following record:

Surface soil,	0 feet to	2 feet	Pensauken.
Coarse yellow gravel with large pebbles,	2 " "	22 "	Pensauken.
Black clay,	22 " "	46 "	Matawan.
Bluish-white coarse gravel,	46 " "	60 "	Matawan.
Mixture of coarse gravel and fine sand, bluish-white in shade,	60 " "	75 "	Matawan.
Mixture of clay, coarse gravel and very large pebbles,	75 " "	113 "	Matawan.
Mixture of fine sand and very coarse gravel, with large pebbles and cobbles, containing a clay streak at 129 feet. *First Water-Horizon*,	113 " "	155 "	Matawan.

Streak of sticky red plastic clay, at . .	155 feet.			Raritan
Mixture of fine sand, coarse gravel, with a little clay, the whole yellowish-white in color, ...	155 feet	to	170 "	
Solid bed of red, sandy, plastic clay, . .	170 "	"	217 "	
Decidedly white, coarse gravel, water-bearing. *Second Water-Horizon*, . .	217 "	"	228 "	
Red clay, ...	228 "	"	231 "	
Sand, ...	231 "	"	241 "	

An abundance of water was had in this lower sand, but it was found impracticable to free it from the red color contributed by the red clay, and the well was therefore not put into use.

ARTESIAN WELL IN CAMDEN AT SEVENTEENTH AND STEVENS STREETS.

Depth, 81 feet.
Water rises to within 3 feet 6 inches of the surface
Was pumped 250 gallons a minute.

Hon. George Pfeiffer, through W. H. Boardman, C. E., furnishes the following record of a well put down by him at the Keystone Morocco Works, at Seventeenth and Stevens streets, East Camden:

Thickness of Strata.		Intervals of Depth.
3 feet.	Surface sand, ...	0 to 3 feet.
4 "	Sand, ...	3 " 7 "
4 "	Coarse sand, ...	7 " 11 "
3 "	" "	11 " 14 "
6 "	Dark "	14 " 20 "
4 "	Coarse, dirty sand, ...	20 " 24 "
3 "	Very coarse sand, ...	24 " 27 "
4 "	" " gravel, ...	27 " 31 "
8 "	Light-yellow clay, ...	31 " 39 "
2 "	Fine clayey sand, ...	39 " 41 "
18 "	Red plastic clay, ...	41 " 59 "
2 "	Red and white clay, ...	59 " 61 "
3 "	Fine sand, ...	61 " 64 "
6 "	Fine white sand, ...	64 " 70 "
3 "	Coarse white sand, ...	70 " 73 "
8 "	Coarse, clean, white sand, ...	73 " 81 "
	Black clay at	81 "

This well was finished with an eighteen-foot strainer, whose base rests at the depth of 81 feet. "The well was pumped 250 gallons a minute on 18-foot draft."

ARTESIAN WELL NEAR PENSAUKEN.

Elevation, 40 feet; diameter, 4 inches; depth, 102 feet.
Water rises within about 41 feet of the surface.

A four-inch artesian well has been put down for John Collins by A. G. Dunphey, near Pensauken station, northeast of Merchantville. The locality has an elevation of about forty feet and the well a depth of 102 feet. The well is nearly on the line of strike (northeast and southwest) with the wells at Jordantown, which supply Merchantville with water and which are about one mile to the northeast. This well and those at Jordantown both draw from the Raritan group of water-horizons, but from higher beds within that formation than are utilized by the wells at Morris Station for the supply of Camden. In the sinking of the wells at Jordantown, two water-horizons were encountered, viz., at 58 to 78 feet, and at 128 to 140 feet, but the upper one was there cased off and only the lower one used. The well at Pensauken, however, was not prospected so far as the lower horizon, but was finished in the upper one.

At the locality of this well, as likewise at the locality of the Jordantown wells, the clay marls are absent, although a short distance to the eastward they overlie the Raritan formation. In both cases the quality of the water is said to be excellent, and is so probably because of this fact. The water obtained from many of the beds within the Matawan clay marls is apt to be "irony", probably from the presence in these clays of iron pyrites. The contamination from this source seems to be sometimes contributed by seepage therefrom into the upper portion of the underlying Raritan beds.

From an excellent series of samples furnished by A. G. Dunphey, and taken every two or three feet as the drilling progressed we are able to report the following record of strata:

Orange-yellow sand, with a streak of iron stone at 8 feet, and a second streak of iron stone at 38 feet,	0 feet	to	38 feet.	Pensauken.
Yellow gravel and sand with large pebbles,	38 "	"	53 "	Raritan.
White gravel, large pebbles,	53 "	"	75 "	
White fine sandy clay,	75 "	"	83 "	
Fine yellowish white *water-bearing* sand,	83 "	"	102 "	

ARTESIAN WELL NEAR COLESTOWN.

Elevation, 40 feet; diameter, 3 inches; depth, 347 feet.
Water rises within 24 feet of the surface.

W. C. Barr has put down a well on the farm of the Sharpless Brothers, near Colestown, of which he has furnished the following record:

Top soil and greenish clay,	6 feet	=	6 feet.		
Greenish-gray quicksand,	12 "	=	18 "		
Black clay,	100 "	=	118 "	Matawan.	Cretaceous.
Green clay,	20 "	=	138 "		
Black clay,	12 "	=	150 "		
Green clay,	10 "	=	160 "		
Water bearing loamy sand,	1 "	=	161 "		
Chocolate clay stratum, 4 inches thick					
White sand and gravel with "irony" water,	130 "	=	291 "		
White clay,	5 "	=	296 "	Raritan.	
Coarse white sand with "irony" water,	10 "	=	306 "		
White clay,	8 "	=	314 "		
Fine white sand,	6 "	=	320 "		
Red clay,	10 "	=	330 "		
Coarse sand with unsatisfactory water,	6 "	=	336 "		
White clay,	2 "	=	338 "		
White sand with wood (lignite),	7 "	=	345 "		
White clay and large boulders,	2 "	=	347 "		

This well has not yet been finished. Excepting the water from the one-foot stratum at 160 feet, which is said to be good, all the water found proves quite "irony" and unsatisfactory.

ARTESIAN WELL, TWO AND ONE-HALF MILES NORTHEAST OF MARLTON.

Elevation, 65 feet; diameter, 3 inches; depth, 69 feet
Water rises within 7 feet of the surface.

A. G. Dunphey has bored a well on the property of Jacob L. Evans, situated on the road from Evesboro to Medford at point about two and one-half miles slightly north of east from Marlton. The well has a depth of 60 feet. It is about one-fourth of a mile northwest of a bored well on the farm of Josiah Ballenger, on ground a few feet higher, and which has a depth of 76 feet, as noted in the Annual Report of 1894, page 210.

From specimens of the borings we make the following record:

Iron rusty, sandy clay, from near the surface to				7 feet.
Greensand marl light green in color, ...	7 feet	to	50	"
Greensand, dark, olive green, ...	50 "	"	54	"
Olive-colored sand, with comminuted shell, ...	54 "	"	58	"
Belemnites at 58 feet.				
Water-bearing sand, ...	58 "	"	60	"

The water rises within seven feet of the surface, the supply coming from the Marlton water-horizon, as designated in former annual reports. This horizon furnishes most of the wells in the region about Marlton. The well for the town supply, however, taps a lower water-bearing bed, viz., the Cropwell horizon, which is about 100 or 110 feet deeper.

ARTESIAN WELL TWO MILES SOUTHEAST OF MARLTON.

Elevation, 65 feet; diameter, 3 inches; depth, 83 feet.
Water rises within 9 feet of the surface.

A. J. Dunphey has put down a well for Joseph K. Evans at a point about two miles southeast of Marlton and about one-half mile south of a well at the residence of the late Benjamin Cooper. The well has a depth of eighty-three feet. This boring was discontinued in sand immediately under a stratum containing *belemnites*, which occurs at and marks the division between the base of the marl series and the top of the Matawan

clay marls. No specimens were preserved, but the record of strata would doubtless be the same as has already been noted in past annual reports for other wells near by.

ARTESIAN WELL AT MILFORD.

Elevation 90 feet; diameter, 3 inches; depth, 58 feet.
Water rises within 6 feet of the surface

A well has been put down for Adam Olt at Milford. From A. G. Dunphey, who bored it, we have received specimens of the borings, from which we make the following record:

Surface soil,	0	feet to	4	feet.
Orange-yellow gravel,	4	"	" 7	"
Fine light yellow sand,	7	"	" 14	"
Dark micaceous clay,	14	"	" 40	"
Olive-colored sand, containing some greensand (glauconite),	40	"	" 50	"
Lime-sand, contains *Bryozoa*, also *Echinus* plates and spines,	50	"	" 56	"
Gray sand, consisting of white quartz and greensand grains resembles a mixture of pepper and salt, *water-bearing*,	56	"	" 58	"

This well is supplied from the Lindenwold water-horizon, which is interbedded within the limestone layers above the middle marl.

ARTESIAN WELL, ONE AND ONE-HALF MILES EAST OF RIVERTON.

Elevation, 80 feet; depth, 117 feet.
Water rises within 69 feet of the surface.

This well was put down by A. G. Dunphey, who furnishes by letter the data tabulated above. He further says the well was finished at the base with a ten-foot strainer and has been pumped 15 gallons a minute without lowering the natural level of the water. He also states that the water was found in a "fine free white gravel and sand mixture."

TWO BORED WELLS AT BURLINGTON FOR H. F. POTTER, TO SUPPLY AN ICE PLANT.

Depths, 58 and 71 feet.

These wells were bored by Stotthoff Bros., who furnish the following record:

Record.	Well No. 1.	Well No. 2.
Earth,	6 feet.	6 feet.
Gray quicksand,	37 "	50 "
Coarse gray sand, with water,	15 "	15 "
	58 "	71 "

Well No. 1 produces 18 gallons a minute, and Well No. 2 60 gallons a minute. These wells are 100 feet apart, but are on ground of the same level.

ARTESIAN BORING AT EAST BURLINGTON.

Elevation, 10 feet; depth, 95 feet.

Hon. George Pfeiffer, contractor, made a well-boring near the railroad station at East Burlington, N. J., the purpose being to find a water-supply for the intended plant of a prospective ice manufacturing company. The well was not completed, however, as the enterprise was abandoned. The following accurate record of strata penetrated, furnished by Wm. H. Boardman, C. E., is interesting and valuable:

Thickness of strata.		Intervals of depths.
6 feet	top soil,	0 to 6 feet.
13 "	clayey gravel,	6 " 19 "
6 "	coarse gravel,	19 " 25 "
7 "	coarse red sand,	25 " 32 "
4 "	fine red sand,	32 " 36 "
14 "	coarse white sand,	36 " 50 "
12 "	fine dark sand,	50 " 62 "
5 "	stiff gray clay,	62 " 67 "
18 "	stiff red clay,	67 " 85 "
5 "	sandy gray clay,	85 " 90 "
4 "	slush gray sand, very little water,	90 " 94 "
1 foot	soft [disintegrated] micaceous rock,	94 " 95 "

ARTESIAN WELL NO. 2, AT SMITHVILLE.

Elevation, 20 feet; diameter, 6 (?) inches; depth, 110 feet.

This is the second well put down at this place for the H. B. Smith Machine Company. The former one was noted in the Annual Report for 1897, page 278. The present well, as also the former one, was drilled by W. C. Barr, who furnishes the subjoined record of this one, which he states differs from the previous well in the occurrence, near the top, of an 8-foot bed of gray sand similar to that of the first water-bearing sand at Marlton, which, indeed, it probably represents, and which had evidently been eroded from the place where the other well was put down, although the wells are probably not more than 100 feet apart. The location of these wells is on the flood plain of Rancocas creek.

Made ground,	10	feet = 10	feet.
Gray sand, same as in the first water-horizon at Marlton	8	" = 18	"
Black clay,	2	" = 20	"
Green quicksand,	35	" = 55	"
Black clay,	55	" = 110	"
Water-bearing sand at		110	"

At the base of this well, as also in the former well, there were found fragments of fossil bone, probably representing some extinct Cretaceous reptile. Some teeth also, probably reptilian, were obtained at the same horizon in the first well.

ARTESIAN WELL AT COLUMBUS.

Elevation, 70 feet; diameter, 4 inches; depth 225 feet.
Water rises to within 60 feet of the surface.

An artesian well with a depth of 225 feet has been put down the past summer at Columbus. The work was done for the Columbus Water Company, by A. G. Dunphey, from whom we have received samples of the borings. From these specimens and from information verbally received from several of the directors, also from Edgar A. Alcott, C. E., and from A. G. Dunphey, we have computed the following record:

Soil,	2 feet,	=	2 feet.	
Orange-yellow sand and gravel,	8 "	=	10 "	
Orange-yellow sand, light in shade,	18 "	=	28 "	
Gray sand,	2 "	=	30 "	Matawan. Cretaceous.
Black clay with coarse sand,	2 "	=	32 "	
Flat stone concretion at			32 "	
Olive-colored sandy clay,	14 "	=	46 "	
Bluish or black clay, Greenish, marly clay, with glauconite,	74	=	120 "	
Bluish clay,	76 "	=	196 "	
Bluish-white sand, with lignite, water-bearing,	29 "	=	225 "	

This well was finished at the bottom with a Cook strainer twenty feet in length. This strainer or sieve consists of a brass tube with fine horizontal slits, about one-fourth of an inch apart, which are arranged around its circumference in parallel perpendicular rows.

The water obtained is described as "clear, cool and quite soft."

The water-horizon is the same as that at the dwelling on the Lorillard stock-farm, east of Jobstown,* at the depth of *356* feet, the elevation there being about 85 feet.

TWO ARTESIAN WELLS AT LAKEWOOD.

No 1.—For the Lakewood Water Company.

Elevation, 30 feet; diameter, 6 inches; depth, 600 feet.
Water rises 20 feet above the surface.
Overflows at the surface 150 gallons a minute.

No. 2.—For the Lakewood Hotel and Land Association.

Elevation, 30 feet; diameter, 6 inches; depth, 600 feet.
Water rises 20 feet above the surface.
Overflows at the surface 100 gallons a minute.

Kisner & Bennett inform us that in November they sank a well at Lakewood for the Lakewood Water Company, the location being "just below the dam and about 150 feet north of the tail-race and 300 feet north of the pumping station." They also state that "the ground is 25 feet lower than the Laurel House and 10 feet below the surface of the lake." The well flowed

* There is at the barn on this stock farm another well to a much deeper horizon, the depth of this water horizon being at about 660 feet, although the boring was prospected to 715 feet.

about 150 gallons a minute, and produced by pumping about 300 gallons a minute. The water rose 20 feet above the surface of the ground and 10 feet above the level of the lake.

Kisner & Bennett also inform us that in December they sank a second well at Lakewood, this time for the Lakewood Hotel and Land Association. This well "is located about 100 feet west of the N. J. S. R. R., under the hill, on the same level as the first well." The flow of this well is not as strong as that of the first well, being but "100 gallons a minute," and "the pumping capacity about 200 gallons."

The succession of strata, and the depths and thickness in each well are the same, and are, as described by Kisner & Bennett, as follows:

Sand and sandy clay,	80 feet =	80 feet.
Marls,	332 " =	412 "
Yellow sand bed,	30 " =	442 "
Muddy sand,	55 " =	497 "
Hard black clay,	40 " =	537 "
Fine white sand with abundance of water,	53 " =	590 "

Both the above wells were finished at the bottom with strainers 60 feet long.

FOUR ARTESIAN WELLS AT WEST ASBURY PARK.

Elevation, 20 feet; diameter of each, 6 inches.
Depth of Well No. 1—508 feet.
Depth of Well No 2—542 feet.
Depth of Well No. 3—558 feet.
Depth of Well No. 4—550 feet ±.

The American Pipe Co. has put down four artesian wells at West Asbury Park. The wells are arranged nearly in a straight line on ground about 20 feet above mean tide, and are about 200 feet apart. The drilling was done by Kisner & Bennett. Through the co-operative courtesy of the officers of the contracting company and of the well-drillers, we have been furnished with data respecting these wells and with one full series of the borings taken every ten feet in depth. The wells are said to yield, by pumping, about 150 gallons each per minute with a 23-inch vacuum.

After inspection of the specimens, both with and without the microscope, we present the subjoined record :

Soil, ...	0	feet to	6	feet.	Miocene.	
Brown clay with *sponge spicules*, . .	6	" "	14	"		
Greensand marl, . . .	14	" "	50	"		Eocene.
Ash marl, ...	50	" "	90	"		
Greensand marl, . . .	90	" "	100	"		
Micaceous sand, . . .	100	" "	150	"		?
Greensand, ...	150	" "	160	"		
Ash marl, ...	160	" "	170	"		
Sand, consisting of greensand grains and white quartz grains mixed, . . .	170	" "	190	"		?
Ash-colored clay, . .	190	" "	210	"	Upper marl bed.	
Sand, consisting of greensand grains and white quartz grains mixed, . . .	210	" "	230	"		
Dark greensand, (glauconite), large *Nodosaria* and other *Foraminifera* throughout, ...	230	" "	260	"		
At 250 feet, *Echinus spines.*						
Greensand similar to next above but slightly darker, . .	260	" "	310	"		Cretaceous.
At 260 and 270 feet, *Echinus spines* and *Bryozoa.*						
Mixture of white quartz sand and greensand grains, .	310	" "	360	"	Middle marl and lower marl beds.	
Echinus spines and comminuted *shell* at 330 feet; also fragments of flat forms of *echinus* at 340 feet.						
White quartz sand with a little greensand	360	" "	400	"		
A little comminuted *shell* at 380 feet.						

Water-bearing at 380 to 400 feet.	Clay marls. Matawan formation	Cretaceous
Micaceous sand with a little greensand, . . 400 feet to 420 feet.		
Nearly pure greensand, glauconite marl, . . 420 " " 430 "		
Dark micaceous sand, with very little greensand, ... 430 " " 450 "		
Darker micaceous sand with much greensand . . . . 450 " " 470 "		
Same shade micaceous sand, with little greensand, ... 470 " " 500 "		
Dark but lighter colored micaceous sand, with very little greensand—water-bearing, ... 500 " " 558 "		

ARTESIAN WELL AT SEABRIGHT.

Elevation, 15 feet; diameter, 6 inches to 344 feet, 4½ inches to 650 feet; total depth 715 feet.
First water-horizon at depths of from 260 to 300 feet.
Second water-horizon at depths of from 350 to 390 feet.
Third water-horizon at depths of from 685 to 715 feet.
Water from the last horizon rises within 5 feet of the surface

This well was put down by Uriah White, and is much deeper than any well, so far as we know, heretofore sunk at this locality. It is on the Rumson road about one mile west of the draw-bridge. The record as furnished is as follows, no specimens having been obtained:

Succession of strata same as in former wells on Rumson Neck already noted in previous annual reports, to the depths of	190 feet to 230 feet.
Dark black mud, from	230 " to 675 "
Clay, 10 feet thick, from	675 " to 685 "
White sand, 30 feet thick, from	685 " to 715 "

A bluish stone was found at the depth of 375 feet, and seashells are said to have occurred more or less throughout the dark black mud.

Numerous wells, many of which have been noted in the annual reports for 1897 and 1898, have been put down in the vicinity of Seabright—reaching two higher water-horizons, the first at depths varying from 260 to 300 feet, and the second also varying from 350 to 390 feet. These are evidently in the upper portion of the clay marls and represent the 525 to 600-foot Asbury Park horizon. The supply of this well, however, is in the lower part of the clay marls, and is probably the equivalent of that at 1,083 feet at Asbury Park. It is also the same horizon as that which supplies wells at Atlantic Highlands, depth 465 feet; at Holmdel, depth 575 feet; at Brookdale, at the depth of 660 to 715 feet, and at Barren Island, N. Y., at the mouth of Jamaica Bay, L. I., at 720 feet.

Wells Reported by Matthews Bros.

The four following wells in Monmouth county, all of which draw from Cretaceous strata, are reported by Matthews Bros., who drilled them:

ARTESIAN WELL AT SEABRIGHT.

Elevation, 6 feet; diameter, 6 inches; depth, 275 feet.
Overflows 15 gallons a minute. Yields, when pumped, 69 gallons per minute.

Matthews Bros. have drilled an artesian well for the Seabright Hygeia Ice Company. The location is in the borough of Seabright, on Church street, about 100 feet from the South Shrewsbury river. The well is 6 inches in diameter, and has a natural flow of fifteen gallons per minute, and yields, when pumped, 69 gallons per minute. The elevation is 6 feet above tide-level.

The strata penetrated are:

White sand,	40 feet =	40 feet.
Marl,	47 " =	87 "
Cemented *shells*,	4 " =	91 "
Gravel,	4 " =	95 "
Dark-colored sand,	74 " =	169 "
White clay,	14 " =	183 "
Marl,	47 " =	230 "
White sand and wood, water-bearing,	45 " =	275 "

ARTESIAN WELL AT PORT MONMOUTH.

Elevation, 8 feet; diameter, 4½ inches; depth, 240 feet.

Matthews Bros. write: "We have sunk an artesian well for the Port Monmouth Steamboat Co. The location is near the steamboat landing, the surface being 8 feet above tide-level. The well is 4½ inches in diameter and yields a supply of 45 gallons per minute. The water is used to supply the boilers and for other uses on the boats."

The strata drilled through were:

Made ground,	6 feet =	6 feet.
Salt meadow,	3 " =	9 "
Yellow sand,	12 " =	21 "
Marl,	29 " =	50 "
Black sand,	47 " =	97 "
White clay,	20 " =	117 "
White sand and wood, water-bearing but salt,	43 " =	160 "
Blue clay,	35 " =	195 "
Gray sand, water bearing,	45 " =	240 "

ARTESIAN WELL ON RUMSON BLUFF.

Elevation, 12 feet; diameter, 3 inches; depth, 282 feet.

Matthews Bros. write that they have put down an artesian well for Dr. Seman. The location is on the Rumson bluff, about ⅛ of a mile west of South Shrewsbury river; the elevation above tide-level is about 12 feet; the water rises to within 3 feet of the surface; the well is 3 inches in diameter.

The strata penetrated were:

Sand,	2 feet =	2 feet.
Clay,	3 " =	5 "
Brown sand,	9 " =	14 "
Black sand,	29 " =	43 "
Marl,	42 " =	85 "
Shells,	5 " =	90 "
Pebbles (colored),	3 " =	93 "
Dark sand,	70 " =	163 "
White clay,	22 " =	185 "
Marl,	39 " =	224 "
White sand,	58 " =	282 "

ARTESIAN WELL AT LITTLE SILVER.

Elevation, 18 feet; diameter, 4½ inches; depth, 280 feet.

Respecting this well, Matthews Bros. write as follows: "We have bored an artesian well for Dean & McMahon. Location about ¼ of a mile south of Little Silver depot. The elevation above tide-level is 18 feet, and the water rises to within 2 feet of the surface.

"The diameter of the well is 4½ inches, and is about 280 feet deep. We are not in possession of the different strata passed through in this well and so cannot send a better report."

[End of Matthews Bros.' records.]

ARTESIAN WELL SOUTH OF BABYLON, L. I., N. Y., ON MUNCIE'S ISLAND, GREAT SOUTH BAY.

Elevation, nearly at tide level; diameter, 3 inches to the depth of 200 feet, and two inches below that; total depth, 270 feet. Continuation of the Matawan-Cretaceous belt eastward beneath the southern border of Long Island.

An artesian well was finished in the spring of 1898 for Dr. C. E. Muncie, at his sanitarium, on a meadow island in the Great South bay, inside of the Great South Beach, about three and one-half miles almost south of Babylon. From E. K. Hutchinson, of Oyster Bay, N. Y., who bored the well, we have received the following record:

Muck and sand, with shells.	0 feet to 10 feet.
Heavy yellow micaceous (?) sand and gravel, with water salt as the ocean and which stood nearly at the surface of the meadow. This stratum is very similar to that obtained from most of the shallow wells on Long Island, ...	10 " " 45 "
Clay and fine sand, like beach sand; sand and clay mixed. The color was blue and gray, ...	45 " " 150 "
Clay sand etc., much like the last only darker, with water which flowed 14 gallons a minute over the top of the casing, which was two feet above the ground. This water was fresh, but was colored black; pumped out much wood [lignite], about three wheelbarrow loads. The pipe seemed to be in wood, ...	150 " " 200 "

Lighter colored sand and clay mixed; amount of lignite gradually decreased. Sand a little heavier at the base, where good water was obtained. Water flowed from 2 inch pipe two feet above the surface 8 gallons a minute, ... 200 feet to 270 feet.

This well probably draws from sands within the clay marls or that division of the Cretaceous known in New Jersey as the Matawan formation, and which has been heretofore demonstrated by wells bored in the vicinity of Jamaica and on Barnum and Barren Islands, to pass northeastward across Raritan bay and to underlie a belt on the southern side of Long Island.

The well on Barren Island at the entrace of Jamaica bay was, however, bored much deeper (depth, 720 feet) and opened an horizon probably also stratigraphically much lower than that of this well south of Babylon. The latter probably draws from an horizon nearly equivalent to that of the wells of the Brooklyn water department in the vicinity of Jamaica, whose depths vary from about 150 feet to nearly 300 feet. The records of these wells are briefly tabulated on pages 162 and 163 of the Annual Report for 1896. In the same annual there is a very full stratigraphical record of the well on Barren Island.

ARTESIAN WELL AT WOODSIDE, L. I., N. Y.

Depth, 227 feet.

Stotthoff Bros. write that late in the year they commenced a boring for the Citizens Water Co., at Woodside, Long Island, N. Y., of which they furnish the record below:

Earth, clay and boulders, ...	38 feet =	38 feet.
Hard clay mixed with sand, ...	60 " =	98 "
Quicksand, ...	20 " =	118 "
Blue clay, ...	20 " =	138 "
Rock "gneiss layer, &c.,"	89 " =	227 "

Of the above section, the beds below 98 feet, and perhaps below 38 feet to the rock at 138 feet, probably represent the eastward continuation of the New Jersey Raritan Cretaceous, which is now known to skirt the northern border of Long Island.

ARTESIAN WELL AT KENNEDYVILLE, MD.

Elevation, 20 feet; depth, 100 feet.

A few years since a well was drilled for the Baltimore and Delaware Bay Railroad at their station at Kennedyville, Md., which place is located slightly east of the 76th parallel of longitude, and about 4½ miles south of the Sassafras river. Thomas B. Harper, the contractor, reports the depth at about 100 feet, and the strata mainly clay till a gravel was reached at the bottom, in which he says there was plenty of water that came within ten feet of the surface.

ARTESIAN WELL AT CENTREVILLE, MARYLAND.

Elevation, 10 feet±; depth as finished, 428 feet. Boring was prospected beyond this to the depth of 665 feet

Water-horizons at 428 feet and 665 feet. Water rises nearly to the surface from both these horizons. The upper one only was, however, utilized.

Lucina crenulata Conrad, at . . . . . 150 feet
Cylichna—sp? at . . . . . 170 "
Terebratula harlani, Morton and Gryphea vesicularis, Lamarck, at 365 "
Exogyra costata, Say., and Pecten—sp? at . . . . . 428 "

Early in the present year J. H. K. Shannahan contracted to sink a well at Centreville, Md., for the supply of the public waterworks plant there. The work was done under the immediate supervision of Norman M. Shannahan, who has courteously furnished some data respecting the borings. A full series of specimens of earths from below the depth of 150 feet has been kindly furnished by the water company's engineer.

This well was finished with a depth of but 428 feet, but was, however, prospected beyond this to the depth of 665 feet, where another water-horizon was found, which, however, was not utilized.

After a careful study of the borings in the light of data furnished by N. M. Shannahan, supplemented by the lithological appearance of the various earths and the evidence presented by the fossils, we present the following record, with our geological interpretation upon the right:

	Thickness.	Total Depths.		
Made ground, ...	8 feet =	8 feet,	Recent.	
Marsh mud, ...	17 " =	25 "		
Green clay, not very hard, . . .	81 " =	106 "		
Material described by the well driller as "a kind of gunpowder stuff." Specimens at 150 and 170 feet were a micaceous, sandy clay, both containing Foraminifera. The mollusk, *Cardita ? granulata*, Say, occurred at 150 feet, also a *Cylichna* —— sp.? at 170 feet,	64 " =	170 "	Miocene.	
Olive-yellow, coarse sand, consisting of a mixture of greensand and white quartz grains, somewhat finer at the base, .	60 " =	230 "	Eocene, = 186 feet.	
Nearly pure greensand (Glauconite). A few white quartz sand grains, ...	10 " =	240 "		
Olive-colored sand, same shade, composition and texture as at 170 to 230 feet, . . .	40 " =	280 "		
Very decidedly darker olive-colored mixture of greensand and yellow quartz sand grains, ...	76 " =	356 "		
Gray sand, ...	4 " =	360 "	Rancocas.	Cretaceous.
Stony lime sand (concretions), consisting of greensand and yellow quartz sand cemented with a whitish material, .	5 " =	365 "		
Terebratula harlani, Morton and *Gryphea vesicularis* Lamark, in a stratum, say, ...	5 " =	370 "		
Mixture of greensand and yellow quartz sand, contains *Nodosaria* and other *Foraminifera*, varying from fine to coarse sands and from quite light to medium dark olive color. At 428½ there was brought up an *Exogyra* and a *Pecten*, ...	60 " =	430 "		

Reddish mixture of greensand and reddish-yellow quartz sand,	30 feet = 460 feet.	Matawan.	Cretaceous.
Very dark olive-colored mixture of clay, greensand and olive-colored quartz sand,	20 " = 480 "		
Light olive-yellow mixture of greensand and yellow quartz sand,	10 " = 490 "		
"Light clay, 490 to 530 feet,"	40 " = 530 "		
"Greenish clay, 530 to 650 feet,"	120 " = 650 "		
Light sand with water that stood 3 feet below the surface,	5 " = 655 "		

A well has recently been put down at Chesapeake Beach on the opposite side of the Chesapeake bay, through beds which we correlate with those penetrated by this well. For such correlation and for remarks upon the dip of the beds, read the succeeding record.

ARTESIAN WELL AT CHESAPEAKE BEACH, MARYLAND.

Elevation, 10 feet+; depth, 295 feet

A well has been recently put down at Chesapeake Beach, a new pleasure resort on the western shore of Chesapeake bay, nearly four miles south of Herring bay. The locality is the terminus of the recently constructed Chesapeake Beach Railroad, whose line runs nearly southeastward from Washington, D. C.

From Dr. W. B. Clark, who informed us of this well, we learn that it has a depth of 295 feet, the first 60 feet being in Miocene, the remaining 235 feet being mainly Eocene.

The writer's study of wells in this region in which he has been aided by some vertical sections prepared by him from various data in hand, inclines him to the view that the following is probably the correct correlation of the strata in this well and in the one of the preceding record at Centreville, this well being say eight or ten miles further up the slope of the beds. Total depths from the surface are given:

	Chesapeake Beach.	Centreville.
Miocene from near the surface to, ...	60 feet.	170 feet.
Eocene to, ...	250 "	356 "
The Rancocas division of the Cretaceous here intervenes.		
Water bearing horizon, at	295 "	428 "

The writer's section indicates the dip of the Miocene beds to be 10 to 12 feet per mile, towards the ocean, and the dip of the Cretaceous bed to be about 25 feet per mile in the same direction.

ARTESIAN WELLS ON TILGHMAN'S ISLAND, MD.

Depths, 370 to 420 feet.
Water rises 12 feet above tide.

I. A. Harrison, of Tilghman, Md., reports having sunk a number of wells on Tilghman's Island, on the eastern side of Chesapeake bay and north of the mouth of the Choptank river. He says "the depths of these wells vary from 370 to 420 feet, according to the location" of each, and that "the dip is about 30 feet per mile to the southeast." He also says the strata in all the wells are very much alike, and describes the general section as follows:

Clay or sand of a greenish color, ... to 150 feet.
Three or four thin "pans" of rock imbedded in black sand.
Continuation of black sand and clay, ... to 370 and 420 feet.
"The water-bearing sand at the base is a thick black sand, very coarse, interspersed with a shelly formation, the whole seeming like soft sandstone."

In all the wells this basal sand produces an abundance of water, which has been noticed to rise 12 feet above tide-level at the south end of the island.

ARTESIAN WELLS ON TAYLOR'S ISLAND, MD.

No 1.—Elevation, 5 feet? depth, 155 feet.
No. 2.—Elevation, 5 feet? depth, 390 feet.
Water from No. 2 rises within 2 feet of the surface.

Hon. Levi D. Travers some years since furnished us with data respecting two wells on Taylor's Island, Maryland, on the eastern side of Chesapeake bay.

No. 1, the more shallow well (depth 155 feet), he says is on his brother's place, near the river, while No. 2 (depth 390 feet) is on his own property, one mile from the former, and in the middle of the island, the whole of which is elevated only a few feet above tide.

Of his own well he makes the following statement: "Within the first thirty feet water was abundant but brackish, and between 20 and 30 feet was strongly impregnated with iron. Scarcely any water was found between 30 and 250 feet, and only four gallons a minute at that depth. Between 250 and 390 there was no increase of the flow of water."

He also furnishes the following stratigraphical data for this well:

Quicksand,	8	feet to	30	feet.
No record,	30	" "	40	"
Whitish sand,	40	" "	50	"
Gravel, marl, clay and sand mixed,	50	" "	100	"
Some gravel, clay and greenish sand,	100	" "	150	"
White sand. *Water-horizon* of well No. 1,	150	" "	155	"
Gravel, clay and sand similar to that at 100 to 150 feet,	155	" "	200	"
Clay and sand, without marl, principally black and brown sands,	200	" "	245	"
White sand with *water*,	245	" "	270	"
Clay and sand without marl, principally black and brown sand,	270	" "	390	"

At the depth last named, on "what is called black sand," further boring of No. 2 was abandoned. The water-supply probably comes from the white sand at 245 to 270 feet.

Leach Brothers, who drilled this well, describe the beds between 50 and 150 feet as mainly "blue clay," and the material entered at 270 feet as "hard clay."

ARTESIAN WELL ON THE SEVERN RIVER, GLOUCESTER COUNTY, VA.

Elevation, 5 feet; diameter, 6 inches; depth, 716 feet.
Overflows at one foot above the surface, 50 gallons a minute.
Overflows at 23 feet above the surface, 7 gallons a minute.
Terebratula harlani, Morton, at about 570 feet.

In 1898 a six-inch well was put down in Gloucester county, Va., on the Severn river, an estuary of Mobjack bay, which is itself an indentation on the western shore of the Chesapeake, north of the mouth of the York river. The well was bored for Alfred W. Withers, of Roanes, Va., who has furnished the data tabulated above, and who further states that *shells* were found at different depths, and that deep strata of blue clay and fine packed sand were penetrated, and also that water was found at various other depths than that above noted, which in some cases would rise within a few feet of the surface and afford a considerable quantity for pumping purposes, while at other depths it would flow small, thin streams, not enough to be of any practical use.

From A. W. Withers, and also from A. P. Sharp, a chemist to whom a sample of the water from the stratum at the base of this well was sent, we learn that the water is quite strongly charged with mineral matter, consisting in part at least of "chlorides of soda, potash, lime and magnesia."

N. H. Darton, of the U. S. Geological Survey, has also submitted to the writer specimens of fossil mollusks believed by him, from information he has received, to have come from the depth of 560 to 573 feet. Among these mollusks are numerous shells of a brachiopod, *Terebratula harlani*, Morton.

There are also two other bivalves represented, neither of which we are able certainly to identify. One of these is a cast that somewhat resembles a *Calista*, but that this is the correct genus we cannot be positive. The other is represented by a number of shell fragments of a *Pecten*, the specific form of which we are as yet unable to determine.

Respecting the occurrence of *Terebratula harlani*, Morton, southward from New Jersey, the writer would state that he has so far had this fossil placed in his hand from well-borings at

Centreville, Md., depth 365 feet; from Fairport, Va., depth 640 feet; from this locality, depth 560 to 573 feet; and from a well at the Hotel Chamberlin, at Old Point Comfort, Va., depth said to be 840 feet, though it is possible that at the latter place its true position was somewhat higher.

At all the localities, except Fairport,* this *Terebratula* was associated, in the specimens received, with a conglomerate of greensand grains and quartz sand grains cemented together; the color, however, of the conglomerate varied at the several localities. We are inclined to consider that this conglomerate represents the limesand layer that occurs above the *Terebratula* horizon of the Middle Marl bed in New Jersey.

ARTESIAN WELL, NEAR NORFOLK, VA., AT LAMBERT'S POINT.

Elevation, 10 feet; { Diameter, 8 inches to 400 feet; / Diameter, 7 inches to 616 feet; } Depth 616 feet.

Water flows 65 gallons a minute from the top of the casing, seven feet above the surface.

Upper two-thirds mainly through the Miocene.

Lower one-third through the Ripley or Matawan Cretaceous.

Ripley—Matawan fossils.

Dip of Miocene beds about 14 feet per mile.

Dip of Cretaceous beds about 30 feet per mile.

About the year 1890 an artesian well was sunk for the use of the Norfolk and Western R. R. Co. at Lambert's Point, some two miles northwest of Norfolk, Va. The well draws its supply from a fine sand, "apparently silica and mica," between the depths of 610 and 616 feet. The quality of the water is not, however, entirely satisfactory, being somewhat saline. It is, however, used by the workmen in preference to other water obtainable at the locality. We are informed that "sixty-five (65) gallons a minute is discharged (by overflow) seven feet above the ground," and that the "temperature of the water is 70 degrees Fahrenheit."

From Charles S. Churchill, the company's engineer for maintenance of way, the writer, early in 1891, received small portions of the borings from various depths, representing, however, nearly a full series. This series is a duplicate of a somewhat larger one retained at that time in the office of the company.

* The conglomerate may or may not exist at Fairport, but if so, no specimens of the rock were sent us.

Either this retained series or another duplicate one has since then been placed in the hands of N. H. Darton, of the U. S. Geological Survey, who has noted the occurrence in the lower strata near the base of the well of Ripley Cretaceous fossils.* These we will again refer to in this record, corroborating his observations as to their age by additional ones of our own.

Below we separately present for each stratum a triple record. The first is that made by N. H. Darton,† from an examination of the borings submitted to him. We have added thereto his initials, N. H. D.

The second is that of George S. Churchill, the company's engineer. We also add thereto his initials, G. S. C.‡

The third consists of notes and comments by the present writer, and are the results of a study of the borings in his possession. Mention is made therein of fossils, both microscopic and macroscopic.

A bed of clay sparingly diatomaceous occurs at a depth of 17 to 44 feet, containing mixed marine and fresh-water forms of both Pleistocene and Miocene species. This bed we correlate in age with a similar bed that occurs at Moore's Bridges between the depths of 21 and 65 feet. (See last paragraph, page 98.)

The specimens from the central or lower portion of the borings fail to reveal the occurrence of the great Miocene diatom bed that exists in the deep wells at Norfolk and Old Point Comfort.

It is interesting to note in the basal beds penetrated by this well certain Ripley or Matawan Cretaceous marine fossils, as noted in the succeeding record.

The writer has made a very careful comparison, stratum for stratum, of this well and of one at Moore's Bridges, six and one-half miles east, to the depth in the latter of 815 feet, and finds that the beds of the upper two-thirds or thereabouts on both wells are Miocene and Eocene,§ excepting the first 50 or perhaps 65 feet, which in both cases probably represents quite recent Pleistocene. The lower one-third or less in both wells is of Ripley or Matawan Cretaceous age. The dip of the Miocene beds near their base he finds to be about 14 feet to the mile, and of the Cretaceous

* Bulletin Geol. Soc. of America, 1898, Vol. IX, page 414 to 416.

† Bulletin No. 152 U. S. Geol. Survey, 1896, page 172.

‡ This we copy verbatim from a record furnished by G. S. Churchill to the present writer in 1891.

§ The Eocene, however, compared with the Miocene, is relatively quite thin in these two well-sections.

beds beneath to be about 30 feet per mile, the dip being eastward. In the succeeding record of the Norfolk waterworks deep well (1,760 feet), at Moore's Bridges, we note more particularly the correlation of the strata and of their contained fossils.

The clays in the well-borings at the base of the Miocene and occupying the interval between the depth of 475 and 625 feet (including the great Miocene diatom bed at 580 to 625 feet) seem not to occur at all in this well, thus evidencing considerable unconformity between the Cretaceous and the overlying post-Cretaceous beds.

The water-bearing horizon is probably the equivalent of that the depth of 805 to 810 feet at Moore's Bridges (see page 92), and at the depth of 562 feet at Money Point,* on the southern branch of the Elizabeth river, five miles south of Norfolk.

The writer deems it very probable that the same Cretaceous beds that occur at the base of this well were entered by a boring made many years since at Newport News† to the depth of about 600 feet.

"Beach sand, shell fragments" (N. H. D.). "Clean sand" (G. S. C.). Sand slightly yellowish, shell fragments, *Turritella* —— Sp.? &c.	Surface to 17 feet.
"Bluish clay, shell fragments" (N. H. D.). "Stiff blue mud" (G. S. C.). *Diatoms, sponge spicules* and broken *shell.*	17 feet to 44 feet.
"Gray micaceous sand fine; *shell* fragments" (N. H. D.). "Fine gray sand" (G. S. C). Contains *foraminifera* and *echinus spines.*	44 " " 183 "
"Greenish gray sandy clay" (N. H. D.). "Sand mixed with blue mud" (G. S. C.). Contains *sponge spicules* some of them pin-head forms.	183 " " 191 "
"Gray micaceous sands" (N. H. D.). "Fine sand mixed with some mud" (G. S. C.). No organisms observed in this.	191 " " 233 "

*Artesian Wells, &c., N. H. D. Darton.
Bulletin 138, U. S. Geol. Survey, pages 166, 173, 183 and 188.
†Same Bulletin, pages 166 and 173.

"Fine sand and clay, greenish gray, tough when dry, shell fragments, *Pecten, Venus*" (N. H. D.). "Cemented mixed mud sand and *shells*" (G. S. C.). Clay with comminuted *shell* exactly identical in all respects with clay and small broken shell from Norfolk water-works well at the depth of 325 feet.	233 feet to 264 feet.
"Gray clay" (N. H. D.). "Stiff blue mud" (G. S. C.). Contains *sponge spicules*.	264 " " 286 "
"Fine gray sand, shell fragments" (N. H. D.). "Mixed fine gray sand and blue mud" (G. S. C.). Contains greensand grains or glauconite.	286 " " 355 "
"Gray clay" (N. H. D.) "Cemented blue mud" (C. S. C.).	355 " " 377 "
"Fine gray sand, shell fragments" (N. H. D.) "Fine sand and mud" (G. S. C.). Contains *echinus spines*, *sponge spicules* and fragments of *mollusks*.	377 " " 397 "
"Dark gray clay" (N. H. D.). "Cemented blue mud" (G. S. C.). No specimen received by the writer.	397 " " 407 "
"Gray sand, moderately coarse; some glauconite' (N. H. D.). "Fine dark-gray sand, consisting of a large amount of white particles mixed with black particles" (G. S. C.). The "white particles" are the shells of *foraminifera*, the "black particles" are glauconitic greensand. This stratum also contains *echinus spines*.	407 " " 526 "
"Small gravel, *shell* fragments" (N. H. D.). "Very coarse, clean sand mixed with pieces of *shells*" (G. S. C.).	526 " " 534 "
"Rock (no sample)" (N. H. D.). "Half formed stone made of blue mud, sand and shells" (G. S. C.). Rock, two specimens furnished the writer, one of them a fine stone without fossils, the other consists largely of very small fragments of mollusks unidentifiable.	534 " " 540 "
"Gray clay" (N. H. D.). "Cemented blue mud" (G. S. C.). Clay contains *foraminifera*.	540 " " 563 "

"Rock stratum ; *shell* fragments" (N. H. D.). "Same material as 534 feet to 540 feet" (G. S. C.). Rock stratum. Specimens received contain casts of what C. W. Johnson refers to a young *Axinea* —— Sp.? and also one individual form which he identifies as probably *Gouldia decemnaria* Conrad. There was also a single quite perfect flat valve of *Gryphea vesicularis*, Lamarck. This was received separate, however, from the rock matrix N. H. Darton reports *Exogyra* from the depth of 563 feet.*	563 feet to 564 feet.
"Gray clay" (N. H. D.) "Half formed stone made of compressed blue mud ; stone cuts like chalk" (G. S. C.). Dark, hard, fine micaceous sandy clay, well laminated ; *does* "cut like chalk."	564 " " 568 "
"Rocky strata, with thin layers of clay and shell fragments" (N. H. D.). "Same material as between 534 and 540 feet interspersed with thin layers of clay" (G. S. C.). No specimen furnished the writer. This is probably the stratum from which T. W. Stanton determined the following Marine Ripley Cretaceous fossils as noted by N. H. Darton :* "Astarte octolirata, Gabb. Ostrea plumosa, Morton. Gryphea vesicularis. Liopistha (Cymella) bella, Conrad Corbula Sp. Modiola, Sp. Baculite?"	568 " " 603 "
"Small gravel in coarse sand ; *shell* fragments, water" (N. H. D.). "Medium coarse sand with broken *shells*" (G. S. C.). The writer's specimen agrees with both the above descriptions. The *shell* fragments are not identifiable.	603 " " 606 "
"Rocky stratum" (N H. D.). Same as between 534 and 540 feet (G S C). The writer's specimens show comminuted shell, one individual form being an *Exogyra*, a genus also noted at this depth by N. H. Darton.*	606 " " 610 "

* Bulletin Geol. Soc. of America, 1896, Vol. IX, page 415.

"Gray sand; moderately coarse; micaceous; *oyster shell*" (N. H. D.). "*Water-bearing* stratum of fine sand (silica and mica apparently)" (G. S. C.). Fine siliceous gray sand with considerable mica, closely similar to a specimen the writer has from the depth of 805 feet, at Moore's Bridges Norfolk water-works, six and one-half miles eastward and which was there also water-bearing.	610 feet to 616 feet.

ARTESIAN WELL NEAR NORFOLK, VA., AT MOORE'S BRIDGES. BORED FOR THE NORFOLK CITY WATER DEPARTMENT.

Elevation, 10 feet; depth, 1,760 feet.
Diameter, 12 inches to 780 feet
Diameter, 10 inches to 1,210 feet.
Diameter, 8 inches to 1,539 feet.
Diameter, 6 inches to 1,708 feet.
Diameter, 4½ inches to 1,760 feet.

Water flowed over the surface at the following depths:*

At 738 feet 10 gallons a minute; salt, 112 grains per gallon.
The interval between 738 to 775 feet is described as containing water its entire depth.
At 785 feet 35 gallons a minute. Salt, 125 grains per gallon.
At 805 feet to 810 feet 25 gallons a minute. Saline.
At 950 feet 75 gallons per minute. Slightly salt.
At 975 feet to 980 feet 10 gallons per minute. Slightly salt.
At 985 feet 15 gallons per minute. Slightly salt.
At 1,038 feet 25 gallons per minute. Salt, 159 grains per gallon.
At 1,072 feet 150 gallons per minute. Salt, 164 grains per gallon.
At 1,190 feet 350,000 gallons per 24 hours. Fresh at first but afterwards became salty.
At 1,255 feet to 1,300 feet, some water.
At 1,480 feet good flow of very salt water.
At 1,510 feet to 1,517 feet salt water overflowed
At 1,535 feet salt water overflowed.
At 1,742 to 1,760 feet, or immediately below, there was evidently a water-yielding horizon, as indicated by the sand rising up in, and choking the casing, doubtless caused by strong pressure of water rising and carrying the sand with it.

* In a well drilled some years previously, on the same premises, to the depth of 730 feet, water was obtained that flows over the surface. This must be the same horizon now noted at 738 feet. The water from the former well, we have been informed, "has 262 parts per 100,000 of mineral matter—192 common salts, 52 soda, 7 lime and some magnesia, also 3 of a part of free ammonia."

Beds of diatoms and sponge spicules occur at the following depths:

Bed No. 1, Diatoms at	25 feet to	65 feet.	} Late Pleistocene.		
Bed No. 2, { Sponge spicules at . . .	355 "	" 580 "	} Miocene.		
{ Diatoms at	580 "	" 625 "			
Bed No. 3, Diatoms at	665 "	" 685 "			

Dip of Miocene strata about 14 feet per mile.
Dip of Cretaceous strata about 30 feet per mile

During the years 1896-97-98 a deep artesian boring was made at Norfolk, Va., for the water department of that city. The well is located at Moore's Bridges, five miles eastward from the city. Through the courtesy of the contractor, C. L. Parker, of Ithaca, N. Y., and of George W. Wright, chief engineer of the water department, both of whom have an appreciation of geological science, we have been furnished with specimens of the borings, taken every ten feet from the depth of 25 feet downward, and also with records of strata and other information. The boring was made by the use of the drill and sand bucket, a process which furnishes unusually good specimens for geological study, much better, in fact, than the various hydraulic or jetting methods that are often employed in drilling through soft beds such as were penetrated by this well. The diameter of the boring at the commencement was 12 inches; this was successively reduced to 10, 8, 6 and 4½ inches at the depths noted in the above outline.

The various depths to water, its quality and the amount of flow in each instance, are as tabulated at the head of this record. The strong flow of 75 gallons per minute at 950 feet, doubtless represents the horizon, the top of which was met with at the depth of 920 feet at "The Chamberlin," at Old Point Comfort,* eleven miles nearly due north of the locality of this well.

From a careful study of the samples of earths and of the contained fossils, both macroscopic (*shells*) and microscopic (*sponge spicules*, *diatoms* and *foraminifera* and *coccoliths*), supplemented by information contained in various letters from G. W. Wright and C. L. Parker, the author is enabled to present the subjoined detailed record:

* Consult record of the well at Old Point Comfort, Ann. Rept. Geol. Survey, N. J., 1898, pages 122 to 126.

Usual surface sand, to . . . . . 18 feet.
Sand, water-bearing, ... 18 " to 21 feet.
Bluish clay, with *fossil diatoms* and numerous *sponge spicules* of recent geological age; also one specimen of a small *Mactra*, ... 21 " " 65 "
Bluish clay, without diatoms, ... 65 " " 85 "
Small streak of gravel, at 80 feet.
Clayey sand and gravel, ... 85 " " 105 "
Pecten Madisonius Say, at 105 feet.
Clayey sand with some rather large white quartz pebbles small *echinus spines*, ... 105 " " 115 "
Clayey sand, ... 115 " " 125 "
*Rangia** *cuneata* Gray (= *Rangia clathrodonta* Conrad) at 125 feet.
Clayey sand, with comminuted shell but no micro-organisms, ... 125 " " 165 "
Fine bluish clay, no micro-organisms, *Pecten Clintonius* Morton, at 185 feet, ... 165 " " 250 "
Clay, with much sand, described as consisting of "10 feet of shells, each shell being about five inches in length, the boring for 10 to 20 feet would not stand up to drill through. The shells fell in and had to be cased off." . . . . . 250 " " 260 "
Sandy clay, decidedly darker than at 165 to 250 feet and of a somewhat greenish cast, no micro-organisms, ... 260 " " 285 "
Twenty feet of soft clay, which "ran up into the well for 20 feet or so till cased off by the pipe," . . . . 285 " " 305 "
Clay, ... 305 " " 310 "
Ten feet of very sandy clay that "would cave in and had to be cased off, as at 285 to 305 feet," . . . . . 310 " " 320 "
Sandy clay, no micro-organisms, ... 320 " " 355 "
Note—No micro-organisms in any of the above beds from 260 to 355 feet.
Sandy clay, with a few *sponge spicules*, ... 355 " " 375 "
Fine clay, less sandy, *sponge spicules*, plentiful throughout, ... 375 " " 445 "
Fine clay, *sponge spicules*, but less plentiful Some comminuted *shell* at 405 to 475 feet, ... 445 " " 485 "
Fine clay, with only a few *sponge spicules*, ... 485 " " 505 "
Fine clay, no micro-organisms, ... 505 " " 555 "
Fine clay, with small microscopic black objects, either discs or globules, nature not understood, ... 555 " " 580 "

* The genus Rangia was formerly known as Gnathodon, a name that is now relegated to the synonymy, because pre-occupied in another group of the animal kingdom.

Fine clay, slightly lighter in color, described by the well driller as "brown mud," contains *marine diatoms* throughout: also *sponge spicules* and *foraminifera*, ... 580 feet to 605 feet.

Fine clay, similar to next above, also contains *diatoms*, *sponge spicules* and *foraminifera*, but with the addition of *coccoliths*, ... 605 " " 625 "

Greensand marl (glauconite) mixed with white quartz sand and an abundance of the white shells of *Textularia* and other *foraminifera*, ... 625 " " 635 "

Dark greenish clay with *foraminifera*, ... 635 " " 665 "

Sticky, hard clay, with *coccoliths* and *foraminifera*, also a few *diatoms*, ... 665 " " 685 "

Similar clay, with *foraminifera* and greensand or glauconite grains but no diatoms, described by the driller as "sand gravel and marl," . . . . . 685 " " 705 "

"Sticky bed" of lighter colored fine clay, with *foraminifera*, ... 705 " " 728 "

Specimen from 715 feet showed much comminuted shell, some of the fragments consisting apparently of fine laminæ with an irridescent nacreous lustre.

Sand seam, a small flow of *water, with 112 grains of salt per gallon* . . . . . 728 " " 730 "

Soft clay more sandy, with much comminuted *shell*, . 730 " " 735 "

Seam of small gravel, ... 735 " " 745 "

Water flowed at 738 feet, salty.

Very sandy greenish clay, ... }
Water at 740 to 750 feet, ... } 745 " " 765 "
Comminuted shell at 755 to 765 feet; also one lower valve of an *Exogyra*. }

Gray sand, with a little glauconite, flow of water at 780 to 783 feet, ... 765 " " 783 "

All the sands between 750 and 783 feet are said to "have run into the well." This indicates an *abundance of water between these depths*.

Both upper and lower valves of several individuals of the two following mollusks were received labeled "from above 780 feet," to wit numbers of specimens of a small young *Exogyra*, surface of the lower or convex valve mostly smooth; a few, however, showed faint costæ, as in E. costata, Say; the upper or flat valves are rugose.

And small or young forms of *Gryphea vesicularis* Lamarck.

"White sticky clay." No specimen,	783	feet to	785	feet.
Gray quartzose sand without any greensand, at times clayey, contains *water at 786 to 805 feet*, which flowed over the surface 35 gallons a minute; *slightly salt, 125 grains per gallon*,	785	" "	815	"
Decidedly darker gray sand, also without greensand,	815	" "	835	"
Lighter colored sand,	835	" "	870	"
Gray very sandy clay,	870	" "	890	"
"Black sticky mud," so described, but of this no specimen was received,	890	" "	898	"
Clayey sands or alternations of sands and clays,	898	" "	991	"
Lignite at 925 and 965 feet. *Water* flowed over the surface at 950 feet 75 gallons per minute, *slightly salt*. *Water* also flowed over the surface at 975 to 980 feet 10 gallons per minute *slightly* salt, and at 985 feet 15 gallons a minute, also *slightly salt*.				
Slightly yellowish sandy clay,	991	" "	1,033	"
Gray sands, water-bearing,	1,033	" "	1,078	"
Water flowed over the surface at 1,038 feet 25 gallons a minute, *salty*. Pebbles at 1,060 and 1,070 feet. *Water* again flowed over the surface at 1,072 feet, 150 gallons a minute; *salt, 160 grains* per gallon.				
Gray sands and clayey sands,	1,078	" "	1,120	"
Darker sandy clays, texture fine to coarse, contain no micro-organisms,	1,120	" "	1,160	"
Heavy pebbles at 1,130 feet.				
Coarse gray sand,	1,160	" "	1,190	"
Lignite at 1,160 feet. Heavy pebbles at 1,190 feet from which *water* rose to the surface but, it is said, did not overflow. Quantity, 350,000 gallons per 24 hours fresh at first, afterwards became *salty*.				
Reddish and reddish-yellow clays and clayey sands. Heavy pebbles at 1,210 feet,	1,190	" "	1,230	"
Dark fine clay, described by the driller as "black marl," but it is not a greensand marl,	1,230	" "	1,255	"
Sand, slightly yellowish-olive in color, yielded "some water,"	1,255	" "	1,290	"
"White marl," (?) so described. No specimen received,	1,290	" "	1,295	"

Reddish and yellowish clays and sandy clays described as "red marl," though not a glauconite marl. . . . . 1,295 feet to 1,330 feet.

G. W. Wright states that at 1 320 feet he obtained "a fossil shell with a peculiar curl to it [an *Exogyra*]. and had sent it to Prof. Darton, who, he further states, "was surprised at its occurrence at this point," a surprise in which the present writer also shares.

Alternations of sands and clayey sands varying from whitish to yellowish in color . . . . . 1 330 " " 1,580 "

Heavy pebbles at 1,470 to 1,480 at 1,540 and 1,570 feet.

The following clay seams, of which no specimens were received, were described by the well-driller for this interval, viz.:

Clay seam, 1 356 to 1,358 feet.
"Blue marl," (?) 1,400 to 1,410 feet.
"Black marl," (?) 1,557 to 1,560 "
"Blue marl, (?) 1,568 to 1,571 "

The water-bearing horizons were as follows: "Good flow, *very salt water*. at 1,480 feet." Flow of *salt water* at 1,510 to 1,517 feet, and also at 1,535 feet.

Dark clay, slightly variegated, ... 1,580 " " 1,600 "

Yellowish or slightly reddish-yellow coarse sands and clayey sands, ... 1,600 " " 1,680 "

The following, of which no specimens were received, except one at 1,680 feet, were described by the well driller:

Blue (marl ?), 1,640 to 1,647 feet.
Blue (marl ?), 1,650 to 1,654 "
Blue (marl ?), 1,677 to 1,680 "

The specimen at 1,680 feet shows these seams to be a fine non-glauconitic clay, which was doubtless blue in shade when wet, as it came out of the well.

Dark, coarse, very sandy clay, slightly variegated with red, similar in most respects to that at 1,580 to 1,600 feet, but coarser and more sandy, 1,680 " " 1,700 "

The following thin seams, of which no specimens were received, are described by the driller:

Blue (marl ?), 1,683 to 1,685 feet.
Marl (?) and clay, 1,693 to 1,695 feet.

Reddish variegated clay, ... 1,700 feet to 1,742 feet.
' Sand, which ran up some 150 feet or more into the well with great pressure," *evidently strongly water-bearing* . . . . . 1,742 " " 1,760 "
No specimen was received of this.

Having reached the depth just noted, 1,760 feet, the further drilling was discontinued and the pipes cut at certain of the water-horizons, which, in passing downward, had been cased off. This permitted the water to enter the well so that it now, we are informed, "produces by natural flow, some 60,000 gallons of water each day, which is used with the city water-supply." Respecting the quality of the water from various depths, C. L. Parker recently writes, "large and small veins of water were found, some flowing and some non-flowing, nearly all of which were more or less saline in character, but otherwise of good quality." After noting that "a flowing water at 730 feet had 112 grains of salt per gallon, one at 1,038 feet had 159 grains and another at 1,072 feet had 164 grains, as per analysis made at Richmond." He states that "a gradual reduction in the amount of salt shows as time passes."

It may be proper to state respecting the occurrence of Exogyra that Dr. N. H. Darton, in a communication before the Geological Society of America,* at the Montreal meeting, 1889, says: "The fossils from the depth of 715 to 775 feet were all of one species, which is a small *Exogyra* precisely similar to *E. Costata*,† but having a smooth surface and showing only very faint costations. They vary in length from ¼ inch to 1¼ inches. The shell from 1,320 feet clearly is of the same species, and, although it is claimed by the drillers there can be no mistake about the depth stated, I do not feel convinced as to its authority. However, it cannot be ignored."

Three beds containing *diatoms* and more or less *sponge spicules* have been revealed by microscopic examination; two of these also contain *foraminifera*, and one, the lowest, contains *coccoliths* in addition.

The first of these beds occurs at the depth of 21 to 65 feet, and contains an assemblage of marine diatoms mixed with a few

* Bulletin Geological Society of America, Vol. IX, pages 414 to 416, Discovery of Marine Cretaceous in a boring at Norfolk, Va. N. H. Darton.

† As recorded above, our specimens from doubtless the same horizon showed, associated with the Exogyra, also Gryphea vesicularis.

fresh-water species. It also contains a mixture of recent diatoms, such as are now living on the Atlantic coast, and also of Miocene forms which have probably been contributed by the erosion and re-deposition in geologically recent times of Miocene clays. These peculiarities have also been noticed by the writer as pertaining to a deposit shortly below the surface of the Dismal Swamp.* The bed is probably continuous between the two localities. The presence of *Tricceratium favus*, Ehr., a diatom which does not occur in the Miocene, indicates a recent age for this bed. It is probably late Pleistocene.

The second infusorial bed occupies the interval between the depths of 355 and 625 feet, and presents three phases or subdivisions, as follows:

At 355 to 580 feet, sponge spicules only.
At 580 to 605 feet, diatoms, sponge spicules and foraminifera.
At 605 to 625 feet, diatoms, sponge spicules, foraminifera and coccoliths.

The assemblage of diatoms includes the characteristic forms especially indicative of the great 300 to 400-foot Miocene diatom bed of the Atlantic coastal plain.

The third diatom bed is sparingly diatomaceous. It occurs between the depths of 665 and 685 feet and probably marks the division line between the Miocene and the underlying Eocene formation.

After a final careful comparison of the specimens of the borings with the above record, which, as already stated, has been made from a separate study of each specimen and comparison of the same with several descriptions received from those who personally supervised the drilling, the writer considers the various beds penetrated by this well as the equivalent of and extension southward of the following geological subdivisions known and heretofore described by Prof. G. H. Cook and others as underlying southern New Jersey. The intervals of depth occupied by each of these divisions is noted on the right.

* Proceedings of the Academy Natural Sciences, Philadelphia, 1898, pages 422 to 427. Fossil Mollusks and Diatoms from the Dismal Swamp, Va. and N. C., &c. Lewis Woolman with Notes on the Diatoms. C. S. Boyer.

	Intervals of depth.
Pleistocene, Recent, ...	0 feet to 65 feet.
Miocene, ...	65 " " 625 "
Miocene mollusks clearly defined at 105, 125, 185 feet, and *probably* at 250 feet, &c.	
Sponge spicules at 355 to 585 feet.	
Characteristic Miocene marine diatoms at 585 to 625 feet.	
(See details in record above.)	
Eocene, ...	625 feet to 715 feet.
Cretaceous, Rancocas, ...	625 feet to 715 feet.
Cretaceous, Matawan, with *Exogyra* and *Gryphea*,	715 " " 783 "
Cretaceous, Matawan (?) or Raritan (?), ...	783 " " 1,320 "
Cretaceous, *Exogyra* at 1,320 (?)	
Cretaceous, —Raritan (&c. ?), ...	1,320 " " 1,740 "

Two other wells have been put down in recent years in this region, one on either side of the James river, from each of which the writer has an ample series of specimens of the borings which have been used for comparison with those from this well. One of these wells is at Lambert's Point, a short distance north of Norfolk, (see record, page 87,) and the other at the Hotel Chamberlin, Old Point Comfort, adjacent to Fortress Monroe.*

On comparing the borings from Old Point Comfort and those to the depth of 950 feet in this well at Moore's Bridges, Norfolk, there is found to be considerable correspondence in the succession of strata, with, however, but little variation in depth to corresponding changes in material, say not over from 25 to 50 feet, the depths being the greater at Norfolk. The Old Point Comfort well is eleven miles slightly west of north from the Moore's Bridges well, while the strike of the beds is probably nearly north and south. In this connection we may note that the great Miocene diatomaceous bed of the Atlantic coastal plain occurs at the following depths in these wells, viz., in the Old Point Comfort well at 530 to 560 feet, in the Norfolk Moore's Bridges well at 580 to 625 feet.

On comparing the borings from this, the Moore's Bridges, and the Lambert's Point wells, there is also seen to be a close correspondence, lithologically, in the succession of the materials penetrate, but a decided difference in the depths to corresponding

*Annual Report Geol. Survey of N. J., 1898, page 122.

changes, the depths being much greater at Moore's Bridges and about twice greater for the lower one-third next above the depth of 900 feet than for the middle one-third.

These two wells are approximately east and west of each other. The comparisons show that the lower portion of the Miocene beds dip about 100 feet between the two localities, or about 14 feet per mile eastward. Similarly the underlying Ripley Cretaceous beds dip some 200 feet or more, or about 30 feet per mile, likewise eastward.

Below we correlate the beds in these two wells, stratum for stratum. The depths at Lambert's Point are as marked on each specimen, all the specimens being described. Those noted at Moore's Bridges are also as they were marked when received, but have been selected from among numerous others at various intervening depths as most nearly resembling those from Lambert's Point.

Depths at Lambert's Point.		Depths at Moore's Bridges.
Yellowish sands, .	0 to 17 ft., equivalent to specimens from	0 to 18 ft.
Blue clay, ...	17 " 44 " " " "	21 " 65 "
Gray micaceous sand with *shell* fragments, . . .	44 " 183 " " " "	at 205 "
Greenish gray sandy clay, . .	183 " 191 " " " "	from 260 " 285 "
Gray micaceous sand, ...	191 " 233 " " " "	at " 315 "
Fine sand and clay, ...	233 " 264 " " " "	from 325 " 345 "
Gray clay, . . .	264 " 286 " " " "	at 385 "
*Fine gray sand with *shell*, . . .	286 " 355 "	
Gray clay, ...	355 " 377 " " " "	at 475 "
*Fine gray sand, .	377 " 397 "	
Dark gray clay, .	397 " 407 "	
Gray sand mixture of glauconite sand and *foraminiferal shells*,	407 " 526 " " " "	at 625 "

*The specimens received from the depths marked 286 to 355 feet, 377 feet, and 397 to 407 feet wer too minute and unsatisfactory for correlation.

Excepting the first 50 or 65 feet, which probably represents the Pleistocene, the strata noted *above* are mainly Miocene in age.

The strata noted *beneath* represents the Cretaceous, and judging by the fossils, mainly the Matawan or Ripley division thereof. The Miocene interval of 150 feet between the depths of 475 feet and 625 feet at Moore's Bridges, which includes the great Miocene diatom bed, seems wanting at Lambert's Point. This indicates considerable unconformity between the Miocene and the underlying Cretaceous.

	Depth at Lambert's Point.		Depth at Moore's Bridges.
Small gravel,	526 to 534 feet,	equivalent to specimen at	735 feet.
*Rock stratum,	534 " 540 "		
Gray clay,	540 " 563 "	" " "	755 "
*Rock stratum,	563 " 564 "		
Gray clay,	564 " 568 "	" " "	765 "
*Rock stratum,	568 to 603 "		
Ripley or Matawan *fossils* from,	563 " 608 "	equivalent to fossils from	715 to 780 feet
*Small gravel in coarse sand,	603 " 606 "		
Rock stratum,	606 " 610 "		
Gray sand micaceous, exactly identical at both places,	610 " 616 "	" " " "	805 "

Sec. 2. Wells in Miocene Strata.

ARTESIAN WELL AT BRIDGETON.

Elevation, 40 feet; diameter, 6 inches; depth, 126 feet
Water rises within 66 feet of the surface.

Joseph W. Pratt furnishes the following record of strata in a well bored by him at the Cumberland county asylum, near the old fair grounds, at Bridgeton:

* There were no rock nor gravel specimens from the Moore's Bridges well with which to correlate these lithologically.

Surface and yellow gravel,	0	feet to	12	feet.
Yellow loam and sand,	12	" "	78	"
Sand, color of brown sugar,	79	" "	88	"
White pebbly gravel,	88	" "	92	"
Slightly water-bearing, at 70 to 92 feet.				
Light brown quicksand,	92	" "	118	"
Open quality sand, color of brown sugar, *water-bearing*,	118	" "	126	"

This well was finished with an 8-foot strainer at the base. The quality of the water is said to be excellent, and there is also said to be plenty of it, as a test was made, when 40 to 50 gallons a minute were pumped, this amount being up to the capacity of the pump used.

The location is not far from that of a well put down at the residence of Orlando Cook, on the *western* border of Bridgeton,* and which was abandoned at the depth of 90 feet, because of the small amount of water obtainable, which water was first noted at the depth of 80 feet. The same scant water-supply was found in this well at an equivalent depth—the surface at both wells being said to be of about the same elevation.

No specimens of the borings were preserved, and without these the writer would not, with present data in hand, venture to certainly determine the geological age of all the strata penetrated, but as the lowest of these are possibly Miocene, he includes it under the heading of "wells in Miocene strata." The more shallow well of 1893 was reported under the heading of "Wells in the Superficial Strata."

ARTESIAN WELL AT CEDARVILLE.

Elevation, 15 (?) feet; diameter, 3 inches; depth, 93 feet.
Water rises within 12 feet of the surface.

Haines Bros. report a well bored by them for John H. Diament, at Cedarville, Cumberland county, eight miles south of Bridgeton. Its depth is 93 feet. Haines Bros. say the material passed through was all white sand to the bottom, where a black clay was touched. Water was first found at a depth of 20 feet and continued the rest of the way down.

The black clay touched at the bottom was probably Miocene clay. The water-bearing sand is probably also of Miocene age,

* Erroneously stated to be at *East* Bridgeton in the Annual Report for 1893, page 418.

and if so, the horizon would seem to be the same as supplies wells at Weymouth (depth, 40 feet, elevation, 25 feet), and Mays Landing (depth, 196 feet, elevation, 20 feet).

WELL AT GREENBANK, N. J.

Elevation 20 feet; depth, 54 feet
Water rises 10 feet above high tide.

This well is located on the banks of the Mullica river at the store of Wm. Sooy, who some years since furnished the writer the record below:

	Thickness	Total Depth.
Gravel and sand, with hard water, to	13 feet	= 13 feet
Clay,	20 "	= 33 "
Black clay,	5 feet to 12 "	= 45 "
Gravel with water to		54 "

It may be remarked that a *black tenaceous clay* outcrops at Herman City, also on the Mullica river, one mile westward.

ARTESIAN WELL AT SMITH'S LANDING.

Elevation, 30 feet; diameter, 6 inches; depth, 704 feet.
This well was prospected beyond this to the depth of 715 feet.
Water rises to within 17 feet of the surface.

During the summer Uriah White put down a well at the Atlantic county asylum, near to and south of Smith's Landing, the location being more accurately stated as at Dolphin station, on the branch railroad from Pleasantville to Somer's Point. The depth of the well as finished is 704 feet, though the boring was prospected beyond this to 715 feet, where the top of a clay stratum was found. The top of the water-bearing sands occur at 640 feet. The well is six inches in diameter and is finished at the base with a 4½-inch strainer 41 feet in length. This draws water from between the depths of 663 and 704 feet. The water rises to within 17 feet of the surface. When pumped at the rate of 100 gallons a minute the water level was lowered to 23 feet from the surface, but quickly rose again to 17 feet when the pumping was stopped. The water-horizon is the equivalent

of that which we have heretofore designated as the 800-foot horizon at Atlantic City, which is four miles to the eastward, nearly directly on line with the natural dip of the beds.

Through the courtesy of the contractor and his assistants we have been furnished with a full series of the borings taken every 10 feet in depth all the way down. From an examination of this series, supplemented by considerable information verbally obtained, we make the subjoined record.

Loamy soil underlaid by yellow gravel,	0 feet to	15 feet.	Recent.
Yellowish sands, ranging from fine to very coarse sand and fine gravel,	15 "	173 "	Age (?)
Yellow sandy clay seams at 40 to 45 feet.			
Decidedly orange-colored coarse sand at 140 to 160 feet.			
Clay streaks at 161 to 173 feet.			
Dark clay,	173 "	180 "	Miocene.
Alternations of sands, clayey sands, and sandy clays all brownish in shade and varying from fine to medium in quality. No micro-organisms,	180 "	310 "	
Decidedly sandy clay at 280 to 300 feet.			
Nearly solid clay bed containing *diatoms* and some *sponge spicules* throughout,	310 "	570 "	
Sand with *shell*, 420 to 430 feet.			
Diatoms especially plentiful between 490 to 570 feet.			
Comminuted shell, 560 to 570 feet.			
Loose rock described as boulders, at		570 "	
Alternations of clayey sands and sandy clays; no diatoms nor other micro-organisms,	570 "	640 "	
Water bearing sands decidedly coarse at the bottom,	640 "	715 "	
Clay beneath,		715 "	

The upper or the great diatom bed of the Atlantic coastal plain Miocene deposits is 260 feet thick in this well, and occupies the interval between the depths of 310 and 570 feet. In this connection we may state that well-borings at Wildwood,*

* Annual Report Geol. Survey, N. J., 1894, foot of page 164, Diatom bed No. 4, at Wildwood.

N. J., and at Lewes, Del., have revealed at those places a lower diatom bed within the Miocene and about 200 feet below the base of this bed. This second or lower bed probably exists beneath this locality and also Atlantic City, but at a still lower depth than the horizons (the 700 and the 800-foot Atlantic City horizons) that are utilized for water-supply, and for the same reason has therefore not been reached by the numerous borings along the coast from Brigantine to Avalon, these having been made only to the depths of these two (700 and 800-foot) water-horizons.

It was, however, probably penetrated by two extra deep borings at Atlantic City that were at first unsuccessfully made, so far as obtaining water was concerned, to the depths of about 1,100 and 1,400 feet in the early efforts to obtain water there, as stated in the Annual Reports for 1887, page 26; 1888, pages 72 to 75, and 1889, pages 89 to 99, the latter with an illustrated vertical section.† The existence, however, of this second or lower diatom bed was not then learned, probably for the reason that specimens of the borings covering this interval were not preserved.

ARTESIAN WELLS AT ATLANTIC CITY, N. J.

At The Traymore, ... Depth, 830 feet
At The Waldorf-Astoria, . . Depth, 837 feet.
At the Gas Works, ... Depth, 790 feet.

Deep wells have been put down at Atlantic City during the past year at The Traymore, at The Waldorf-Astoria and at the Gas Works.

* Annual Report Geol. Survey, N. J., page 89, Marine Fossil Diatoms at Lewes, at the depths of 1,000 to 1,020 feet.

† Noted also with illustrated vertical section in Proceedings of the Academy of Natural Sciences, 1890, pages 132 to 147, Geology of Artesian Wells at Atlantic City, by Lewis Woolman.

Both of these wells afterward obtained water, one of them, on the meadows, by parting the casing and opening the 800-foot water-horizon, and the other, at the gas works, by withdrawing the casing a short distance and opening a water-horizon still deeper, but one the exact depth of which has not been certainly learned. In the Annual Report for 1889, its depth was stated to be at 1,121 feet, and in the Annual Report for 1890, this depth was revised and stated to be probably at about 925 feet. A deep well at Young's ocean pier, in process of boring as this goes to print and which has reached a depth of about 1,500 feet, shows, however, that probably neither of these statements is correct. It is hoped this well, when finished, will reveal its true depth. This boring also shows that the records furnished the survey of the first two deep wells is more or less incorrect. An entire revision of the vertical section beneath the depth of 850 feet is needed, but must be left for the future, however.

From Uriah White, who put down all three of these wells, we have received data respecting them, which we report below, the succession of strata penetrated being, of course, identically the same as has been heretofore frequently noted in these annual reports for other wells at this locality. Those especially interested can consult these reports for the years from 1889 to 1898 inclusive.

At the Traymore.

Elevation, 10 feet +; diameter, 6 inches; depth, 830 feet.
Water rose to the surface, but did not overflow.
Was pumped 225 gallons a minute, lowering the water to 11 feet from the surface.

Uriah White, the contractor, furnishes the information tabulated above. The well draws from the 800-foot Atlantic City water-horizon.

At the Waldorf-Astoria, at Beach End of Ocean Avenue.

Elevation, 10 feet; diameter, 6 inches; depth, 837 feet.
Water rose to the surface, but did not overflow.
The well was pumped 140 gallons a minute, lowering the water 8 feet below the surface.

Uriah White also furnishes the information tabulated above. This well likewise draws from the 800-foot Atlantic City water-horizon.

At the Gas Works, Corner of Michigan and Arctic Avenues.

Elevation, 10 feet; diameter, 6 inches to 505 feet; 4½ inches to 720 feet; 3 inches to 790 feet; depth, 790 feet.
Water barely overflowed at the surface
Was pumped 100 gallons a minute, lowering the water to 20 feet from the surface.

This well had been sunk with a six-inch bore previously to 1888, by another well-driller, to the depth of 505 feet and abandoned.* Uriah White continued the boring the present year to the depth of 790 feet, finishing it at the bottom with a strainer 50 feet in length and procuring a satisfactory supply of

* No record of this old well has heretofore appeared in these annual reports.

good water from the "800-foot" Atlantic City Miocene water-horizon. The wells at Atlantic City vary in depth in accordance with the dip seaward and the depth to which they are continued into the water-bearing sand, which is about 60 to 80 feet thick. The variation in depth ranges from a minimum of about 750 feet on the meadows to a maximum of about 860 feet on the beach front.

ARTESIAN WELL NO. IV, AT OCEAN CITY.

Elevation, 5 feet +; diameter, 8 inches; depth, 830 feet.
Rock band, 2 feet thick, at 629 feet, below which the diameter was reduced to 6 inches
Water overflowed, but amount not ascertained.

There are now at Ocean City four artesian wells, all belonging to Ocean City Water Company and all drilled by Uriah White. This, the fourth well, was put down during the early summer. All the wells are located on the west side of the Pennsylvania Railroad Company's track, and are distributed between Eleventh and Fourteenth streets, each being a few hundred feet apart; this, the fourth one, being about 500 feet south of well No. III. The diameter of well No. IV is 8 inches to the depth of 629 feet, where a rock band about 2 feet thick was encountered, below which the boring was reduced to six inches. The well has a total depth of 830 feet and was finished with a 50-foot slotted pipe that answers as a strainer at the bottom.

The water overflows at the surface, but on account of the heavy and nearly continuous pumping from the other wells, its amount could not be ascertained. The beds penetrated, as should be expected, were essentially the same as in the former wells, for the stratigraphical record of which the interested reader is referred to the Annual Reports for 1892, 1893 and 1896.

We may, however, mention that in this well a black or very dark clay was observed at 300 to 330 feet, below which was a 40-foot bed of sand to the depth of 370 feet, where the top of the great 300-foot diatom clay-bed that occurs beneath the Atlantic coastal plain was met with.

ARTESIAN WELL AT SEA ISLE CITY.

Elevation 10 feet; diameter, 6 inches; depth 825 feet.
Water rises within one foot of the surface.
Fossil mollusks at the depth of 795 feet.

In the spring of 1898 Uriah White finished the sinking of a six-inch well at Sea Isle City.

This well has a depth of 825 feet and is finished with a 70-foot strainer at the base. A rock stratum was met with at 690 feet, and the top of the water-horizon at 730 feet. The well has a natural overflow of 60 gallons a minute. The water-horizon utilized is probably the equivalent of the 800-foot Atlantic City Miocene horizon.

We have been favored by the contractor with samples of the borings. One specimen from the depth of 795 feet, a grayish, medium, coarse, free sand, without any mixture of clay, contains exceedingly great numbers of the shells of two small bivalves, with the nacreous lustre as well preserved as it is on the small clam shells that may now be picked up on the beach. The species, however, are different from those of the present day.

These shells have been referred to Dr. W. H. Dall, who writes as follows:

"One is an *Ervilia* not far from *E. concentrica* Gould, but a distinct species. The other is a *Crassinella*, but not, I think, the genuine *C. lunulata* Conrad, though allied to it. It is very like some I have named *lunulata* in the past, but I am now in doubt as to whether the determination was correct. Conrad's species came from Suffolk, Va., and as all the species are closely related, it will take a close study to determine them," for which he further states time is not now at command.

Associated with these bivalves were a *very* few univalve or gastropod shells, which time does not permit us to identify.

From a well at the same place, reported in the Annual Report for 1896, page 176, the same two specific forms of bivalves were obtained from the depth of 805 feet, doubtless representing the same bed. This shell-deposit is within the water-bearing sands, but toward their base.

ARTESIAN WELL AT MAHON RIVER, DEL.

Elevation 5 feet ; depth 350 feet.
Water rises 16 feet above tide.

From I. A. Harrison, of Tilghman, Md., we learn that in the year 1897 he bored a well near the mouth of Mahon river, Delaware, on Delaware bay, to the depth of 350 feet, where he says he found "a hard sand almost like stone, which afforded an abundance of water of excellent quality, which flowed 16 feet above tide-level." He also furnishes the following descriptive record:

Sand and clay, surface to . . . . . 200 feet.
Solid green clay, ... 200 feet to 350 "
Then hard sand, water-bearing.

The water-horizon is doubtless in the Miocene.

In the Annual Report for 1893, page 401, there is a record of a well at this locality with a depth of only 206 feet, thus showing two water-horizons at this locality.

ARTESIAN WELL AT BOWER'S BEACH, DEL.

Elevation, 5 feet — ; diameter, 3½ inches ; depth, 500 feet.
Water at 240 feet that rises 2 feet above tide-level. Very little water lower than 240 feet.

I. A. Harrison also informs that he has bored a well at Bower's Beach, Delaware, about eight miles south of Mahon river. This location is on the Delaware bay, at the mouth of the Murderkill creek.

He states that at the depth of 240 feet he found water that rose about two feet above tide-level and that yielded, by pumping, about 20 gallons a minute. It is said this boring was prospected to the depth of 500 feet and that but very little additional water was obtained below the 240-foot horizon. The water-horizon of this well is probably in the Miocene. Had the well been prospected a short distance further, it is probable the horizon met with at Mahon river at the depth of 350 feet, as noted in the preceding record, would have been found.

FIVE ARTESIAN WELLS TWO MILES NORTHEAST OF MADISON, MD.

Elevation, 5 feet + (?); depth, 320 feet.
Wates rises about 4 feet above tide

The locality of these wells is near Madison, Md., and about eight miles southwest of Cambridge and near Little Choptank bay, on the Chesapeake side of the eastern shore peninsular part of Maryland.

The wells were put down by I. A. Harrison, of Tilghman, Md., who furnishes from memory the following record, which may be regarded as approximately correct:

Sand,	20 feet	= 20 feet.
Thin stratum of shells, hard packed.		
Sandy clay,	60 "	= 80 "
Soft stone streak.		
Sandy clay,	10 "	= 90 "
Harder stone streak.		
Sandy clay,	20 "	= 110 "
Very hard stone streak.		
Clay,	190 "	= 300 "
Sand, water-bearing,	20 "	= 320 "

The water-horizon opened is doubtless the same as that developed by an artesian at Cambridge, at the depth of 360 feet, as incidentally noted in the Annual Report for 1890, page 275, last paragraph but one.

ARTESIAN BORING AT DELMAR, DEL.

Depth, 402 feet.

In the year 1885 the Delaware division of the Philadelphia, Wilmington and Baltimore Railroad Company had a well drilled at their station at Delmar, Del., to the depth of 402 feet, when the work was abandoned without having obtained a supply of water.

Of this boring the writer, in the early 90's, obtained, at the company's office, at Clayton, Del., copies of three records which had been separately kept by three of the company's civil engi-

neers who had been interested in the work. No specimens, however, of the borings had been preserved, and until the writer came recently to study the record and specimens from a well four miles south, at Salisbury, Md., he was unable to harmonize the three records.

It is, however, now found that all three records are in substantial agreement and differ only in that the three observers each noted and described separate phases of the strata and at different depths.

Below we present a revised record compiled from the three records already noticed:

Fine sand at		48 feet.
Coarse sand,	48 to	85 "
Water at 80 feet.		
Sand,	85 "	136 "
White sand and soft sand (rock?)	136 "	157 "
Black sandy clay,	157 "	168 "
Sand, gravel and pebbles; sand at top and bottom, reddish,	168 "	207 "
Light-colored bluish sand, very hard,	207 "	220 "
Fine sand,	220 "	264 "
Light gray clay,	264 "	306 "
Fine white *shells* at 300 to 304 feet.		
Hard sand,	306 "	341 "
Marl or clay with fine *shells*,	341 "	374 "
Sand,	374 "	386 "
Clay,	386 "	402 "

ARTESIAN WELLS AT SALISBURY, MD.

15 gang wells for water-works—Elevation, 5 feet; depths, 18 to 75 feet.
One well—Elevation, 5 feet; depth, 101 feet.
One well—Elevation 30 feet; diameter, 4½ inches; depth, 72 feet.
Yields, by pumping, 42,300 gallons a day.
One well—Elevation, 30 feet; diameter, 6 inches; depth, 267 feet.
The last named well was prospected to the depth of 424 feet.
Water overflows from the 101-foot well, having an elevation of but about five feet, while from the wells with an elevation of thirty feet it rises to within 3 to 5 feet of the surface

Salisbury, Md., is supplied with water "from a gang of 15 driven 6-inch wells to depths of 18 to 75 feet. They yield in all

about 200 gallons a minute."* The level is about five feet above tide, while from about the same level "a deeper boring was made to 101 feet for lower waters, but the result was not satisfactory, because the water was strongly impregnated with mineral matters." *

During the year 1893, Dr. L. S. Bell put down for an ice factory, on somewhat higher ground, estimated at 30 feet above tide, two other wells, one of which was prospected much deeper, or to the depth of 424 feet from the surface, although this well was afterwards finished so as to draw water from about the depth of 267 feet. The other well at the ice factory reached the depth of 72 feet only.

Dr. Bell courteously furnished a full series of specimens of the borings from the second or more shallow well and a nearly equally full series from the first or deeper well from below the depth of 105 feet, together with quite complete stratigraphic data. From a careful study of these data and of the specimens from the two borings, we have compiled the following record, in which, wherever we use Dr. Bell's exact language, we enclose the same in quotation marks, and wherever we have inserted a word in his description we place the same in brackets.

	Thickness.	Total depths.
"Surface sand,"	6 feet,	6 feet.
"Dark clay,"	19 "	25 "
White sand,†	10 "	35 "
"Fine sand,"	9 "	44 "
"Sand gradually getting coarser and more yellow,"	21 "	65 "
Fossilferous pebbles at 50 to 60 feet, is a *water-horizon*.		
"Hard pan, iron formation,"	2 "	67 "
"Light strata of white, sandy, loamy clay,"	1 foot,	68 "
"Iron (colored) sand," is a *water-horizon*,	25 feet,	93 "
Fine clayey sand, with lignite,	9 "	102 "
Fine gray sand, furnishes *pure water*,	14 "	116 "
"Blue sticky clay, strongly mixed with gray sand,"	19 "	135 "
"Fine gray sand, with water, which comes near the surface and seems to be colo ed by rotten wood,"	25 "	160 "
"Gray sand gradually getting coarser,"	25 "	185 "

*Bulletin 138, U. S. Geol. Survey, page 131. Artesian Wells, &c., N. H. Darton.

†Dr. Bell informs that this white sand occurred only in the 72 feet well and not in 424 feet well although the two wells are scarcely 25 feet apart.

	Thickness.	Total depths.
"Very coarse gravel mixed with much fine gray sand," . *Water-bearing.*	72 feet,	257 feet.
'Clay and fine sand full of small sea-shells," described in a letter received as "*Conch* and other *snail* and *clam shells*, but no oysters." . . . . . None of these shells were received with the borings, having been previously given away.	6 "	263 "
'Solid blue clay," containing much greensand or glauconite grains. "*Clam shells* frequent at 274 feet,"	87 "	350 "
Streak of gray, coarse gravelly sand at		350 "
'Clay mixed with fine black sand,"	5 "	355 "
"Black marl mixed with clay and gravel," decidedly glauconitic, ... "Struck big cobble stones at 376 feet."	21 "	376 "
Marl slowly changing to gray, gritty sand, ... *Small mollusks* in the two last-named strata (see specific description in a later paragraph).	12 "	388 "
Gray sand, ... "Struck other cobblestones at 404, 410 and 420 feet."	36 "	424 "

Dr. Bell writes that "there was a great deal of water in the wells at the ice factory at about 48, 80, 158, 214 and 250 feet. Also that the water-horizon at about 80 feet in the water-works wells was met with at 105 feet at the ice-factory, and that the latter is on ground about 25 feet higher than the former."

On studying carefully these two records (at Delmar, Del., and Salisbury, Md.), we find that the upper strata, say probably to the depth of about 185, or possibly to 200 feet, lie nearly level, while below that depth the beds dip decidedly toward the ocean. If we assume these underlying beds to strike northeast and southwest, which they probably approximately do, their distance apart, along the line of dip to the southeast, would be about four miles. As noted in the records, marl with shells occurs at Delmar between 280 and 332 feet, while at Salisbury marl with shells, probably the same bed, occurs at 350 to 388 feet, making a dip of 70 feet between the two points.

These facts, considered in connection with our knowledge respecting wells at Lewes, Del., and at Wildwood and Avalon, N. J., indicate that the uppermost beds of the Miocene in lower Delaware and in the Cape May peninsula dip seaward at the rate of about 17 feet per mile. This is somewhat less than our

previous studies show to be the case along the coast, say from Ocean City and Atlantic City northward, where we calculate the dip at about 25 feet per mile.

Dr. Bell, in a letter, describes the shells noted above at 257 to 263 feet as "*conch and other snail shells and clams*," and states that there were no oysters.

The shells noted at from 355 to 388 feet were taken out by the writer from the borings received. They were mostly small, sometimes nearly entire shells, and at other times broken and very fragmentary. C. W. Johnson has identified the following forms, which, collectively, may be considered characteristic of the upper Chesapeake Miocene, or the equivalent of the St. Mary's fauna:

Teinostoma umbilicata, H. C. Lea.	Nassa peralta.
Turritella plebeia, Say.	Crucibulum ——— Sp. ?
Turritella variabilis, Conrad.	Cardium laqueatum (?) Conrad.
Turritella alticostata Conrad.	Anomia ——— Sp. ?
Dentalium ——— Sp. ?	Solen ensiformis, Conrad.

From the same fossil-horizon we obtained a small otolith or ear-bone of a fish. Judging from the size of this otolith the fish to which it belonged was probably not over three or four inches in length. We are, however, unable to make out the species.

There were also small fragmentary specimens of a Crustacean, probably *Balanus proteus*, Conrad.

The nearest deep well suitably situated for comparison of strata, from which the writer has specimens of the borings, is at Lewes, Del. Here the top of the great 300 to 400-foot Miocene diatomaceous bed was met with at 407 feet. The specimens from Salisbury, as already stated, show, however, on microscopic examination, no diatoms. It is therefore probable that this well does not reach that bed. The clay at the depth of 402 feet at the bottom of the well at Delmar probably represents the top of the diatom bed, so that it seems quite possible (on calculating the dip) that had the well at Salisbury been prospected some 70 or 75 feet deeper, the top of the great diatom bed would have been found there likewise.

ARTESIAN WELL AT POKOMOKE CITY, MD.

Diameter, 2 inches; depth, 105 feet.
Water rose 18 inches above the surface, or about 5 feet above high water.

In 1895 a trial well was drilled at Pokomoke City, of which specimens and some data were furnished the writer by W. J. Young, C. E. From these the following record has been compiled:

12 feet	Sand and loam, to				12 feet.
3 "	Coarse yellow gravel, large as shellbarks, with plenty of water (surface water),	12 feet to	15	"	
28 "	Fine blue clay,	15 " "	43	"	
10 "	Clay with *shells*,	43 " "	53	"	
15 "	Clay, with greater numbers of *shells*,	53 " "	68	"	
27 "	Fine gravel and sand, not much water,	68 " "	94	"	
1 "	Gravel and clay,	94 " "	95	"	
11 "	Fine quicksand.	95 " "	105	"	

Abundance of water at 97 feet.

TWO ADDITIONAL ARTESIAN WELLS AT POCOMOKE CITY, MD.

Depth of each about 290 feet.
One of these wells was prospected to 496 feet.
Diameter of each, 6 inches.

Five water-horizons, as follows:

"Good water" between the depths of	75 feet and	85 feet.	
"Hard water" " " "	120 " "	123	"
Water utilized between the depths of	195 " "	225	"
" " " " "	247 " "	290	"
"Sulphur water" " " "	485 " "	496	"

During the present year, J. H. K. Shannahan, contractor, drilled for the Pokomoke water-works two much deeper wells at Pocomoke City, Md., than the one noted in the preceding record. From Norman M. Shannahan, in immediate charge of the work, we have received the following description:

Made ground to			15 feet.
Yellow and brown mixed clay,	15 feet	= 30	"
Dark clay,	45 "	= 75	"
Gray sand with good water, flowed 3 gallons a minute,	10 "	= 85	"
Green clay,	35 "	= 120	"
Coarse sand with water, which overflowed; pumped 60 gallons a minute. Water was very hard,	3 "	= 123	"
Dark green clay,	63 "	= 186	"
Gravel and *sea shells*,	3 "	= 189	"
Sand rock,	6 "	= 195	"
Light-colored coarse sand; when dry nearly white; contains *water* which flowed 45 gallons a minute and from which there was pumped about 150 gallons a minute—(salty),	30 "	= 225	"
Dark green clay with some *sea shells*,	20 "	= 245	"
Very hard fine-grained sandstone rock,	2 "	= 247	"
Sand like that at 200 feet, only this had *sea shells* in it, also contained *water* of quality same as at 200 feet. Flowed 45 gallons and pumped about 175 gallons a minute,	43 "	= 290	"
Light gray clay, like putty,	180 "	= 470	"
Hard and soft marl beds,	15 "	= 485	"
Coarse sand with water; flowed 50 gallons and pumped 100 gallons a minute. Strong with "sulphur,"	11 "	= 496	"

The water of the last horizon not being at all potable the first well drilled was finished to draw from the two higher water-horizons at 195 to 225 feet and 247 to 290 feet. Afterward another 6-inch well was put down to the same two water-horizons. The two wells together, since being finished, flow about 150 gallons a minute. The water-horizon not used but noted above at about 85 feet is evidently the one reached by the well (depth, 105 feet) in the preceding record (see page 115) *as occurring at the depth of 97 feet.*

Sec. 3. Wells in Post-Miocene or Surface Strata.

TEST BORINGS AT PHILADELPHIA NAVY YARD, ON LEAGUE ISLAND.

Elevation, 10 feet +; diameter, 4 inches; depths, 25 to 38 feet.

During the latter part of the year 1898 a number of test borings were made for the United States government on League Island,

preparatory to the construction of a dry-dock at the Philadelphia Navy Yard. These test borings were made near the location of a deep well (600 feet deep) at that place, of which records appear in the Annual Reports for 1896, page 114, and 1897, page 270, and which entered the Plastic clays and gravels of the Raritan formation at the depth of about 50 feet. As the record of the well then reported affords but scant information of the upper portion of the boring which penetrated the much more recent deposits that overlie the Cretaceous, and as through the kindness of C. C. Walcott, C. E., U. S. N., in charge of the engineering work, we have been furnished with a complete series of specimens from one of the test borings, as also several specimens from others of these test borings, we insert their record and particularize the results of our study of the same, in which we have been aided by the microscope.

We may, however, first state that these test borings reveal a depth of alluvium or quite recent mud or clay along the Delaware river front, on east side of the mouth of the Schuylkill, varying from about 25 feet to 38 feet, and that this alluvium contains, throughout its entire vertical extent, the siliceous cases or remains of single-celled plant organisms, known as diatoms. These diatoms present a mixed assemblage of fresh-water and marine species, among the latter being a triangular form, *Triceratium favus, Ehr*, which is found living to-day in the Delaware river at the latitude of Philadelphia, and also occurs in the muds on the river margin from the Breakwater northward to that city, but which the writer has been unable to find, either buried in the muds or living in the water, at Burlington. This particular fossil is indicative of deposits of quite recent geological age, say Pleistocene, and possibly also Pliocene; this Navy Yard alluvium being, however, certainly *decidedly late* Pleistocene.

At its base this marshy alluvium rests upon a coarse gravel with pebbles of considerable size, as revealed by the test borings and also by the dredgings brought up by a rotary dredging machine from the depth of 25 feet in the back channel. This heavy gravel, from an examination of its constituent pebbles, the writer deems to be Pensauken in age.

It may be interesting, for comparison, to note the depth of similar alluvial deposits at the debouchure into the Delaware of other tributaries, all of which exhibit a similar mixed assemblage of marine and fresh-water deposits. They are as follows:

Location.	Depths of marsh in feet.	Noted in Annual Reports for
Newtown Creek, Gloucester well record, . .	15*	1893, page 404
Pensauken Creek, ...	25 to 41	1898, page 111
Hog Island, at Tinicum Creek, ...	40	1896, page 115

We now insert the record in detail. The first column on the right gives the number of the borings in the order of the time when they were made, while the second gives the depth, in feet, of each specimen.

Result of Microscopic Examination of Late Pleistocene Alluvium (marsh mud) in Test Borings at Philadelphia Navy Yard, League Island, Pa.

No. of Well.	Depths of specimens.	
IX.	2 feet.	*Pinnularia* and some discoid diatoms.
IX.	2 "	*Eunotia* and circular discoid diatoms; also pin-head sponge spicules.
IX.	4 "	Diatoms, fairly plentiful.
IX.	6 "	Diatoms.
IX.	8 "	Diatoms, circular discoid forms noticeable.
IX.	10 "	Diatoms fairly plentiful in a fine, sandy, micaceous silt.
III.	10 "	Diatoms and a few sponge spicules.
IV.	10 "	Diatoms.
III.	12 "	No diatoms observed; silt quite sandy.
IX.	12 "	Diatoms, a few small discoid forms.
IV.	12 "	Diatoms, a few, with a few sponge spicules in fine silt.
IV.	14 "	Diatoms, a few.
IX.	14 "	Diatoms.
III.	14 "	Diatoms and sponge spicules.
IV.	16 "	A few sponge spicules; no other micro-organisms observed.
IX.	16 "	Diatoms. Large discoid forms plentiful.
III.	16 "	Diatoms.
V.	17 "	Diatoms.
IX.	18 "	Diatoms in a very fine sandy silt.
III.	18 "	Diatoms *Eunotia*, &c.; also a few sponge spicules.

* This boring was made quite close to the inner margin of the marshy flat; had it been farther out toward the stream and the centre of the marsh, it would probably have shown a still greater depth of alluvium.

No. of Well.	Depths of specimens.		
IX.	20 feet.	Diatoms.	
IV.	20 "	Diatoms, large discoid forms.	
III.	20 "	Diatoms.	
V.	21 "	Diatoms, a few.	
IV.	22 "	Sponge spicules; no diatoms seen.	
IX.	22 "	Diatoms.	
III.	22 "	Diatoms and sponge spicules.	
V.	23 "	Diatoms, *Triceratium favus*, &c.	
IX.	24 "	Diatoms.	
III.	24 "	Diatoms fairly plentiful.	
IV.	24 "	Diatoms fairly plentiful.	
V.	25 "	No micro-organisms seen—sand and very sandy clay.	
V.	29 "	No micro-organisms seen; very sandy, gravelly clay.	
IX.	26 "	Diatoms, a few.	
III.	26 "	Diatoms, a few in a mixture of gravel and sand, with a little clay.	
IV.	26 "	Diatoms.	
V.	27 "	No micro-organisms seen; very sandy clay.	
IX.	28 "	No micro-organisms seen; coarse sand with a little clay.	
IV.	28 "	Diatoms.	
IV.	29 "	Diatoms and sponge spicules.	
IV.	30 "	No micro-organisms; gravel and sand.	
IX.	30 "	No micro-organisms; sand, with a little clay.	
IX.	32 "	Diatoms, a few.	Coarse sand, with a little clay.
IX.	34 "	No micro-organisms.	
IX.	36 "	No micro-organisms.	
IX.	38 "	No micro organisms.	

DUG WELL AT NORTHFIELD, ATLANTIC COUNTY, N. J.

Elevation, 30 feet; depth, 30 feet.

Early in 1898 a well was dug at Northfield for an Atlantic City organization, the Northfield Country Club. This well is located on the shore road near Northfield Station, on the Somer's Point branch of the Seashore Railroad, about one mile south of Smith's Landing.

The record is said to have been about as follows:

Yellow loam and gravel to . . . . . 21 feet = 21 feet.
Whitish clay, ... 5 " = 26 "
Yellow sand and hard gravel, with water, ... 4 " = 30 "

The water is said to be good and to stand 7 feet above the bottom of the well. The supply is entirely from the superficial sands or beds known as the Cape May formation.

ARTESIAN WELLS AT ABSECON FOR ATLANTIC CITY WATER-SUPPLY.

Elevation, 5 feet ±.
Two wells—Diameter, 4½ inches; depth, 100 feet.
One well—Diameter, 10 inches; depth, 70 feet.
Three wells—Diameter, 4½ inches; depth, 25 feet.

All the above wells were drilled by Uriah White.

In the Annual Report for 1892, pages 282 to 285, there is an extended notice with record of strata of a considerable number of wells with a depth of 24 feet. These wells have an elevation of about 5 feet above tide, and are located within the area occupied by a receiving basin, into which they naturally overflow.

Three additional wells of 4½ inches diameter have been sunk the past year within the same basin to the depth of 25 feet, the lower 6 feet being through a clay containing a mixed assemblage of marine and fresh-water diatoms of recent geological date. The water from these wells, as in those formerly sunk, flows directly into the basin.

Also, within the past year two other wells, 4½ inches in diameter, have been put down outside of the basins and at about the same level to the depth of about 100 feet, finding water in a coarse gravel, while one other 10-inch well has been put down on the top of the retaining bank of one of the receiving-reservoirs to the depth of only 78 feet, the elevation being about 15 feet.

Two series of the borings were received, one from one of the 4½-inch wells, depth 100 feet, and the other from the 10-inch well, depth 70 feet. Allowing about 10 feet for the difference in the elevation of the surface at the two wells, we have compiled the following stratigraphical record, the depths being from the elevation of 15 feet:

Heavy white gravel with fossiliferous pebbles, ...	0	feet to		18	feet.
Blue clay containing sponge spicules and *marine diatoms*, geologically very recent, ...	6	"	"	25	"
Orange-yellow coarse sand with water, ...	25	"	"	70	"
Streak of white clay at				70	"
Gravel with large white pebbles and water at the base,	70	"	"	100	"

Our recent study of the borings at this location confirm what we had formerly written in the before-mentioned Annual Report for 1892, and as we cannot now do better, we quote as follows from that report respecting the diatom bed and other associated and correlative facts:

"This section is especially interesting, since the marine diatoms noted are generally of so recent an appearance as to indicate at once to any experienced diatomist that the clay in which they are found was laid down not only comparatively recently, geologically, but also that it must be an entirely different stratum from the great 300-feet diatomaceous clay bed associated with the numerous deep wells in southern New Jersey.

"The conclusion, furthermore, seems irresistible that the heavy gravel with fossiliferous pebbles must have been placed on the top of the clay by a working over and re-depositing of the Quaternary yellow gravel and sands of the higher ground to the westward.

"The author has traced for three miles along the shores of the Great Egg Harbor river, near Mays Landing, a bed of clay containing a somewhat similar assemblage of diatoms, and likewise overlaid by gravels with fossiliferous pebbles.

"C. W. Coman has also furnished the Survey with specimens of clays from near the banks of the Maurice river, at Buckshutem, and from the banks of the Cohansey river, at Bridgeton, which, on examination under the microscope, also exhibited diatoms.

"The diatoms at these three localities were mixed marine and fresh-water forms, the marine predominating; but few fresh-water forms, however, were seen in the Absecon wells deposit. Strewn mounts of the diatoms from Absecon were submitted to C. H. Kain, an acknowledged authority upon their specific forms. He writes: "The species are almost exclusively marine; very rarely a fresh-water form is seen. I can discover no species not now to be found in the mud of Absecon marshes.

The abundance of circular [disc] forms, however, suggests a fossil deposit, although I can find no form which is now only found in the fossil state. I should suspect the deposit to be of comparatively recent formation. It greatly resembles in this respect the Bridgeton and Buckshutem deposits, although both of the latter contain a much greater proportion of fresh-water forms. The Absecon deposit may not be any more ancient, but probably it was not so much within the reach of fresh-water influences."

"These facts suggest some interesting relations between these various deposits. Additional careful investigation, especially in the field, will be needed, however, before their exact bearing upon each other can be fully defined.

"The wells at Atlantic City, after penetrating about 40 feet of beach sands and 10 feet of mud, the probable bottom of an old channel, enter a succession of gravel and clay beds which the author deems the equivalent of these at Absecon, a conclusion reached after careful study.

"So much of the Atlantic City section as may be needful to show its relation to the Absecon wells will now be given:

Record.				Age.
"Beach sand,		to 40	feet.	Very recent.
Mud *foraminifera* and *diatoms*,	40 "	50	"	Very recent.
Heavy gravel, fossiliferous pebbles,	50 "	58	"	Recent.
Clay, *recent marine diatoms*,	58 "	63	"	Recent.
Heavy gray gravel, fossiliferous pebbles, fresh water.	63 "	72	"	Recent.
Clay, *recent marine diatoms*,	72 "	75	"	Recent.
Gray sand and gravel, water,	75 "	86	"	Recent.
Fine and coarse sand	86 "	105	"	Probably also recent.
Heavy gray gravel,	105 "	109	"	Probably also recent.
Streaks of gray clay and sand	109 "	116	"	Probably also recent.
Alternations of fine and coarse sands and gravels	116 "	265	"	Quaternary.
Most of the strata of this division are yellowish in color and contain no micro-organisms.				Quaternary.

"The similarity of the assemblage of diatoms in the clays from the Absecon wells with those noted above in clays at 58 to 63 feet, and again at 72 to 75 feet, considered in connection with

the alternations of gravels with fossiliferous pebbles, suggests an identity of strata at the two localities.

"The water at the 24-foot wells at the water-works plant at Absecon is fresh and wholesome, as proved by its long use at Atlantic City. Its original source where it enters the sand that dips beneath this recent diatomaceous clay bed is probably not very distant. This water-horizon, however, under the beaches has not been considered satisfactory, and it or some horizons very closely related to it have been tried at a number of points between Atlantic City and Cape May. It was met with in Fifield's boring at the depth of 84 feet, associated with a similar succession of beds as at Atlantic City. In the absence of specimens of the clays, however, the presence of diatoms, which most likely occurred there, cannot be positively asserted.

"Fresh-water springs, long known and used by boatmen for filling their casks, occur at various points in the marshes between the beaches and the mainland. One such may be noted on Barrel island, in the bay near Beach Haven, and another, until recently, on Peter's Beach, near Atlantic City. The storms, however, have washed away a large portion of this beach and buried this spring beneath the waters of the inlet. These springs are probably fed from this Absecon artesian horizon.

"The writer is inclined to class as of the same geological age with these recent diatom beds the gravels and sands below them to the depth, at Atlantic City, of at least 125 feet."

SHALLOW ARTESIAN WELLS AT ATLANTIC CITY, N. J., AT ATLANTIC CITY COOLING CO.'S PLANT.

Elevation, 5 feet ; diameter, 4½ inches ; depth, 93 feet.
Water rises barely to the surface.

During the past year four wells have been put down, to the depth of about 93 feet each, into a water-bearing heavy gravel. The water obtained, being several degrees lower in temperature† than that from the deeper wells, is better adapted for

* Annual Report, 1892, page 181.

† The temperature of the deeper wells varies from 58 to 62 degrees according to depth—that of the deepest wells being the highest. We have been unable to learn the exact temperature of these shallow wells above reported.

the cooling and condensing purposes, for which the company requires a considerable amount of water.

At the depth of 50 to 60 feet a bluish clay or alluvium was penetrated, which, on microscopic examination, we find to contain *diatoms* of fresh water and marine forms. The assemblage of *diatoms* shows this to belong to one of the most recent geological deposits along the coast, one of probably late Pleistocene age. Below the blue clay fairly heavy gravel was encountered which contains water that just rises to the surface. This gravel occupies the interval from 60 to 93 feet.

BORED WELLS AT SHINNECOCK HILLS, NEAR MONTAUK POINT, LONG ISLAND, N. Y.

Depth, 60 feet.

P. H. and J. Conlin inform "that they have sunk wells at Shinnecock Hills, near Montauk, and found gravel and water at 60 feet from the surface."

BORED WELL ON A HILL NORTH OF SIASCONSETT, TOWARD SANKATY HEAD, NANTUCKET, MASS.

Elevation, 70 feet; diameter, 4½ inches; depth, 103 feet.
Water rises within 70 feet of the surface.

This well is located at the cottage of S. Murray Mitchell and was bored by George H. Orcutt, who in 1896 furnished the above information, and who says that the boring was in sand throughout, and that he did not observe the occurrence of any sea shells.

ARTESIAN WELL AT LAUREL, DEL.

Elevation, 26 feet above mean low water.
Diameter 4 inches; depth, 115 feet.
Water rises within 19 feet 6 inches of the surface.
Yield, 110 gallons a minute.

During the summer of the present year a well was put down by J. H. K. Shannahan at Laurel, Del., to furnish that place with a public water-supply. From Charles S. York, C. E., we have received the following record:

Yellow clay,	2 feet	=	2 feet.
Light gray sand,	6 "	=	8 "
Yellow clay,	15 "	=	23 "
Coarse yellow sand ; yielded water, 10 gallons a minute,	40 "	=	63 "
Yellow clay, 20 inches, say,	2 "	=	65 "
Small flinty gravel ; yields water, 60 gallons a minute,	6 "	=	71 "
Yellow clay,	2 "	=	73 "
Small pebbly gravel, with water,	8 "	=	81 "
Yellow clay, 9 inches, say,	1 foot	=	82 "
Water-bearing sand with pebbly gravel,	9 feet	=	91 "
Water-bearing sand,	14 "	=	115 "

The horizon 91 to 115 feet yielded 110 gallons a minute.

This well was finished with screens so as to draw from between the depths of 64 to 70 feet and of 72 to 85 feet.

ARTESIAN WELLS AT SEAFORD, DEL.

Two wells—Depths, about 65 feet each.
Elevation near high-tide level.
Overflow, at high tide, 15 gallons each per minute.
Overflow at low tide, very little

J. H. K. Shannahan reports having put down two wells at Seaford, Del., the location being a little above high-water mark and the depth of each about 65 feet. The wells were finished with screens so as to draw from between the depths of 53 and 65 feet.

This horizon is evidently the same as that supplying the wells of the preceding record at Laurel, seven miles southward.

IV. Wells Mostly in Northern New Jersey.

Sec. 1. Wells Reported by Stotthoff Bros.

The following 36 wells were put down the past year by Stotthoff Bros., who have courteously furnished the data respecting them.

Most of these wells are in northern New Jersey; a few are, however, on Staten and Long Islands, N. Y., and a few others in

Pennsylvania, the latter mainly in the Delaware valley. The well at New Dorp, Staten Island, with a depth of 600 feet, is noticeable, since all below the depth of 28 feet was through serpentine.

Besides these the records of two other wells bored by them at Burlington appear with the wells classified under the heading "Wells in Cretaceous."

BORED WELL AT HUNTSVILLE, SUSSEX COUNTY, FOR E. E. HAWK.

Earth, ... 16 feet = 16 feet.
Limestone, ... 170 " = 186 "

Practically no water; not more than one-half gallon per minute.

BORED WELL AT HUNTSVILLE FOR W. J. YOUNG.

Sand, ... 95 feet = 95 feet.

Supply, 15 gallons per minute at 60 feet from the surface.

BORED WELL AT SPARTA FOR C. C. COX.

"Gray mixed rock or soft granite with flint and limestone. . . to 55 feet.

Supply, 5 gallons per minute.

BORED WELL AT BERNARDSVILLE FOR MISS M. APPLETON.

Depth 128 feet.

Yellow clay and loose stones to rock at . . . . . 39 feet.
Gray rock, with seams of much softer yellow rock, . . 89 feet = 128 "

This well produces 35 gallons a minute at 29 feet below the surface.

BORED WELL AT BERNARDSVILLE FOR MISS S. F. CONDICT.

Depth, 224 feet.

Earth, ... 2 feet = 2 feet.
Gray rock, ... 222 " = 224 "

Supply, 7 gallons per minute at 140 feet from the surface.

BORED WELL AT BERNARDSVILLE FOR GEORGE B. POST.

Depth 621 feet.

Earth and loose stones to rock,		26 feet.
Dark gray rock,		595 "
		621 "

Supply, 3½ gallons a minute.

BORED WELL AT FLEMINGTON FOR GEORGE C. PEDRICK.

Depth to solid rock,	15 feet	= 15 feet.
Red shale,	36 "	= 51 "

Supply, 18 gallons per minute.

BORED WELL AT FLEMINGTON FOR FLEMINGTON WATER CO.

Earth	4 feet	= 4 feet.
Gray and blue rock, "very seamy, similar in character to what is called blue jingler,"	164 "	= 168 "
"Vein of clay" (?)	8 "	= 176 "
Red shale,	229 "	= 405 "

Supply, 107 gallons a minute at 161 feet from the surface.

BORED WELL AT READINGTON, FOR JOHN E. HOAGLAND.

Earth,	20 feet	= 20 feet.
Red shale,	67 "	= 87 "

Supply, 15 gallons per minute.

BORED WELL AT THREE BRIDGES FOR FARMERS' DISPATCH CO.

Earth	6 feet.
Cased and cemented to	30 "
Balance red shale to total depth of	94 "

Supply, 15 gallons per minute.

BORED WELL AT LIBERTY CORNERS FOR FRANK BALLENTINE.

Earth,	5 feet =	5 feet.
Red shale,	104 " =	109 "

Supply, 7 gallons a minute at 65 feet from the surface.

BORED WELL AT SOMERVILLE AT CHILDREN'S MEMORIAL HOME.

Depth, 152 feet.

This well was drilled 8 inches in diameter to the depth of 51 feet and then cased with a six-inch pipe and cemented. The boring was then continued beyond this entirely in red shale to a total depth from the surface of 152 feet. The yield is 25 gallons per minute at 125 feet from the surface.

BORED WELL AT GOODMAN'S CROSSING, L. V. R. R.

Earth,	33 feet =	33 feet.
Red shale,	73 " =	106 "

Supply, 20 gallons per minute at 40 feet from the surface.

BORED WELL AT MAYWOOD FOR MRS. C. M. GOMEZ.

Earth	15 feet =	15 feet.
Red shale,	104 " =	119 "

Supply, 18 gallons per minute at 43 feet from the surface.

BORED WELL AT MAYWOOD, BERGEN COUNTY, FOR JOHN ENGLISH.

Red sandstone,	46 feet.

Supply, 10 gallons a minute.

BORED WELL AT TRENTON FOR R. M. JONES.

Earth.	3 feet =	3 feet.
" Hard but fine grained red and blue sandstone," . .	140 " =	143 "

Supply, 10 gallons a minute at 125 feet from the surface.

BORED WELL AT MARTINVILLE, SOMERSET COUNTY.

Diameter, 8 inches; depth, 114 feet.

Earth, ...	10 feet =	10 feet.
Cased and cemented to keep out surface water to . . .		50 "
Balance, blue and red shale to a total depth of		114 "

Supply, 15 gallons a minute at 60 feet from the surface.

BORED WELL AT UNION, UNION COUNTY, FOR C. H. JOHNSON.

Earth, ...	23 feet =	23 feet
Red shale, ...	153 " =	176 "

Supply, 10 gallons per minute at 60 feet from the surface.

BORED WELL AT LINDEN FOR THE P. R. R.

Depth, 122 feet.

This well was drilled 8 inches in diameter to the depth of 40 feet and then cased with a 6-inch pipe and cemented to prevent surface drainage.

The boring was continued beyond this to a total depth of 122 feet, producing 15 gallons a minute at 22 feet from the surface.

BORED WELL AT ELIZABETH FOR WILLIAM HEILICH.

Earth and hard pan, ...	58 feet =	58 feet.
Red shale, ...	158 " =	216 "

Supply, 10 gallons a minute at 125 feet from the surface.

BORED WELL AT PASSAIC FOR CHARLES E. BELL.

Earth,	26 feet =	26 feet.
Red sandstone,	36 " =	62 "

Supply, 20 gallons a minute at 26 feet from the surface.

BORED WELL AT PASSAIC FOR ISADORE BRAVEMAN.

Earth and quicksand,	46 feet =	46 feet.
Red sandstone,	101 " =	147 "

Supply, 14 gallons a minute at 27 feet from the surface.

BORED WELL AT PASSAIC FOR MOORELAND BROS.

Earth, stones and sand,	52 feet =	52 feet.
Red sandstone,	168 " =	220 "

Supply, 10 gallons a minute at 60 feet from the surface.

TWO BORED WELLS AT PASSAIC FOR THE BOTANY WORSTED MILLS.

Diameter of each, 8 inches; depths, No. 1, 402 feet: No. 2, 558 feet

	No. 1.	No. 2.
Sand and gravel,	20 feet.	35 feet.
Quicksand,	30 "	7 "
Clay and sand to rock,	42 "	52 "
Sandstone rock,	310 "	464 "
Total depths,	402 feet.	558 feet.

Well No. 1 was bored last year (1898).

BORED WELL AT PASSAIC FOR A. EHRHART.

Earth and sand,	35 feet =	35 feet.
Red sandstone,	115 " =	150 "

Supply, 10 gallons per minute at 88 feet from the surface.

BORING AT NEW DORP, STATEN ISLAND, N. Y., FOR CHARLES F. SCHMEIDT.

Earth,	28 feet =	28 feet.
Soapstone, soft [Serpentine],	572 " =	600 "

No water.

BORED WELL AT NEW DORP, STATEN ISLAND, N. Y., FOR WILLIAM ARNDT.

Sand and gravel,	85 feet.

This well produces 10 gallons a minute at 68 feet from the surface.

BORING AT BURDETTE, N. Y., FOR FARMERS' DAIRY DISPATCH.

Earth,	58 feet =	58 feet.
Gray sandstone or flaging,	236 " =	294 "

No water found. "Gas in the layers at 250 to 270 feet."

BORED WELL AT WOODSIDE, LONG ISLAND, N. Y., FOR THE CITIZENS' WATER CO.

This well has a depth of 227 feet and enters Gneiss rock at 138 feet. A detailed record appears on page 80 in its proper place with the records of other wells on Cretaceous.

BORED WELL AT WHITESTONE, LONG ISLAND, N. Y., FOR GEORGE KNEUPERT.

Depth, 96 feet.

Commenced in dug well at a depth of		16 feet.
Clay,	40 feet =	56 "
Quicksand,	14 " =	70 "
Medium coarse gravel, water-bearing,	26 " =	96 "

This well was finished with a screen and produces 10 gallons a minute at 60 feet below the surface.

BORED WELLS AT FAIRFIELD, CONN., FOR MRS. O. B. JENNINGS.

Well No. 1—Sand and gravel, ... 39 feet = 39 feet.
Gneiss rock, ... 10 " = 49 "

Supply, 60 gallons a minute at 9 feet from the surface.

Well No. 2—On nearly the same level, but 350 feet from well No. 1.
Earth and sand, ... 42 feet = 42 feet.
Gneiss rock, ... 16 " = 58 "

Supply, 60 gallons a minute at 6 feet from the surface.

BORED WELL AT EASTON PA., FOR VEILES BREWERY.

Diameter, 8 inches; depth, 500 feet.

Earth, ... 31 feet = 31 feet.
"Limestone," . . . . . 469 " = 500 "

Supply, 105 gallons per minute at 43 feet from the surface.

BORED WELL AT BETHLEHEM, PA., FOR T. C. CAFFREY.

"Hard pan," . . . . . 30 feet = 30 feet.
Loose yellow sand, with clay, ... 16 " = 46 "
Yellow sand, ... 20 " = 66 "

Supply, 35 gallons a minute at 27 feet from the surface.

BORED WELL AT ROSE GLEN, PA., FOR J. N. MEGARGEE.

Earth, ... 11 feet = 11 feet.
Mica rock, ... 88 " = 99 "

Supply, 10 gallons a minute at 28 feet from the surface.

BORED WELL AT SEIGFRIED, PA., FOR THE LAWRENCE CEMENT CO.

Rock, "all cement stone" to . . . . . 194 feet.

The well produces 10 gallons of water a minute; the boring, however, was not completed.

BORED WELL AT YARDLEY, PA., FOR FRANK ANDERSON.

Earth,	15 feet	= 15 feet.
Red shale,	30 "	= 45 "

Supply, 3 gallons per minute.

BORED WELL AT YARDLEY, PA., FOR R. C. BELVILLE.

Sand and loose stones,	37 feet	= 37 feet.
Red sandstone,	21 "	= 58 "

Supply, 15 gallons per minute at 35 feet from the surface.

Sec. 2. Bored Wells Reported by P. H. and J. Conlan.

The following records of wells put down during the year by P. H. and J. Conlan have been courteously furnished by that firm. Among them the well records at Summit and vicinity are especially interesting, and supplement those reported last year by C. L. Tribus at Chatham and Madison, in that they demonstrate a phenomenal and abundant overflow of water in this region at depths of from 80 to 150 feet in gravel overlying the Newark red sandstone rocks, and apparently overlaid by an impervious bed of clay. (See note by H. B. Kümmell, second paragraph, next page.)

TWO BORED WELLS NEAR SUMMIT, BETWEEN SUMMIT AND CHATHAM.

Depth of each, 120 feet.

Near Summit, N. J., remarkable water-bearing strata were encountered in the glacial drift. Two wells were sunk near the old mill, on the Passaic river, midway between Summit and Chatham. Both wells are 120 feet deep. Glacial till and clay formed the overlying beds, beneath which a water-bearing bed of gravel, resting upon the red shale, was struck. The water rose 10 feet above the surface. Owing to the large amount of free ammonia present, the water was unfit for use and the wells have been closed.

TWO BORED WELLS THREE MILES NORTHEAST OF SUMMIT, ALONG CANOE BROOK.

Depths 90 and 125 feet.

Two wells were put down along Canoe brook about three miles northeast of Summit. The first well was 125 feet deep and the second 90 feet, the latter with an 8-inch hole. The overlying strata were mainly till and clay, beneath which the water-bearing gravel bed was struck. The water rose 25 feet above the surface. One million gallons per day is the estimated flow from these two wells. The water is excellent.

(All four of these wells, together with those near Chatham reported by Mr. Tribus in the Annual Report for 1898, are in the basin of the glacial lake Passaic, and the impervious clay beds overlying the water-bearing gravels may in part be the lacustrine deposits. H. B. K.)

WELL IN NEWARK, N. J., FOR THE CELLULOID MFG. CO.

Depth, 827 feet

"We put down a 10-inch well for the Celluloid Mfg. Co. to a depth of 827 feet; it is 100 feet to rock and there is a 10-inch hole in the rock. The well yields a very large quantity of water, over 200 gallons per minute. It is situated on Ferry and Fillmore streets, at their works."

WELL IN NEWARK, N. J., FOR CAULEY, CLARK & CO.

Depth, 400 feet

"In the Newark meadows, near the Lehigh Valley Railroad track, we sunk a well for the firm of Cauley, Clark & Co. We went down to a depth of 400 feet, obtaining but a very poor supply of water. It is 225 feet to the red sandstone, which is the prevailing rock all along that district in Newark."

WELL AT HARRISON, N. J., FOR PETER HAUCK & CO.

Depth, 400 feet.

This well, which we put down for Peter Hauck & Co., is situated on the east side of the Passaic, and is 400 feet deep. It is 135 feet to rock, the remainder being in soft red shale. The yield is about 100 gallons per minute. The water is of a very excellent quality. Harrison avenue and 5th street.

WELL AT KEARNY, N. J., FOR THE LINOLEUM WORKS.

Depth, 335 feet.

The depth of this well is 335 feet; 35 feet to rock. A 12-inch pipe is sunk to rock, which is a red sandstone. The water is very good in quality and the yield is over 150 gallons per minute.

WELL AT WEST ORANGE FOR E. V. CONNETT.

Depth, 384 feet.

The well for this firm was sunk to a depth of 384 feet and is 8 inches in diameter. It yields about 100 gallons per minute. The water is of excellent quality. It is 50 feet from the surface to rock, which consists of red shale and sandstone.

TEST BORINGS TO ROCK ALONG THE PASSAIC RIVER.

We have recently made several test borings along the Passaic and at the Dundee dam for the U. S. Engineer Corps, and find that the rock lies about 20 feet from surface at the dam, and 50 feet from surface at the Passaic bridge of the Erie Railroad. Those tests were made with a view of finding the depths to rock incidental to making the Passaic river navigable as far as Paterson.

WELL AT PASSAIC FOR THE OKONITE CO.

Depth, 492 feet.

We sunk this well to a depth of 492 feet. It is 110 feet to rock, which is red shale. The yield is about 60 gallons per minute, and the water is excellent.

TWO WELLS AT PASSAIC FOR THE PATERSON PARCHMENT PAPER CO.

Well No. 1—Depth, 1,000 feet.
Well No. 2 (not finished)—Depth 400 feet.

The first well we sunk for the Paterson Parchment Paper Co. was 1,000 feet deep; pipe was sunk to rock, 55 feet. Well yields a very small quantity of water. We are at the present time sinking a second well for the same company and have already drilled to a depth of over 400 feet. So far we cannot give full account, as well is only nearing completion.

WELL AT PASSAIC FOR ACHESON, HARDEN & CO.

Depth, 352 feet.

About a half-mile north of the paper factory we have just completed a well for Acheson, Harden & Co. The well is 352 feet deep; rock is 75 feet from surface. It is a remarkably good well and yields about 100 gallons per minute, while the water is of an excellent quality.

TEST BORINGS AT PASSAIC FOR THE GARA MILLS.

Depth to rock, 65 feet.

We also made test borings for the Gara Mills and found rock to be 65 feet from the surface, and the water seemingly of a good quality.

WELL AT POMPTON FOR J. D. STRATTON.

Depth, 200 feet.

At Pompton, N. J., we sunk a well for J. D. Stratton, east of railroad station, 200 feet through a close stratum of blue rock. Very little water was obtained and the well is not used.

TEST BORINGS AT RAHWAY FOR MERCK & CO.

Depth, 100 feet.

We have made some tests at Rahway to the depth of 100 feet, near where we drilled wells for the Pennsylvania Railroad Co. at their water-scoops. The rock is the usual kind found between Paterson and Trenton—that is, red shale.

BORED WELL AT JERSEY CITY FOR THE GREENVILLE BREWING CO.

Depth 64 feet.

In Jersey City, on the west side, near Newark bay, we sunk a well for the Greenville Brewing Co. to a depth of 64 feet and encountered the blue trap-rock of the Palisades; no water was obtained.

WELL ON SHOOTERS' ISLAND, SOUTHERN END OF NEWARK BAY AND NEAR ELIZABETH.

Depth 200 feet.

For the firm of Townsend & Downey we sunk a well 200 feet deep, 55 feet to rock, and met with very peculiar strata, consisting of beds of a yellow, hard rock, interspersed with layers of black slate. We drilled to a depth of 200 feet, but found no water. (These are probably the metamorphosed shales overlying the Palisade trap-sheet.—H. B. K.)

BORED WELL IN NEW YORK CITY AT BOULEVARD AND 72D STREET.

Depth, 700 feet.

This well was put down for W. E. D. Stokes, and was drilled to a depth of 700 feet in gneiss rock with micaceous strata, and the yield is about 25 gallons per minute. The water is of a hard quality.

WELL AT ROCKAWAY, L. I., N. Y., FOR WM. S. ROGERS.

This well we sunk for Wm. S. Rogers, at Rockaway, L. I., and is a remarkably good one. The water was found in great abundance in sand and gravel near the surface. The quality is good.

Sec. 3. Wells at Jersey City.

Two wells are reported by the Joseph Dixon Crucible Co. as having been put down at their works at Jersey City.

Well No. 1.—1,205 feet yields 22 gallons per minute.
Well No. 2.— 400 " " 28 " " "

No report was made of the strata penetrated, but they were probably glacial drift and red shale and sandstone.

PART III.

Chlorine in the Natural Waters of the State.

By WILLIAM S. MYERS.

Chlorine in Natural Waters of the State.

By WILLIAM S. MYERS.

The well-known significance of chlorine in potable waters is of sufficient importance to render the adducement of theories relating to it unnecessary. Sanitary authorities are in agreement as to the value and importance of the chlorine factor in the formation of a judgment as to the quality of a water-supply. As supplementary to the Geological Survey's studies of the water-supplying of the State, analyses have been made with a view to securing data for a map of the State, showing the normal chlorine in its potable waters in each locality throughout the State. Satisfactory progress has been made and valuable data secured during the past ten months. Considerable data are yet to be obtained and the variation in chlorine content is so wide as to well warrant the continuance of the work; and a map, at least a preliminary one, can soon be made.

The data, as published, will be useful, it is hoped, to sanitarians; and it will invite the attention of every one interested in water-supply; a subject of evergrowing importance to all communities.

As an illustration of the use of the map, for example: Should examination show the chlorine content of a given water to be, say, ten parts per million, and the normal for that place be known, from our map, to be several parts less per million, some explanation of the difference would be necessary, otherwise the quality of the water would be regarded as impaired. In the absence of adequate explanation, sewage or other contamination might properly be suspected.

If the sources of pollution could not be discovered and removed, the water should be rejected. On the other hand,

should the content fall below the normal, or equal it, the fact would be strong evidence in favor of pronouncing the supply to be a good one.

In short, the data which we are securing will serve, we believe, to render the results for the chlorine determination in waters of New Jersey of more value and importance than ever before. Instead of more or less conjecture as to the significance of the figures for chlorine, we shall have more rigorous and exact interpretation of results, and consequently more trustworthy opinions.

As to artesian supply and waters not regarded as strictly surface-waters, a separate table of analyses is given. These are to be taken as a separate study, but only after more complete data can be had of surface supplies.

In regard to the surface supply, when rivers and small streams are recorded, the particular places will be indicated when the map is published.

The data for total solids in the surface waters will be interesting to those who study the Surface Geology of the State, and the amount of annual erosion and weathering may be considered in this connection.

Chemical sanitary analyses are given of certain waters, and these will be studied in connection with the analyses for total solids and chlorine. Taken as a whole, the standards for this State may be found to be somewhat different from other localities. The data are as yet not complete enough to enable one to draw inferences of a trustworthy nature. As our data increase we expect that careful comparative studies will throw some additional light on the relations of surface, ground and artesian supplies.

Referring to the general subject of water-supply, it may be well to note that in a recent station report the Vermont official chemists state that, of the large number of waters examined by them during a period of five years, 20 per cent. of the spring waters examined were impure. Of the wells, 50 per cent. were impure. Of the pond and stream supplies, 41 per cent. were impure or unfit for use.

In view of the steady increase in the population of our State and of our adjoining great cities, and in view of the steady increase in *per capita* daily consumption of water, it is difficult

to overestimate the importance of conserving our present supply. Equally essential is the completion of the Survey's investigation of the whole subject as a matter of vital importance to our commonwealth.

All the samples were taken with great care; some by Professor Smock, State Geologist; some by Professor S. R. Morse; some by Mr. W. C. Hawley; others by Mr. Kümmel, assistant State Geologist, and Mr. Smith of the Survey. A number of the waters were also sampled by the writer.

RUTGERS COLLEGE CHEMICAL LABORATORY, DECEMBER 1, 1899.

WILLIAM S. MYERS,
Department of Chemistry.

Table of Analyses of Surface-Waters.

	Port Jervis, N. Y. Delaware River.	Delaware River. Delaware Water Gap. (159)	Spring Holmdel. Monmouth County.
Total Solids, ...	36.40	48.00	. . .
Chlorine, ...	1.20	2.90	6.80
	Clinton Reservoir. (167)	Macopin. (168)	Intake Reservoir. (169)
Total Solids, ...	63.20	74.80	60.00
Chlorine, ...	2.80	2.60	2 70
	Lake Hopatcong. (184)	Hurd's Hopatcong. (172)	South River at Spotswood.
Total Solids, ...	45.00	90 00	25.00
Chlorine, ...	2.30	2.40	5.30
	Lake Mashipacong. (175)	Sand Pond. (176)	Swartswood Lake. (177)
Total Solids, ...	16.00	48.00	71.00
Chlorine, ...	0.80	1.20	2.10
	Culver's Lake. (178)	Big Flatbrook. (179)	Spring, Culver's Gap. (180)
Total Solids, ...	78.00	30.00	38.20
Chlorine, ...	0.80	1.10	1.20
	Bevan's Spring. Peter's Valley. (181) ?	Red Medina, 1½ ml. S. W. Wallpack. (182)	Budd's Lake. (183)
Total Solids, ...	194.00	25.00	100.00
Chlorine, ...	2.40	0.70	2.40

	Matchepanix River. (186)	Ambrose's Brook at Bound Brook. (187)	Robinson's Brook. (188)	Morristown City. (190)
Total Solids, . .	55.00	90.00	167.00	110.00
Chlorine, . . .	6.40	5.60	6 20	2.90

	Somerville, Raritan River. (157)	Trenton, Delaware River. (161)	Lambertville, Delaware River. (160)	East Millstone, Millstone River. (193)	Stony Brook. (192)
Total Solids, .	98.00	80.00	78.00	63.00	75.00
Chlorine, . . .	5.20	4.80	3.70	6.60	5.90

Table of Detailed Analyses of Surface Waters Submitted for Chemical Sanitary Analysis.

	Delaware River at Delaware Water Gap.	Delaware River at Lambertville.	Delaware River at Trenton, Calhoun St.
Total Solids, ...	48.00	78.00	80.00
Total Organic and Volatile Matter, ...	8.00	38.00	40.00
Total Salts, Mineral Matter,	40.00	40.00	40.00
Chlorine, ...	2.90	3.70	4.80
Free Ammonia, ...	0.04	0.11	0.12
Albuminoid Ammonia, . .	0.07	0 05	0.08
Nitrogen in Nitrates, . . .	0.12	0.005	0.01
Nitrogen in Nitrites, . . .	0.004	0.005	0.01

	Raritan River, Somerville.	Clinton Reservoir near Newfoundland, N. J.	Intake Reservoir.	Macopin Lake.
Total Solids, ...	90.00	63 20	60.00	74.80
Total Organic and Volatile Matter, ...	42.00	11.20	28.80	28.00
Total Salts, Mineral Matter,	56.00	52.00	31.20	46.80
Chlorine, ...	5.20	2.80	2.70	2.60
Free Ammonia, ...	0.16	0.14	0.12	0.09
Albuminoid Ammonia, . .	0.04	0.06	0.19	0.23
Nitrogen in Nitrates, . . .	0.02	0.00	0.00	0.00
Nitrogen in Nitrites, . . .	0.01	0.00	0.00	0.00

Table of Analyses of Artesian Well Waters.

	Brigantine.	Lakewood. 600 feet. (150)	Lakewood. 600 feet. (151)	Asbury Park. 600 feet. (152)	Asbury Park. 1,100 feet (153)
Total Solids, . . .	125.00	119.80	108.60	126.00	136.00
Chlorine, ...	10.20	3.90	4.91	5.90	7.10

	Atlantic City. "Consumers' pumping station." (154)	Atlantic City. Gen'l Supply. (155)	Hotel Dennis. 850 feet. (156)	Camden. Artesian. (158)
Total Solids, ...	128.80	42.00	150.00	32.00
Chlorine, ...	9.82	13.30	10.12	5.73

	Marlton Well. (171)	East Orange. (170)	Jersey City and Dixon Ave. (174)
Total Solids, ...	200.80	238.00	216.00
Chlorine, ...	6.80	16.10	40 52

Detailed Analyses of Waters Submitted for Chemical Sanitary Examination—Artesian Wells.

	Lakewood. I.	Lakewood. II.	Asbury Park. I.	Asbury Park. II.
Total Solids, ...	119 80	108.60	126.00	136.00
Total Organic and Volatile Matter, ...	39.30	18.10	28.40	40.00
Total Salts, Mineral Matter,	80.50	90 50	97.60	96.00
Chlorine, ...	3.90	4.91	5.90	7.10
Free Ammonia, ...	0 03	0 05	0 04	0.03
Albuminoid Ammonia, . .	0.05	0.07	0.08	0.05
Nitrogen in Nitrates, . . .	0 10	0 12	0.02	0.02
Nitrogen in Nitrites, . . .	0 25	0.25	0.02	0.04
Depth of Wells, ...	600 ft.	600 ft.	600 ft.	1,100 ft.

	Brigantine Co. Brigantine.	Atlantic City. General Supply.	Atlantic City. Consumers' Station.	Atlantic City Hotel Dennis.
Total Solids, ...	125.00	42.00	128.80	150 00
Total Organic and Volatile Matter, ...	25.00	8.00	38.40	46.00
Total Salts, Mineral Matter,	100.00	34 00	90.40	104.00
Chlorine, ...	10.20	13.30	9.82	10.12
Free Ammonia, ...	0.24	0.04	0.24	0.06
Albuminoid Ammonia, . .	0.00	0.04	0.04	0.03
Nitrogen in Nitrates, . . .	0.00	0.0001	0.00	0.06
Nitrogen in Nitrites, . . .	0.005	0.0000	0.00	0.00
Depth of Wells, ...	700 ft.	30 ft.		856 ft.

	Camden Supply.	Marlton Town Well.	East Orange General Supply.
Total Solids, ...	32.00	200.80	238.00
Total Organic and Volatile Matter, ...	16.00	58.00	86.00
Total Salts, Mineral Matter,	16.00	142.80	152.00
Chlorine, ...	5.73	5.90	16.10
Free Ammonia.	0.05	0.06	0.08
Albuminoid Ammonia, . .	0.07	0.02	0.08
Nitrogen in Nitrates, . . .	0.02	0.10	8.00
Nitrogen in Nitrites . . .	0.00	0.00	0.00
Depth of Wells			

PART IV.

THE MINING INDUSTRY.

I. Report on Iron Mines,

By GEORGE E. JENKINS.

II. Notes on Copper Mines,

By HENRY B. KÜMMEL.

Review of the Iron Mining Industry.

By GEO. E. JENKINS, C. E.

During the past year the iron-mining industry has experienced one of the most remarkable revivals in its history, for at no time were there fewer mines in operation and prices so low as at the close of last year's report. At that time pig iron was commanding only ten dollars per ton at the furnaces, and New Jersey ore sold at an average of two dollars per ton. In January of this year, after a long period of extremely low prices, pig iron began to advance, and in less than six weeks the price had risen more than one hundred per cent. A consequent rise in the price of iron ore took place, and has continued, so that the average price of ore to-day is about three dollars and one-half per ton. All the mines that were in operation last year have put forth every effort for an increased yield, and many of the enterprises which had been closed by low prices have resumed operations, and several sales of mining property have taken place at something like the old-time prices. Many leases have also been made, and, on the whole, the industry is probably in as satisfactory a condition as ever was known in its history.

The question of the concentration of the large quantities of lean ores has also received closer attention, and there certainly is a wide field open for investigation along this line. The concentrating plant at Hibernia, in addition to the one at Edison, has been operated most of the year on the lean refuse from the Hibernia vein and Beach Glen ore. At the close of last year the following mines were in operation: Hurd, Richard, Edison, Lower Wood, and Wharton, on the Hibernia vein, and the new Sterling Slope, at Irondale. To this list is to be added, as now in operation, the Ringwood mines, Green Pond, Beach Glen, Ford, Weldon, Kishpaugh, Oxford mines and the Mt. Hope

mines, and the following notes are a more extended review of these several enterprises as well as references to a number of promising prospective ore properties.

The Iron-Mining Industry.

HURD MINE, HURDTOWN, N. J.

The owners of this property did some prospecting with a diamond drill in search for new shoots of ore, but nothing very promising was secured from the tests, and the results of this work were reported last year.

In the spring of 1899 a lease was made with Pilling & Crane, of Philadelphia, and they have been mining, from old workings, about two hundred tons of ore per month, and in addition have been exploring for new shoots of ore. This work consists in the driving of a cross-cut from the old working, known as the "Clay shaft," in a southeast direction toward the old Hurd shoot of ore for a distance of 120 feet, where a deposit of ore was cut, but it proved to be small and to have been previously worked upon. A shaft 200 feet deep was sunk so as to come down upon the offset, and a cross-cut or drift is now being driven along the throw of the offset toward the large deposit of ore presumed to have been broken off from the old deposit.

RICHARD MINES.

During the year the work on the very remarkably large deposit of ore which has been developed in the past four years has shown that the size and extent of the deposit has not yet been determined. The large quantity of ore found on the foot-wall side of the vein has during the past year been duplicated by the discovery and working of an equally large deposit on the hanging-wall side. The drifts driven in an easterly direction along the hanging-wall have shown ore from fifteen to twenty feet thick, and as much as could be safely removed has been taken out, but a very large amount still remains.

The ore in the foot-wall in No. 2 mine has been blasted down, and carried with it the small "horser," or rock, so that the dis-

tance from wall to wall is very near one hundred feet, and consequently too wide a gap to keep up by timbering.

The drift six hundred feet east of No. 2 shaft has gone forward and pressed through the pinch or roll in the deposit, and from present indications the vein is returning to its regular dip.

No work has been done in No. 3 shaft during the past year, because of the unsatisfactory condition of the shaft near the surface, and all the energy possible has been devoted to the sinking of the new slope, known as No. 5.

The product of the mine has been curtailed about 36,000 tons, owing to the shut-down of the No. 3 shaft.

In the No. 1 mine some explorations were made on both the foot-wall and hanging-wall side of the vein, and ore was discovered which ran about ten feet thick in both drifts.

No sinking has been done during the past year, as it will take at least two years to remove the ore standing in sight on the foot and hanging walls.

The No. 5 slope, which is to be the main outlet of the mine, is now down 700 feet, and at the 500-foot level a cross-cut 110 feet long was driven to the Mount Pleasant vein, and a deposit eight feet thick was cut. The drifts east and west are now being planned, and in all probability ore will be mined from this part of the vein before the year 1900 closes.

The slope known as No. 6, which was planned to strike the Mount Pleasant vein, has been put down 550 feet and "holed through" to the present easterly working on this vein. This will put an end to the long "tram" of more than a thousand feet to Slope No. 1, through which the ore now finds an outlet to the surface.

A large amount of money is being expended in the introduction of new machinery, consisting of a nest of boilers having a capacity of 1,500 horse-power, and a large, latest-improved Ingersoll Sergeant air-compressor of 750 horse-power. A new pumping system will also be installed in No. 5 slope, and a modern hoist-way and equipment will all add to a very decided increase in the ore tonnage of this property.

MOUNT HOPE MINES.

The property of the Mount Hope Mining Company was purchased early in 1899 by the Empire Steel and Iron Company of New York City, and during the year the working in the Elizabeth mine has been unwatered and about 3,000 tons of ore removed from the western end of the mine adjoining the Teabo property. A new shaft which was put down to the face of the eastern stope from the tunnel level has been opened to surface, and this shaft will give improved facilities for removing the ore.

The ore mined was found on analysis to contain:

Metallic iron,	61.822
Silica,	6 700
Lime,	1.600
Magnesia,	trace
Sulphur,	"
Manganese,	"
Aluminum,	1 50

This is the richest of the five veins of ore existing on this tract.

The deepest working in the Elizabeth vein is 195 feet, and the deposit has been worked 200 feet along the vein in its northeast southwest trend. The width of the vein is from 4 to 6 feet. The Taylor mine and the Side Hill mine have not yet been freed from water, but these two mines will be pumped out during the coming year. The workings in the Taylor vein are 576 feet along the vein, and the present ore-shoot has a height, from the top to the bottom, of 240 feet and an average thickness of 10 feet. The Side Hill vein is 480 feet deep to the bottom working, and the ore-shoot is 192 feet high and average 6 feet thick.

The Brennan vein and one other vein are both small, and pay to work only when prices are high.

The Hickory Hill ore-deposits have not been worked for some years, and some plan will be fixed upon to give this property a thorough test. It is the intention of the present operators to make this property yield at least 100,000 tons of ore a year.

NEW STERLING SLOPE AND HURD MINE.

The work during the year has consisted in developing the ground between the eastern offset and the Hurd workings. The old Hurd slope has been pumped out and a drift driven to intersect the old workings in Hurd mine, thus affording much needed relief in the way of ventilation, and enabling a change in the pumping arrangements which will reduce the present water-lift 185 feet. The amount of water is 60 gallons per minute, and it is all pumped by steam pumps.

On No. 5 level, in driving toward Hurd mine, a large body of ore, 9 feet wide, 60 feet high, was opened upon, and in No. 6 level the vein is 6 feet wide. On No. 8 level, in the drifts east of the offset, the vein showed a width of 12 feet of clear granular ore.

The Sterling slope was sunk 30 feet, mostly in barren ground, but the sink is to be put down 60 feet or more in order to test for a lower shoot of ore underlying the old No. 13 shoot.

These developments show what may be expected under the old Hurd slope, and adds considerable encouragement to the operators of this and adjoining property—the Orchard mine.

BEACH GLEN MINES.

The prospecting work carried on by the Beach Glen Mining Company in the year 1898 was stopped after a few months, and a lease made to Joseph Wharton, who has been operating the mine for the purpose of concentrating the ore in the works at Hibernia. The method of mining consists of open cutting, as the deposit is nearly thirty feet wide. The material, as it is mined, yields 30 to 40 per cent. of iron, and the concentrate is 60 per cent. The material crushes and separates well, and, as it is a Bessemer to start with, the final product is very low in phosphorus.

The mill was put in operation during the summer of 1899, and 3,750 tons of concentrates obtained from the refuse rock of Hibernia vein. The Beach Glen ore has been used only in the latter part of the year, and about 900 tons of crude material put

through the mill, yielding 400 tons of concentrates, which ran 60 per cent. in metallic iron and .009 phosphorus.

HIBERNIA MINES.

The group of mines along this deposit consists of the following:

THE LOWER WOOD MINE.

As was stated in last year's report, the amount of work done on this property is very limited, but as it is the outlet for all the ore mined from the adjoining Church or Crane lot, it is of considerable interest and value to the operators on this account. The work for the year in actual mining has been confined to the Church or Crane lot, and it consists of the driving of stopes No. 19 and No. 20 toward the De Camp line to the eastward and sinking on No. 21 level. This is the deepest working on the Hibernia vein, and is 851 feet below tunnel level and 268 feet below sea level. The width of the vein in the present stopes is about thirteen feet, but there is more or less rock in the vein, and it is not at all regular, being very "bunchy." The ore-shoots are lenticular in form and have a pitch of about 27 degrees to the northeast.

CHURCH OR CRANE MINE.

This mine lot owned by the North Reformed Church, of Newark, N. J., and leased by the Andover Iron Company, was purchased by the lessees during the past year and has been operated through the Lower Wood Mine.

DECAMP MINE.

The owners of this property have not had any mining done since 1890, but during the year 1899 Mr. Joseph Wharton became the owner, and the mine will, without doubt, be a producer next year.

UPPER WOOD MINE.

The Glendon Iron Company formerly operated this mine, but during the year Mr. Joseph Wharton secured the title to the property, together with the Glendon mine lot, from the receiver of the Glendon Iron Company. The underground railroad tunnel is being driven in the foot-wall rock so as to connect with the shafts on the Upper Wood and DeCamp properties, and the mine no doubt will be in operation next year.

WHARTON MINE.

At no time in its history has this mine been so great a producer as during the past year, and the future is most promising. During the year every available stope has been worked and these nine stopes have yielded a large tonnage of ore. In addition to the regular stoping a sink of 50 feet was put down and the ore body continued to show the same regularity of width.

The improvements in the mine plant, made note of in last year's report, have been completed, and two well-equipped hoistways are now available, through which the mine's product is hoisted to surface.

The new shaft on the eastern end of the property has been sunk an additional depth, but no great quantity of ore has been discovered. At a depth of 105 feet a shoot of ore was cut, but it lacked continuity and soon cut out. It is the purpose to continue the sinking and "hole" through to the drift which is being driven eastward to intersect the shaft, thus giving an additional outlet for the eastern end of the mine. The recent purchases made by Joseph Wharton now give him control of 3,300 feet along the Hibernia vein and practically consolidating the whole mining interest in one operator. This will certainly lead to valuable results and increase the product of one of the most persistent ore-deposits in New Jersey.

GREEN POND MINE.

For almost twenty years the Green Pond mines have been idle, principally because of legal difficulties and the inability of

the conflicting interests to get together upon some satisfactory basis. In 1898 The Carterette Steel Company, of 31 Nassau street, New York city, began to acquire interest, and the whole tract of the Copperas mine is now owned by this company. The mine has been pumped free from water and a new plant is being erected with which to actively work the mine.

The several lines of attraction across this tract have been opened upon by shallow test-pits, but the work has been done without definite aim or plan in mind, and hence no very satisfactory data is at hand from which to draw accurate conclusions. The workings in Slopes Nos. 1 to 6 have been carried deep enough to give some idea as to the length, width and continuity of the ore body. Slope No. 1 is the deepest working, being 210 feet vertical and 360 feet on the angle of the slope. The deposit is shown to be 70 feet high and from 20 to 25 feet thick, but the material in both the bottom of the slope and overhead carries ore, and no defined cap or bed-rock has yet been found.

Opening No. 3 is 74 feet to the northeast of No. 1, and the ground between these two openings is ore, so that practically the two openings are made in the same shoot of ore. The bottom of No. 3 is 70 feet below the outcrop, and the slope is 170 feet long. At the face of the breast the workings are 60 feet high and 20 feet thick. Nos. 4 and 5 are openings of shallow depths, but large quantities of ore were mined by the previous operators from these two openings. The foot-wall in all these openings is clean, but the hanging-wall is not, and the amount of magnetite in the mass would indicate that the true wall has not been found. The deposit was from 20 to 25 feet wide. The results from the magnetic-needle observations, together with the information gained from test-pits along the out-crop, show this deposit of ore to be continuous to the northeast. There is very little water to contend with and very little timbering is necessary, thus making fixed mining charges very light.

The vein to the northwest, as well as the one to the southeast, has been worked only to a very limited degree, but ore of varying width has been found to exist. The ore from the main deposit is a dense magnetite, high in sulphur and so low in phosphorus as to pass the Bessemer limit. The property has always been looked upon as a most promising deposit, and the work now installed will be watched with great interest.

FORD MINE.

There has been some work upon this property, under the direction of Isaac Hance, of Dover, but it has been confined to recovering ore above water-level and cobbing the refuse ore-heaps from previous operations.

OXFORD MINES.

The Empire Steel and Iron Company purchased and has operated this property during the year 1899.

On July 1st, work was begun in repairing the furnace and pumping out the mine. Only the Washington Mine and Slope No. 3 have been put in working order, and Slope No. 3 is the only one through which ore was mined. In Slope No. 3 the workings are 700 feet long and an east and west stope. On the west stope the vein is 4 feet wide, but the eastern stope has widened out to 10 feet of ore, and a product of over 80 tons per day is being taken out.

FELLOWS AND QUEEN MINES.

The Fellows Mine has been purchased and a lease secured on the Queen Mine by this company, and these mines are both being put into mining shape. Neither of these two mines produced any ore in 1899, and the condition of the workings has not changed since last reported upon, just before they suspended operations owing to the low prices then in command.

KISHPAUGH MINE.

The firm of Pilling & Crane re-opened this mine under lease during the past summer and have been mining about 250 tons of ore per month. The present workings are all on the Cook farm. The depth of the workings and the extent of the deposit are the same as noted in the report of 1896. But the ore is not as rich in metallic iron and is higher in phosphorus and sulphur than what was found in the more shallow workings on the Kishpaugh farm, as is evidenced from the following analysis:

Metallic iron,	48.516
Phosphorus,	.042
Sulphur,	.930

RINGWOOD MINES.

The activity of the iron business has had the effect of re-opening the Ringwood mines, and the two large shoots of ore worked before the mines were closed are producing ore. The product is sold in market, and the most of it has been used at the Pequest Furnace, by Joseph Wharton, lessee.

As a result of the study of the mining enterprises the facts are very prominently brought out that many of the deposits which have been idle for years past were not exhausted, but were closed principally by reason of the remarkably low prices that have been in command.

The acquisition of many of the mining properties by one individual or corporation, such as has been taking place during the past year, will certainly result in a reduction of operating expenses, and will ultimately be beneficial to the general mining interests of the State. In view of the revival of mining industry, and for the purpose of directing the attention of those seeking iron-ore properties, the following list of mines is republished, with such information as could be gathered in reference to the ownership, size of deposit and accessibility of product to points of shipment, etc.

DALRYMPLE MINE, SOUTHWEST OF DOVER, RANDOLPH TOWNSHIP.

The developments made upon this property have thoroughly tested the deposit, and a continuous vein of more than 500 feet in length, and averaging four to five feet of ore, was worked by the last operators. The high royalty and distance from the railroad are the two items of expense which closed the mine. With these out of the way, the property would be a most promising one. The following is an analysis of ore as shipped:

Metallic iron,	54.064
Silica,	18.00
Phosphorus,	.25
Sulphur,	trace.

BROTHERTON MINE, RANDOLPH TOWNSHIP, MORRIS COUNTY.

This property was last worked in 1882, and the parties now controlling it are negotiating a lease.

BLACK HILLS MINE.

The Dickerson Succasunna Mining Company renewed operations here in the fall of 1899. Several of the pits have been pumped out and preparations are being made for active mining. The previous work showed that there are four small veins and the deepest is only 100 feet. The material was rich in iron and very low in phosphorus.

ORCHARD MINE.

Some negotiations are now under way through which this mine will probably be leased and put in operation. The developments on the adjoining property of the New Jersey Iron Mining Company throw considerable light upon the future prospect of this mine, and afford encouragement to the owners.

ERB AND SCRUB OAKS OR DELL MINE.

The large body of ore known to exist on these properties owned by the Andover Iron Company is probably one of the best ores in New Jersey for concentration. The magnetite is found associated with a gangue made up principally of feldspar of a granular structure which crushes easily and is in every way, so far as its physical structure goes, well adapted for separation and concentration of the magnetite. The general run of the ore is about 40 per cent., and very low in phosphorus.

Negotiations are now under way for a lease to a party of capitalists, who propose opening the property and constructing a concentrating plant. The shipping facilities are of the best, as the mine is accessible to two railroads and canal.

HOFF MINE.

The Chester Iron Company operated this mine for a long term of years, but finally gave up the lease, and in 1885 and 1886 it was operated by Oram Hance & Co. There are two veins and the works are not leased. The property is worthy of more careful attention.

ALLEN MINE.

Now owned by Joseph Wharton, and some work is to be done in hopes of finding the remarkable body of ore which has been developed on the adjoining property. A careful study of the Richard mine underground workings, in connection with the Allen workings, will surely throw some light on the probability of finding the ore body on this property.

HIGH LEDGE MINE.

The analysis of the ore from this mine shows it to run 58 to 60 per cent., and the property is worthy of consideration at the hands of parties looking for iron ore.

DEKAY FARM, VERNON TOWNSHIP.

Observations by magnetic needle show a well-defined line of attraction along the strike of the rock, and here and there an outcrop of ore. A small test-pit was put down about 6 feet and a deposit of ore of workable size was uncovered. The following is an analysis of an average of the vein. The high percentage of titanium and silica, and the leanness of the ore, operate against it as a very promising mining property:

Metallic iron,	45.75
Silica,	31.40
Phosphorus,	.11
Sulphur,	.41
Titanium,	2.81

Hematite Ore.

The quantity of hematite ore, in comparison with the magnetic deposits in New Jersey, is of very limited area, but there are some localities where large bodies of this ore have been worked, notably the one at Beattystown. Some prospecting shafts were sunk during the past year, and ore in paying quantities found at a depth of about 20 feet from surface. It averages 40 per cent. of metallic iron, and, if the heavy stripping charges could be eliminated, the property would develop into a valuable one. A modified plan of the "long wall" system of coal mining, which has been used so successful at the Kishpaugh mine, is worthy of careful consideration. The property is close by good hipping facilities and the royalty asked is not excessive. The product of the mine in times past was as high as 4,000 tons per month. Some carbonate of iron was discovered at the bottom of the mine about the time the mining was closed down, but its extent was not determined.

Other hematite deposits which have yielded very considerable ore in times past are the old Pochuck mine near MacAfee, in Sussex county, and the several openings along Marble mountain, near Phillipsburg.

The Zinc Mines.

The New Jersey Zinc Company has operated its mines at Franklin Furnace, during the year, to their full capacity, and a large sum of money has been spent for the erection of a new concentrating plant of a daily capacity of 1,000 tons. The old mill at the Parker shaft, which has been in operation all the year, has a capacity of 500 tons. These two mills are intended to handle product from all the company's mines, both at Franklin Furnace and Sterling Hill, and the entire zinc product, from this district, is passed through the concentrating mill. The quantity of zinc ore mined has been larger than ever before and the future is as promising as ever.

The high prices in the zinc market have stimulated search for new deposits and on the Neighbor farm, near Vernoy station,

in Hunterdon county, High Bridge Branch of C. R. R. of N. J., some work has been done in the hope of finding a paying deposit. The work consists of the sinking of a shaft in the limestone and the discovery of some zinc ore in the shape of "blende." The amount found has not been very considerable and it is in isolated bunches without any well defined line of continuity. The developments had not been carried along very far, but, at the time of our visit, the prospect was not very encouraging.

Analyses of New Jersey Iron Ores.

A knowledge of the chemical constituents of the iron ores used in a modern blast-furnace has become a very important factor in the management of such enterprises, and the Geological Survey in previous reports has published numerous analyses of the ores from the different mines in the State for the purpose of throwing all the light possible upon the value and economic use of the ores. The following collection of analyses, which has been placed at the disposition of the Survey by Mr. B. F. Fackenthal, President of The Thomas Iron Co., is published by his consent and with the hope that the information will be of value to the general iron-mining industry.

MATTISON OPENINGS NEAR ANDERSONTOWN, HUNTERDON COUNTY.

Sampled by Mr. Fackenthal; tested in the Hokendauqua Laboratory, March, 1886.

Silica,	30.15
Titanic acid,	Trace.
Metallic iron,	35.42
Phosphorus,	.006
Sulphur,	4.03

Other analyses furnished by Dr. Mattison showed 37.37 and 37.39 per cent. metallic iron.

HAGER MINE, HUNTERDON COUNTY.

Durham Iron Works found:

Titanic acid,	7.02	5.64	4.09
Phosphorus,	.19		
Silica,	6.64		
Metallic iron,	56 39		

VANSYCKLE'S, OR CHURCH MINE.

Contains .31, .38 per cent. of vanadic acid.

PETTY MINE, NEAR BLOOMSBURY.

Sample taken from 25 or 30 tons on dump, shows:

Metallic iron,	54.37
Phosphorus,	.02
Sulphur,	None.
Manganese,	.18
Silica,	14.87
Lime,	2.32
Magnesia,	5.31
Alumina,	.40
Titanic acid,	None.
Oxide of nickel,	.63

Magnetic Ore.

Mr. Fackenthal will confirm analysis of the above ore for nickel. Property belongs to J. C. Cougle, Bloomsbury, N. J.

LEBANON MINE.

Owner claims to have 1,200 tons on dump at mines.

Silica	20.40	14.185
Titanic acid,	.47	
Metallic iron,	41.50	45.075
Phosphorus,	1.66	1.625
Sulphur,	2.74	3.634

South of New Jersey Central road. The property belongs to the estate of D. K. Hoffman, 1½ miles from Lebanon, N. J.

BEDELL MINE.

Operated and owned by Cooper & Hewitt.

Metallic iron,	34.72	34.93
Silica,	29.69	29.54
Lime,	9.14	10.09
Magnesia,	3.10	2.89
Alumina,	6.41	5 84
Phosphorus,	.008	.012
Sulphur,	.584	.380
Titanic acid,	.31	.21
Manganese,	.35	.34

BEEMER MINE.

Analyses made by Cooper & Hewitt, Durham Iron Works, 1886-1887:

	Blue.	Red.	Red.
Metallic iron,	41.10	54 23	
Phosphorus,	.135	.078	.10
Sulphur,	2.958		

LITTLE MINE.

Owned by Fellows. Sometimes called "Fellows" Mine. 531 cars mined by the Thomas Iron Company during 1893 shows:

Metallic iron,	56.29
Silica,	7.94
Phosphorus,	.103

The Thomas Iron Company found in a shipment of 375 cars of ore from this mine in 1891 an average analysis of 55.34 metallic iron, which included ten cars of unwashed ore in the shipment.

In July, 1891, a shipment of 25 cars showed the highest iron found by the Thomas Iron Company, which was 62.25 per cent. metallic iron. The lowest analysis was found in two cars of washed ore in 1891, which only gave 37.94 per cent. metallic iron.

QUEEN PROPERTY.

343 cars shipped to Thomas Iron Company during 1892 shows 55.29 per cent. metallic iron; 16 cars shipped to Hokendauqua (Thomas Iron Company), February 11, 1893, showed:

Metallic iron,	55.12
Insoluble,	9.81
Phosphorus,	.229

Sample from stock-house at Hellertown, Thomas Iron Company, 1893:

Metallic iron,	54.35
Manganese,	1.264
Phosphorus,	1.52

SHOEMAKER MINE, BELVIDERE.

125 cars to the Thomas Iron Company, October, 1893, shows 46.73 per cent. metallic iron. Other shipments to the Thomas Iron Company show:

Metallic iron,	51.42	46.48	51.87	50.05
Silica,	8.85			
Phosphorus,	1.048			
Manganese,	.17			
Alumina,	3 86			
Lime,	1.68			
Magnesia,	.18			

RAUB FARM, NEAR BUTTZVILLE.

Fine Ore.

Metallic iron,	33.80
Silica,	24.82
Phosphorus,	.192
Manganese,	1.836

Hard Ore.

Metallic iron,	63.87
Silica,	2.97
Phosphorus,	.118
Manganese,	.512

This property contains zinc-blende and has been noted in previous publications of the New Jersey Geological Survey.

OSMUN MINE.

Shipments to Cooper & Hewitt, four carloads.

Metallic iron,	58.302	55.73
Phosphorus,	.033	.065
Manganese,	1.084	

LITTLE MINE.

Little ore, all black, was shipped to Cooper & Hewitt.

Metallic iron,	67.54
Silica,	1.20
Lime,	.31
Alumina,	.74
Magnesia,	.51
Phosphorus,	.02
Sulphur,	.08
Titanic acid,	Trace.
Manganese,	.90

BROTHERTON MINE.

Samples tested by Booth, Garrett & Blair, for Pullman & George, show 0.11 per cent. of phosphorus.

JOHN H. SLACK PROPERTY.

Brown hematite, 2½ miles east of Bloomsbury, N. J. Shaft 8½ feet deep, of which 5½ feet is through ore. Ore in bottom of the shaft. Shipped from near Central Railroad of New Jersey.

Analyses of ore sent to Hokendauqua, Pa.:

Metallic iron,	44 33
Silica,	21.31
Phosphorus,	.17
Manganese,	06

CHARLES THATCHER PROPERTY.

Brown hematite. Between Stewartsville and New Village, N. J., on D., L. and W. R. R.

Metallic iron,	43.64

FORD MINE.

Shipped to Thomas Iron Company during 1899.

Metallic iron,	53.89
Sulphur,	.498
Phosphorus,	.319

Other tests show:

Metallic iron,	52.76	51 45	46.87	49.72

Roasted magnetic ore from Mt. Arlington, N. J., sent to Thomas Iron Company by O. W. Davis, August 20th, 1899.

Metallic iron,	43.18
Silica	21 43
Phosphorus,	.213
Sulphur,	.783

Dalrymple ore shipped by Mrs. Richard May to Thomas Iron Company during 1900. Dump at mine sampled by L. C. Bierwirth.

Metallic iron,	58.61
Phosphorus,	.296
Sulphur,	.026

EDISON.

1,000 tons Edison briquettes shipped to Thomas Iron Company, January, 1899.

Metallic iron,	62.83

MARCUS SAYRE PROPERTY, NEAR EDISON, (?) N. J.

Sample sent during May, 1899, by M. S. Higbie.

Metalli iroen,	40.58
Silica,	35.34
Phosphorus,	.326
Sulphur,	.106
Titanic acid,	2.27
Copper,	.080

Notes on Copper Mines.

By HENRY B. KÜMMEL.

The recent rise in the price of copper has attracted renewed attention to the copper deposits of New Jersey. These occur chiefly in the red shales and sandstones of the Newark formation, nearly always in close proximity to the trap-sheets, or dikes. Some of these localities were opened and ore mined as far back as colonial days, and in a few cases the ore was shipped to England. For many years the low price of copper has rendered it impossible to work these low-grade ores at a profit and the mines have all been closed. In many cases so long a time has elapsed since they were worked that the dump-piles are overgrown with vegetation and the tunnels are filled with fallen rubbish. With the increased price of copper and the modern methods of handling and reducing ores, whereby material formerly thrown away is utilized, it may be possible in some cases to work profitably these low-grade deposits.

SCHUYLER MINE, ARLINGTON.

This mine is the oldest of the copper mines in the State, and among the earliest mining enterprises in the country. It has been worked more or less frequently since 1719, but for the past thirty years nothing had been done, until a few months ago when a party of Boston capitalists secured an option on the property. They are now (November, 1899) engaged in preliminary operations to determine whether there is a sufficient amount of ore to warrant the erection of a large separating and leaching plant.* Two of the old shafts are being cleaned out and

* As this report is being printed, it has been reported that a company capitalized at $2,500,000 has secured these mines and is to operate them.

timbered and the water is to be pumped out of the lower levels of the mine. A tunnel run into the hillside at the level of the Newark meadows affords drainage for the upper 100 feet, but the lower levels—reported to be something over 300 feet deep—are full of water. From present indications it seems probable that a large amount of lean ore will be available. Narrow trap-dikes ramify through the sandstones and shale, and the rock adjoining the trap, particularly where it has been shattered and crushed so as to form a breccia, is impregnated with the copper ores—chiefly the sulphide and the carbonates. Selected lots of the ore also carry 7¼ ounces of silver per ton.* There is no true ore vein with well marked boundaries but the copper minerals occur in strings and bunches, or as finely scattered particles, or as thinly diffused coloring matter. Unless the ore is treated on the spot, a large amount of it must be thrown aside as too poor to pay the cost of transportation. Numerous analyses made of the material of the old dump-piles have led the present parties to believe that the ore, if mined on a large scale and treated economically, is rich enough to pay a good return on the investment.

AMERICAN COPPER MINING COMPANY.

This mine is located at the base of the trap-sheet of First mountain, about three miles north of Somerville, and was formerly called the Bridgewater mine. The first opening was made during the last century, and mining has been carried on at intervals since. About 1881 work was renewed by A. H. Hovey,† and a tunnel was driven into the hillside for a distance of 228 feet, following the dip of the shales and along the base of the trap-sheet. Side-drifts to the linear extent of 240 feet were opened about that time from the main tunnel. Average samples of ore from these galleries yielded "19 per cent. of copper and 6 ounces of silver to the ton of ore."

For a few years following 1883, work was continued and the main tunnel was extended several hundred feet down the dip, but the operations as conducted were not profitable and work

* Annual Report of the State Geologist, 1880, p. 175

† Annual Report of the State Geologist for 1881, p. 39; and Report for 1883, p. 164.

was abandoned. For the past two years or more, exploration has been carried on and a number of short galleries at right angles to the main tunnel have been opened at frequent intervals. All the openings are in the red shale at the base of the trap-sheet. At the time of writing (November, 1899) the work is being pushed with energy and the side galleries are being lengthened.

Above ground, at the mine entrance, a steam plant and air-compressing engine furnish power to operate the drills used in the mine. A small crusher and separating plant have been put up, and tubs for leaching the ore and precipitating the copper are in operation. The work so far has been for the purpose of thoroughly developing the mine and determining beyond a doubt the extent and value of the ore deposits; but the company has in contemplation the erection of a large separating and leaching plant, capable of treating economically a large output.

The large extent of the preliminary operations has disclosed the exact mode of occurrence of the ore. The shale for a distance of from one and a half to two and a half feet from the base of the trap has been slightly altered from its normal condition. Within this altered zone the copper minerals occur. The alteration of the shale is due in part to its impregnation by the copper minerals, and in part to a slight baking, accompanied by a change in color from red to purple. The copper minerals occur in strings or bunches, or disseminated particles. They are usually more abundant near the trap, and when a well-marked pocket or sheet of ore occurs in this position, the adjoining part of the ore rock (1½ to 2½ feet in thickness) is very lean. In other places the mineral is somewhat evenly disseminated throughout the entire ore-rock. Very frequently thin films of ore occur on the faces of cracks and joints in the shale, or along bedding planes. Locally it occurs in the basal portion of the trap, particularly where the latter is somewhat broken, and is of a spongy or vesicular texture. But the thickness of the trap thus impregnated is rarely more than six to eight inches.

Owing to the method of occurrence there is considerable variation within narrow limits in the richness of the ore rock. Seams and pockets of rich ore may end suddenly and be succeeded by several feet of very lean rock. But in spite of these

local and constantly recurring variations in the disposition of the ore, there is a marked uniformity in its distribution, when the whole area explored is considered. The rock along one gallery is about as rich as that along any other gallery. The openings already made render it practically certain that ore of the same grade as that already exposed will be found in the rock between each gallery. Furthermore there is no reason for thinking that the galleries may not be extended for some considerable distance beyond their present limits with the same results. That there is a much larger body of ore than is visible can hardly be doubted. On the other hand, the results already attained give no reason for believing that any marked increase in richness must necessarily be found with increasing depth. Nor in our opinion is there anything in the known or theoretical relations of the trap and shale necessitating or implying a richer ore-deposit at greater depths. This is not saying that the ore cannot become richer. It *may* or *may not* become high-grade, as it is followed down the dip.

A fault plane lies a few yards to the right (south) of the main tunnel, and the ore-bearing rock in each of the galleries on that side is lost at the fracture. The south side of the fracture has been uplifted, but there is strong evidence that the amount of dislocation is small, probably only a few feet, and that the ore-rock can readily be found again by extending the galleries a few yards to the eastward, *i. e.*, in the direction of the dip.

The ores are chiefly the red oxide and the green carbonate. Strips and sheets of metallic copper, however, are not uncommon. Small specimens of rock can be obtained giving a very high per cent. of copper. The average for the entire ore-rock is high enough to warrant the hope that, with the present high price of copper and with economical treatment, the mine will pay. The fact that it is necessary to take out almost an equal thickness of barren red shale, in order to work the ore-rock, is, however, a drawback and adds considerably to the expense.

East Jersey Water Company's Reservoir, Great Notch.

In excavating for the reservoir of the East Jersey Water Company, near Great Notch, Passaic county, a copper deposit of

considerable richness was exposed. The reservoir is situated in a longitudinal valley on the back of First mountain, just west of Great Notch. As was pointed out in the Annual Report of the State Geologist for 1897, pages 121–123, this valley is located along the line of the Garrett rock-Upper Montclair fault, and owes its existence to erosion along the line of weakness produced by the fracture. In the bottom of the valley, beneath the accumulations of glacial drift, which are of considerable thickness, the red shale was found on the west side of the valley, dipping westward so as to pass beneath the ledge of trap which there bounds the depression and on the east abutting against the opposite ledge of trap along the line of fracture.

The copper ores were found along the fault in the sandstone adjoining the trap. Through the kindness of Mr. Clemens Herschel, Chief Engineer, a number of samples of the ore were furnished the Survey, and analysis showed 9.32 per cent. of metallic copper.

The trench was afterwards filled with concrete in the construction of the dam and the locality is not accessible for further investigation.

Zinc.

The attention of the Survey has again been called to the zinc ores found at Neighbor's hematite mine, one and one-half miles northeast of Califon, in Lebanon township, Hunterdon county. A brief note respecting these ores is given on pages 119 and 120 of the Annual Report for 1880. They occur in connection with limonite and iron pyrite, and are chiefly zinc sulphide and zinc carbonate, although other zinc minerals occur. A much-weathered specimen contained 8.42 per cent. of zinc and 3.10 per cent. of sulphur, and a fresh unaltered piece of ore showed 34.76 per cent. of zinc and 21.90 per cent. of sulphur. Some lead is also found associated with the zinc.

No commercial use has as yet been made of these ores, and, indeed, it is as yet impossible to say whether the ore occurs in sufficient abundance to render such use possible and profitable. In his report on the iron mines, Mr. Jenkins has a note concerning more recent operations at the mine.

Mineral Statistics

For the Year 1899.

Iron Ore.

The total production of the mines, as reported by the several mining companies, was 269,293 gross tons.

The total shipments from mines in the State, as reported by the railway companies, and reported to the office of the Geological Survey, amounted to 300,757 gross tons.

The increase in the amount of ore shipped is considerably larger than that reported in 1898.

The table of statistics is reprinted, with the total amount for 1899 added.

TABLE OF STATISTICS.

Year.	*Iron Ore.*	*Authority.*
1790,	10,000 tons,	Morse's estimate.
1830,	20,000 tons,	Gordon's Gazeteer.
1855,	100,000 tons,	Dr. Kitchell's estimate.
1860,	164,900 tons,	U. S. census.
1864,	226,000 tons,	Annual Report State Geologist.
1867,	275,067 tons,	" " "
1870,	362,636 tons,	U. S. census.
1871,	450,000 tons,	Annual Report State Geologist.
1872,	600,000 tons,	" " "
1873,	665,000 tons,	" " "
1874,	525,000 tons,	" " "
1875,	390,000 tons,	" " "
1876,	285,000 tons.*	
1877,	315 000 tons,*	
1878,	409,674 tons,	" " "
1879,	488,028 tons,	" " "
1880,	745,000 tons,	" " "
1881,	737,052 tons,	" " "
1882,	932,762 tons,	" " "
1883,	521,416 tons,	" " "
1884,	393,710 tons,	" " "

*From statistics collected later.

Year.	*Iron Ore.*	*Authority.*
1885,	330,000 tons,	Annual Report State Geologist.
1886,	500,501 tons,	" " "
1887,	547,889 tons,	" " "
1888,	447,738 tons,	" " "
1889,	482,109 tons,	" " "
1890,	552,906 tons,	" " "
1891,	551,358 tons,	" " "
1892	465,155 tons,	" " "
1893	356,150 tons	" " "
1894,	277,483 tons,	" " "
1895,	282,433 tons,	" " "
1896,	264,900 tons,	" " "
1897,	257,235 tons,	" " "
1898,	275,378 tons,	" " "
1899,	300,757 tons,	" " "

Zinc Ore.

The production of the zinc mines is shown by the yearly shipments of zinc ore. The total shipments of zinc and franklinite ores, as reported by Mr. A. Heckscher, General Manager of the New Jersey Zinc Company, amounted to 154,447 gross tons in 1899.

The statistics for a period of years are reprinted from the last annual report.

ZINC ORE.

1868,	25,000 tons,*	Annual Report State Geologist.
1871,	22,000 tons,	" " "
1873,	17,500 tons,	" " "
1874,	13,500 tons,	" " "
1878,	14,467 tons,	" " "
1979,	21,937 tons,	" " "
1880	28 3 1 tons,	" " "
1881,	49,178 tons,	" " "
1882,	40,138 tons,	" " "
1883,	56 085 tons,	" " "
1884,	40,094 tons,	" " "
1885,	38,526 tons,	" " "
1886,	43 877 tons,	" " "
1887,	50 220 tons,	" " "

* Estimated for 1868 and 1871. Statistics for 1873-1890, inclusive, are for shipments by railway companies. The later reports are from the zinc-mining companies.

1888, . . .	46,377 tons,	. . .	Annual Report	State Geologist.
1889, . . .	56,154 tons,	. . .	"	" "
1890, . . .	49,618 tons,	. . .	"	" "
1891, . . .	76,032 tons,	. . .	"	" "
1892, . . .	77,298 tons,	. . .	"	" "
1893, . . .	55,852 tons,	. . .	"	" "
1894, . . .	59,382 tons,	. . .	"	" "
1895 *				
1896. . . .	78,080 tons,	. . .	"	" "
1897, . . .	76,973 tons,	. . .	"	" "
1898, . . .	99,419 tons,	. . .	"	" "
1899,	154,447 tons.	. . .	"	" "

* No statistics were published in the Annual Report for 1895.

Publications.

The demand for the publications of the Survey is continuous and active. So far as possible requests for the reports are granted.

It is the wish of the Board of Managers to complete, as far as possible, incomplete sets of the publications of the Survey, chiefly files of the Annual Reports in public libraries, and librarians are urged to correspond with the State Geologist concerning this matter.

By the act of 1864 the Board of Managers of the Survey is a board of publication, with power to issue and distribute the publications as they may be authorized. The Annual Reports of the State Geologist are printed by order of the Legislature as a part of the legislative documents. They are distributed largely by members of the two houses. Extra copies are supplied to the Board of Managers of the Geological Survey and the State Geologist, who distribute them to libraries and public institutions, and, as far as possible, to any who may be interested in the subjects of which they treat. Several of the reports are out of print, and can no longer be supplied by the office.

The first volume of the Final Report, published in 1888, was mostly distributed during the following year, and the demand for it has been far beyond the supply. The first and second parts of the second volume and the third and fourth volumes have also been distributed to the citizens and schools of the State, and to others interested in the particular subjects of which they treat. The fourth volume includes, in an appendix, all the valuable tables which were in the first volume of this series.

The appended list makes brief mention of all the publications of the present Survey since its inception, in 1864, with a statement of editions that are now out of print. The publications of the Survey are distributed without further expense than that of transportation, excepting the maps, where a stated price covers the cost of paper and printing, as stated.

CATALOGUE OF PUBLICATIONS.

GEOLOGY OF NEW JERSEY, Newark, 1868. 8vo., xxiv + 899 pp.
Out of print.

PORTFOLIO OF MAPS accompanying the same, as follows:

1. Azoic and paleozoic formations, including the iron-ore and limestone districts; colored. Scale, 2 miles to an inch.

2. Triassic formation, including the red sandstone and trap-rocks of Central New Jersey; colored. Scale, 2 miles to an inch.

3. Cretaceous formation, including the greensand-marl beds; colored. Scale, 2 miles to an inch.

4. Tertiary and recent formations of Southern New Jersey; colored. Scale, 2 miles to an inch.

5. Map of a group of iron mines in Morris county; printed in two colors. Scale, 3 inches to 1 mile.

6. Map of the Ringwood iron mines; printed in two colors. Scale, 8 inches to 1 mile.

7. Map of Oxford Furnace iron-ore veins; colored. Scale, 8 inches to 1 mile.

8. Map of the zinc mines, Sussex county; colored. Scale, 8 inches to 1 mile. A few copies are undistributed.

REPORT ON THE CLAY DEPOSITS of Woodbridge, South Amboy and other places in New Jersey, together with their uses for fire-brick, pottery, &c. Trenton, 1878, 8vo., viii + 381 pp., with map.

A PRELIMINARY CATALOGUE of the Flora of New Jersey, compiled by N. L. Britton, Ph.D. New Brunswick, 1881, 8vo., xi + 233 pages.
Out of print.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. I. Topography. Magnetism. Climate. Trenton, 1888, 8vo., xi + 439 pp. Very scarce.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. II. Part I. Mineralogy. Botany. Trenton, 1889, 8 vo., x + 642 pp.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. II. Part II. Zoology. Trenton, 1890, 8vo., x + 824 pp.

REPORT ON WATER SUPPLY. Vol. III of the Final Report of the State Geologist. Trenton, 1894, 8vo, xvi + 352 and 96 pp.

REPORT ON THE PHYSICAL GEOGRAPHY of New Jersey. Vol IV of Final Report of the State Geologist. Trenton, 1898, 8vo., xvi+170+200 pp

BRACHIOPODA AND LAMELLIRANCHIATA of the Raritan Clays and Greensand Marls of New Jersey. Trenton, 1886, quarto, pp 338, plates XXXV and Map. (Paleontology, Vol. I.)

GASTEROPODA AND CEPHALOPODA of the Raritan Clays and Greensand Marls of New Jersey. Trenton, 1892, quarto, pp. 402, plates L. (Paleontology, Vol. II.)

ATLAS OF NEW JERSEY. The complete work is made up of twenty sheets, each 27 by 37 inches, including margin, intended to fold once across, making the leaves of the Atlas 18½ by 27 inches. The location and number of each map are given below. Those from 1 to 17 are on the scale of one mile to an inch.

No. 1. Kittatinny Valley and Mountain, from Hope to the State line.
No. 2. Southwestern Highlands, with the southwest part of Kittatinny valley.
No. 3. Central Highlands, including all of Morris county west of Boonton, and Sussex south and east of Newton.
No. 4. Northeastern Highlands, including the country lying between Deckertown, Dover, Paterson and Suffern.
No. 5. Vicinity of Flemington, from Somerville and Princeton westward to the Delaware.
No. 6. The Valley of the Passaic, with the country eastward to Newark and southward to the Raritan river.
No. 7. The Counties of Bergen, Hudson and Essex, with parts of Passaic and Union.
No. 8. Vicinity of Trenton, from New Brunswick to Bordentown.
No. 9 Monmouth Shore, with the interior from Metuchen to Lakewood.
No. 10. Vicinity of Salem, from Swedesboro and Bridgeton westward to the Delaware.
No. 11. Vicinity of Camden, to Burlington, Winslow, Elmer, and Swedesboro.
No. 12. Vicinity of Mount Holly, from Bordentown southward to Winslow and Woodmansie.
No. 13. Vicinity of Barnegat Bay, with the greater part of Ocean county.
No 14. Vicinity of Bridgeton, from Allowaystown and Vineland southward to the Delaware bay shore.
No. 15. Southern Interior, the country lying between Atco, Millville and Egg Harbor City.
No. 16. Egg Harbor and Vicinity, including the Atlantic shore from Barnegat to Great Egg Harbor
No. 17. Cape May, with the country westward to Maurice river.
No. 18. New Jersey State Map. Scale, 5 miles to an inch. Geographic.
No. 19. New Jersey Relief Map. Scale, 5 miles to the inch. Hypsometric.
No. 20. New Jersey Geological Map. Scale, 5 miles to the inch.

The maps comprising THE ATLAS OF NEW JERSEY are sold at the cost of paper and printing, for the uniform price of 25 cents per sheet, either singly or in lots. Payment, invariably in advance.

TOPOGRAPHIC MAPS, NEW SERIES.

The economic topographic maps of the Survey, on a scale of one inch to 2,000 feet, are sold at 25 cents per sheet. The fol-

lowing sheets are ready: JERSEY CITY, NEWARK, HACKENSACK, PATERSON and CAMDEN. They may be had by addressing the State Geologist, Trenton, N. J., with remittance for amount of order.

ANNUAL REPORTS.

REPORT OF PROFESSOR GEORGE H. COOK upon the Geological Survey of New Jersey and its progress during the year 1863. Trenton, 1864, 8vo., 13 pp. Out of print.

THE ANNUAL REPORT of Prof. Geo. H. Cook, State Geologist, to His Excellency Joel Parker, President of the Board of Managers of the Geological Survey of New Jersey, for the year 1864. Trenton, 1865, 8vo., 24 pp. Out of print.

ANNUAL REPORT of Prof. Geo. H. Cook, State Geologist, to his Excellency Joel Parker, President of the Board of Managers of the Geological Survey of New Jersey, for the year 1865. Trenton, 1866, 8vo., 12 pp. Out of print.

ANNUAL REPORT of Prof. Geo. H. Cook, State Geologist, on the Geological Survey for the year 1866. Trenton, 1867, 8vo., 28 pp. Out of print.

REPORT OF THE STATE GEOLOGIST, Prof. Geo. H Cook, for the year 1867. Trenton, 1868, 8vo , 28 pp. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1869. Trenton, 1870, 8vo , 57 pp., with maps.

ANNUAL REPORT of the State Geologist of New Jersey for 1870. New Brunswick, 1871, 8vo., 75 pp., with maps.

ANNUAL REPORT of the State Geologist of New Jersey for 1871. New Brunswick, 1872, 8vo., 46 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1872. Trenton, 1872 8vo., 44 pp., with map. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1873. Trenton, 1874, 8vo., 128 pp , with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1874. Trenton, 1874, 8vo , 115 pp. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1875. Trenton, 1875, 8vo., 41 pp , with map Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1876. Trenton, 1876, 8vo., 50 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1877. Trenton, 1877, 8vo , 55 pp. Out of print

ANNUAL REPORT of the State Geologist of New Jersey for 1878. Trenton, 1878, 8vo., 131 pp., with map. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1879. Trenton, 1879, 8vo., 109 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1880. Trenton, 1880, 8vo., 220 pp. with map. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1881. Trenton, 1881, 8vo., 87 + 107 + xiv pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1882. Camden, 1882, 8vo., 191 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1883. Camden, 1883, 8vo , 188 pp. Scarce.

ANNUAL PEPORT of the State Geologist of New Jersey for 1884. Trenton, 1884, 8vo , 168 pp., with maps.

ANNUAL REPORT of the State Geologist of New Jersey for 1885. Trenton, 1885, 8vo., 228 pp., with maps.

ANNUAL REPORT of the State Geologist of New Jersey for 1886. Trenton, 1887, 8vo., 254 pp.; with maps.

ANNUAL REPORT of the State Geologist of New Jersey for 1887. Trenton, 1887, 8vo., 45 pp., with maps.

ANNUAL REPORT of the State Geologist of New Jersey for 1888. Camden, 1889, 8vo. 87 pp., with map.

ANNUAL REPORT of the State Geologist of New Jersey for 1889. Camden, 1889, 8vo., 112 pp.

ANNUAL REPORT of the State Geologist of New Jersey for 1890. Trenton, 1891, 8vo , 305 pp., with maps.

ANNUAL REPORT of the State Geologist of New Jersey for 1891. Trenton, 1892, 8vo., xii + 270 pp., with maps. Scarce.

ANNUAL REPORT of the State Geologist of New Jersey for 1892. Trenton, 1893 8vo., x + 368 pp., with maps.

ANNUAL REPORT of the State Geologist of New Jersey for 1893. Trenton, 1894, 8vo., x + 452 pp., with maps.

ANNUAL REPORT of the State Geologist of New Jersey for 1894. Trenton, 1895, 8vo., x + 304 pp., with geological map.

ANNUAL REPORT of the State Geologist of New Jersey for 1895. Trenton, 1896, 8vo , xl + 198 pp., with geological map.

ANNUAL REPORT of the State Geologist of New Jersey for 1896. Trenton, 1897, 8vo., xxviii + 377 pp , with maps of Hackensack meadows.

ANNUAL REPORT of the State Geologist of New Jersey for 1897. Trenton, 1898, 8vo., xl + 368 pp.

ANNUAL REPORT of the State Geologist for 1898. Trenton, 1899, 8vo., xxxii + 244 pp., with Appendix, 102 pp.

ANNUAL REPORT of the State Geologist for 1899 and REPORT ON FORESTRY. Trenton, 1900 8vo., Annual Report, xliii + 190 pp.

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