GEOLOGICAL SURVEY OF NEW JERSEY.

ANNUAL REPORT

OF THE

STATE GEOLOGIST

FOR THE YEAR

1895.

TRENTON, N. J.:
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1896

ERRATA.

Page iii., 8th line, read *Chester* for "Cohester."
Page xxxii., 5th line, this map is not published.
Page 11, 4th line, read *Merchantville* for "Mechanicsville."
Page 59, 10th line from bottom, insert *figure 9* after "figure."
Page 78, right-hand column, under "Miocene" read *450 ft.* in place of "497 ft."
Page 129, 18th line from top, read *adopt* in place of "take."
Page 140, 11th line from bottom, for "southeastern" read *northeastern.*
Page 141, 14th line from bottom, read *northeastern* in place of "southeastern."
Page 174, 3d and 2d lines from bottom, omit the words "not only."
Page 177, 13th line, read *levied* for "levid."
Page 177, 18th line, read *propriety* in place of "prosperity."
Page 192, last line, omit the words "with geological map."

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CLEMENT H. SINNICKSON................................Salem.

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HENRY S. LITTLE......................................Trenton.

III. CONGRESSIONAL DISTRICT.

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M. D. VALENTINE......................................Woodbridge.

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AUGUSTUS W. CUTLER...................................Morristown.
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HENRY AITKEN...Elizabeth.
WENDELL P. GARRISON ....Orange.

To His Excellency George T. Werts, Governor of the State of New Jersey, and ex-officio, President of the Board of Managers of the Geological Survey of New Jersey:

SIR—I beg leave to present herewith the Annual Report of the Geological Survey for 1895.

Respectfully submitted,

JOHN C. SMOCK,
State Geologist.

TRENTON, November 30th, 1895.

ADMINISTRATIVE REPORT.

The report on the work of the Geological Survey here presented is for the years 1894 and 1895 to date. The Annual Report for 1894 contained the reports of the several divisions, but the administrative report was not included because of the want of time for printing it within the limit of the fiscal year.

The several parts of this report are:

Surface Geology.
Archean Geology.
Artesian Wells and Water-Supply.
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GEOLOGY OF THE SURFACE.

The full report made by Professor Salisbury of his division of surface geology, and published in the Annual Report of the Survey for 1893, gave in detail descriptions of Lake Passaic, notes on the Palisades range and on the other districts of the northern part of the State and a more general notice of the gravel and sand formations of the surface in the central and southern parts of the State. In the report for last year, more detailed descriptions of the glacial phenomena of the northern part of the State were published, and in particular, a full account of the character and extent of stratified drift and the extra-morainic drift. These annual reports of this division of surface geology have presented a general view of the whole subject of the surface formations, with much in detail of local nature and occurrences. The work in surveying and studying these formations has been kept steadily going forward under the direction of Professor Salisbury, and the published results of the work have afforded a clear conception of the progress and added to our knowledge of these formations in their manifold phases of occurrence. The extent of the detail in these studies and the differentiation of the surface formations is shown by the geological map of sheet No. 6, published in the report for 1894, and distributed recently. The data for maps in detail over the whole of the northern part of the State have been collected and studied for use in the preparation of the atlas of geological maps of the surface formations of the State.

The State has had the advantage of Professor Salisbury's direction and of his trained assistants for the work at a moderate outlay of expenses, their services having been paid for only during the field seasons and when occupied in the work of preparing reports. The economic consideration has been most important, and as a result no other survey of surface formations in the same degree of detail has been made anywhere else at so small cost as this in New Jersey.

During the field season just ended G. N. Knapp assisted Professor Salisbury, and was engaged in the study of the formations in the southwestern part of the State, in Burlington, Camden, Gloucester and Salem counties, and largely in the greensand marl belt. The short time since the end of the field work has made it necessary for Professor Salisbury to present a short report on the work of the season. He has, however, given a clear and succinct description of the characters of the Beacon Hill, Pensauken and Jamesburg formations, enabling the careful reader or student to recognize their characteristic features and identify the formations. The sub-division of the "yellow gravel" of the older reports is a remarkable geologic work, and gives to New Jersey the typical localities which shall make it classic in geologic science. The several formations are representative of conditions of submergence, between which there were changes of level and uplifts. They afford a graphic picture, as it were, of the later geologic time. The origin of these various gravels and sands, which formerly appeared to be so complex, is now clear in the light of these studies and this differentiation into well-marked subdivisions.

The careful study of the surface formations has contributed indirectly to our knowledge of the greensand marl beds which also crop out on the surface. It has been found necessary to examine them as well as the later formations, and to determine their areas and their relation to the surface as well as to one another. The revision of the geology of these lower beds has shown that the clay marl series is not a unit, but consists of well-defined members; that the red sand bed thins out at the southwest, and that the lime sand of the middle marl bed is much thicker there than at the northeastern end of the marl belt. The mapping of the surface formation will result in some radical corrections in the geological map of the marl beds of the State.

Professor Salisbury has made a general reconnaissance of the southern and southeastern parts of the State—or of the country southeast of the greensand marl belt, and has given the results of this survey. The identification of the Beacon Hill formation as being of Miocene age, and the extent of this formation in the southern part of the State, may be noted as one of the important results of the year's work. After this reconnaissance survey, Professor Salisbury joined the Peary Relief Expedition of 1895 and went to Greenland to study glacial phenomena on the west coast of that island and on the eastern American coast. This trip was suggested for the opportunities of seeing a great continental glacier or ice cap at work and the results of its movement over rocks and in the transport of material, and of noting all the phenomena of existing glaciers which might help explain the work of the ice in glacial times over the northern part of our State. There has not been time to collate the observations and utilize the generalized facts in explanation of the various features and characters of the surface formations of Northern New Jersey, but they are to be used in the preparation of the full reports on the geology of the surface. The reference of the facts of glacial formations here to analagous phenomena in Greenland, with its great glaciers, will give a degree of vividness and assurance of correct generalization to the history of our glacial age, compensating amply for the time devoted to the trip.

The field work on the surface formations is done over all the State, except the southeastern or coastal belt and a small part of Salem and Cumberland counties. Thus far one map only has been published, that of atlas sheet 6, in the Annual Report for 1894. Several other sheets are ready for publication. And the material is in hand for the preparation of maps of nearly all the northern part of the State and much of the greensand marl belt. It is perhaps unfortunate that the maps have not been published as ready, but on the other hand the delay has given time for a more careful consideration of the several schemes of atlas sheets and of the best methods of representation of the various surface features and formations. A more thorough study has shown the necessity of a new plan or atlas scheme, differing from that of the topographic in the larger number of sheets and their smaller size and their junction without overlap. The publication of these maps of the surface as parts of the complete or final report on the geology of the surface is now decided on as necessary, and as fast as they can be prepared and published, consistent with economy. The preparation of this monograph must necessarily require a long time and must await the completion of the field work. The maps may, however, be issued separately in sheets or numbers of a series and precede the text which they shall illustrate in great part. Atlas sheet 6, as published, will therefore be an advance map of a part of the surface, but it will not be one of the new series, although the geology as there mapped may appear later in a different form. It is hoped that one volume on the geology of the surface can be published sometime in 1896 and several of the maps.

The economic aspects of the study or survey of these formations of the surface have been given in previous annual reports. Particular attention is directed to the lists of localities of gravels for road-making in the southern counties and their wide distribution. The amount of road materials and its accessibility are worthy of careful consideration on the part of all who are interested in these ways of inter-communication.

The maps of the surface also may serve to show the outcrops of the marl beds and the localities where they may be conveniently reached.

The relations of these various surface formations to the agricultural development of the State and to its forest reservations are important subjects for mature study after they shall have been viewed in their varying phases and conditions.

These maps of the surface will make the basis for correct agricultural maps, inasmuch as they indicate the origin of the various formations that constitute the surface soils and their relations one to another. The genetic origin of the soils are shown by them. A series of agricultural maps may follow the geological series whenever it shall be wanted. Sheet No. 6, published in the report for 1894, may be considered as an agricultural map in its exhibition of the areas of classes of soils, as, for example, the red shale and sandstone, the trap-rocks, the gneissic or crystalline schists and their residual earths, the gravels, sands and sandy earths of the later formations and the alluvial deposits of the wet meadows may all be considered as great classes of soil divisions. The areas of these formations or classes are shown by colors and patterns on the map. It is, therefore, not a purely scientific and geological map, but is, in fact, agricultural in the last analysis of its divisions, and deserving of patient study and close examination.

CRETACEOUS AND TERTIARY FORMATIONS IN THE SOUTHERN PART OF THE STATE.

The work of the United States Geological Survey in these formations has been in charge of Professor William B. Clark, of Johns Hopkins University. He has been assisted by Robert M. Bagg. The State Survey co-operated with the National Survey in 1894, contributing $300 toward the support. The allotment from the United States Survey for the year ending June 30th, 1895, was $750. No help has been given to this work in 1895. Professor Clark reports that the survey of the geological boundaries has been completed over the territory covered by the Cassville sheet of the United States Survey—or over an area of 235 square miles. The work on the next sheet to the west, the Bordentown, has been revised in accordance with the discoveries made in the survey of the surface formations. These formations of the surface cover and conceal the greensand beds and make it difficult to map the areas of the several formations of the greensand marl series. Some attention has been given to the correlation of the Tertiary formations of New Jersey with those of Maryland and Virginia; in particular, the Miocene with the Chesapeake, as developed in the South. Professor Clark has made use of the results of the detailed surveys of the surface formations by Professor Salisbury and has identified the Beacon Hill gravel and sand as Miocene. The results of the surveys under Professor Clark will be published by the United States Geological Survey in the form of geological maps, and will then be available as parts of the geological map of the State.

The co-operation of the United States Survey in the Highlands and in the greensand marl belt is giving important help in the determination of the geologic structure of the State and the relation of the local geology to the general geology of the country. The careful survey of the surface formations is not only showing their extent and relations, but is also giving valuable data about the older formations and their geography. The geological map of these older formations, or the underlying rocks, is being modified and corrected by the detailed survey of the surface at the same time that these surface formations are being thus carefully mapped.

RED SANDSTONE FORMATION.

The survey of the red sandstone (Triassic) belt of the State has been begun by Mr. Henry B. Kümmel, who was appointed geologist on the staff of the Survey at the last meeting of the Board of Managers. Mr. Kümmel went into the field in September. He has traversed several section lines across the belt, and has given some time to the examination of the rocks of the northwest border, where it abuts against the Highlands, from the Delaware river near Milford to the New York line at Sufferns. On this border he has found several changes necessary in the geological map to a correct representation of the limits of the crystalline schists, the calcareous and siliceous conglomerates, and the shales and sandstones.

Faults have been discovered and evidences of extensive faulting have been obtained, which seem to explain the occurrence of certain beds of shales and sandstones and their relations to the topography of the country. The alteration of the shales near the contacts with the trap-rocks, and other phases of these ranges of rock, have been examined on the section lines crossing the belt, and the general relation of the shales and sandstones to the traps have had some study.

The red sandstone belt has on it more than one-half of the population of the State, and it is the best cleared and farmed division of the State. The drainage is through the Delaware, Raritan and Hackensack rivers. On account of its geographical and political importance and its resources in building-stone and in road-making materials, and its great advantages for residential sites, it is desirable to have a careful and detailed geological survey, which may enable us to trace the history of the deposition of its strata and their changes, and discover the origin, location and extent of its useful minerals already known and of others which may become of industrial importance.

ARCHEAN GEOLOGY.

CRYSTALLINE ROCKS OF THE HIGHLANDS.

Dr. J. E. Wolff, of Harvard University and of the United States Geological Survey, has charge of the geological work on the crystalline rocks of the Highlands. It is carried on by the national survey, cooperating with the State survey. On account of the small appropriation made for his work, he has not been able to make the progress which the interest in the study of these rocks seems to demand. In 1894 the work was carried on without any help on the part of the State. During the present year the allotment has been sufficient to pay the field expenses of an assistant for a part of the season only, although the larger amount will be available for the remainder of the fiscal year of the United States Geological Survey, ending June 30th, 1896.

The mapping of the Lake Hopatcong sheet (of the United States Survey) or that part of the Highlands embraced within the limits of the atlas sheet 3, from the latitude of 41° south to Mendham, and from Morristown west to Budd's Lake, is done; the descriptive text to accompany it is in course of preparation. This territory of 233 square miles is central in the Highlands and its completion marks a most important beginning and positive advance in our knowledge of the crystalline rocks. Dr. Wolff was assisted in the survey by Mr. A. W. Brooks.

The work on the Franklin sheet, north of the Hopatcong sheet, and having the same area and covering the territory between Stockholm on the east and Branchville on the west, has been begun and the field work on thirty-five square miles has been done. The existence of a large area of eruptive granite between Stockholm and Franklin and southwest of Mud pond, is a notable additlon to our knowledge of the geology of this part of the Highlands.

Mr. Lewis G. Westgate, under the direction of Dr. Wolff, has prepared a report on the geology of the northern part of Jenny Jump Mountain, in Warren county, illustrated by a geological map of the area surveyed. The close relations of the gneisses, crystalline limestones and other rocks and the metal-bearing beds and veins make this district one of particular interest in relation to the Franklin region where Dr. Wolff is at work. Mr. Westgate's conclusion that the white limestones of the Jenny Jump range are older than the blue limestones of the valley about it is one of the most important of the results of his work. The detail of the geological map will be of much value in the practical work of the development of the mineral resources of this mountain range. The economic geology has been referred to in the annual reports of the survey and in the Geology of New Jersey.*

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* Geology of New Jersey, 1868, pages 400–404, 659, 664, 680.
Annual Report State Geologist, 1873, pages 84 87.
Annual Report State Geologist, 1871, page 34.
Annual Report State Geologist, 1878, page 101.
Annual Report State Geologist, 1879, pages 83, 84.

ARTESIAN WELLS.

Artesian wells in the southern part of the State have been reported on by Lewis Woolman in the Annual Report for 1894, and also in this year's report. He has been engaged in collecting data and specimens for the Survey since 1889. The geological relations were discussed in the report for 1894, and sections were prepared to show the comparative positions of the several well sections. The full record of the well at Wildwood is notable, as well as the collections of specimens illustrative of that record. The sections running from northwest to southeast across the country show the descent of the beds in that direction, and are proofs of the accuracy of the dip of the lower beds, as given in the reports of the Survey, and suggestive as to the dip to the southeast of the later and higher beds and their position at given localities. Important points on these sections are shown and the probable depths of well-known water-bearing beds. They are not simply records of wells, but also guides to searches for deep-water sources at other points. The extension of the system of artesian-well supply in the southern part of the State is limited by the number of localities only. There is, however, a limit to the quantity of water which can be drawn at any given locality, and already wells are known which appear to affect one another and diminish the flow in some. The increase in the number of wells at any point must be determined by the volume of water in the beds and the extent to which it can be drawn upon without causing a rapid drainage from the surface and consequent danger of pollution. The additional horizons or water-bearing beds give an increased supply, as they may all contribute toward the volume obtainable at a given locality. The system is adapted to smaller towns and in general to localities where the demand is not excessively large. For the southern part of the State it is justly in favor, because of success of the wells, even where there are many streams with equable flow and water of excellent quality on the surface. On account of the value of the artesian well as a source of water-supply, the generalizations given in Mr. Woolman's report for 1894 have more importance than the simple records of well-borings and the attention of all interested in the search for such supply is here directed to that report.*

* Annual Report State Geologist for 1894, pages 154, 155.

The records of wells put down on the Delaware river slope and in the clay-marls belt reveal important geological facts about the thickness and position of the beds. The value of these records in order to a correct knowledge of the stratigraphy of the country and to geologic science is great, and shows the importance of keeping accurate records, and is again emphasized. To the parties who have so generously contributed data the Survey is deeply indebted. The patient and painstaking labor of Mr. Woolman is shown by the large amount of valuable material which he has brought together in these reports, and from the study of which he has drawn conclusions of great and valuable practical application.

In the report submitted for the current year there are several interesting new well records which help to verify the general statements about water-bearing beds, which were given in the report for last year. The well at Gibbsborough shows the existence of a water-bearing stratum in the upper part of the middle marl bed. The borings at Bordentown show the thickness of the plastic clays and their associated beds upon the crystalline rocks. The Hightstown wells also give the depth of these crystalline schists under the earthy beds. These reports on deep-bored and artesian wells in the southern part of the State are commended to the careful study of all who are interested in the subject of water-supply in that part of the State.

The artesian well system has not been general in the northern part of the State, excepting in the red sandstone belt, in which there are wells at Paterson, Newark, Elizabeth and Plainfield, and in the valley of the Raritan river in Hunterdon and Somerset counties. The sandstone strata are more favorable than the shales, and the successful wells get their supply from the sandstone beds generally. The wide extent of sandstone and the occurrence of the more sandy and more pervious beds with the shales suggest an extension of the artesian-well system in all the country where these rocks occur. Some of the failures in the shales are explained by their limitation within the shaly strata and the stoppage before reaching deeper sandstones. The survey of the red sandstone belt is destined to give a more accurate knowledge of the relative position of these various beds aud of the water-bearing character of them.

In the Kittatinny valley and in the Highlands there are so few deep-bored wells that their success is not demonstrated generally. The surveys of the surface formations of this part of the State show that these overlying earthy beds are not of extent and thickness as to favor the probability of successful artesian or deep-bored wells, and the great irregularity in them is unfavorable to the occurrence of water-bearing beds of any extent. They afford water to the ordinary dug well of the country.

The slate rocks are known to have a great deal of water in them, which shows itself in springs of excellent water and in all quarrying for roofing slate or other excavation work. The limestone is not so well supplied with springs, although there are in it some noteworthy on account of their large volumes of water. In the crystalline rocks of the Highlands the many iron mines afford a clue as to the water to be found in them, and the wide variation in quantity is suggestive of uncertainty so great as to afford little hope for artesian wells. The great cost of rock-boring and the abundance of excellent water in the streams of the Highlands and the less rapid increase of population, particularly in the more hilly and mountainous parts of the Highlands, have been in the way of the extension of the artesian or deep-bored well system. The slate belts of the Kittatinny valley and the lesser included Highlands valleys offer promising fields for deep wells and artesian water-supply; the limestone areas are yet to be tested as to their probable value as sources of such supply, and the crystalline rocks are apparently so uncertain as to the occurrence of water-bearing beds that they do not promise success to the artesian well generally.

Following the report of Mr. Woolman are records of wells in the red sandstone and in the clay belt of Middlesex and Union counties, put down by W. R. Osborne and other well-boring firms.

DRAINAGE.

Reference is again made to the law whereby the Geological Survey is authorized to make surveys and drainage plans for tracts "subject to overflow from freshets, or which are in a low, marshy, boggy or wet condition," whenever application is received from at least five owners of separate lots of land in such wet tracts.* In accordance with the provisions of the drainage laws of the State, the Great meadows of the Pequest river have been drained, and the success of the work has been referred to in preceding reports.† Visits to the

* Annual Report State Geologist for 1888, pages 49-60.

† Annual Reports State Geologist for 1884, pages 112-119; 1886, pages 213-216; 1889, pages 73, 74.

Great meadows and correspondence with some of the land-owners of the tract, have shown the necessity of additional work in order to complete the reclamation of these wet lands. The present condition of the main ditch or channel, which was deepened and cleared of obstructions, is not favorable to the permanent improvement. The trees along the stream and on the ditch bank have grown so that the branches hang over and into the water, and interfere with the flow and tend to slacken the current, and cause a silting and a narrowing of the waterway. The obstruction of the limbs increases as the trees grow and the large limbs fall into or hang down in the water. The damage is not yet so great, but is threatening the effectiveness of the channel to deliver the waters coming into it. The oblique position of the piers of the railroad bridge near Danville also tends to prevent the rapid and free flow of the stream. The removal of the obstructions and the clearing out which seems to be necessary, is a work of considerable care and expense and requires some associated effort as well as careful and well-directed supervision. The original drainage act of 1871 provided for the exigency, and directed "that if at any time after any tract has been drained under this act, the ditches or other works of drainage shall require alterations or repairs, the supreme court, on the application of any person interested in such drainage, may appoint three commissioners to make said repairs, who shall qualify and proceed in the same manner as the original commissioners, and the expense, when footed up, shall be assessed upon the same lands which were assessed for the expense of the original drainage." * In a supplement to this act, passed in 1888, it was enacted that "when any water course or river, which has been improved under the provisions of this act, shall have become obstructed, any five owners of land which have been assessed under the provisions of said act, and which shall be injured by such want of repair or obstruction, may apply by petition to the board of geological survey, setting forth a description of the work necessary and desired, with an estimate of the cost to be incurred, whereupon, if the work shall seem to the said board to be of sufficient importance, they shall investigate the application, and in case they shall approve the same shall report to the next term of the supreme court, setting forth what repairs are needed and what obstructions require to be removed, with

* Laws 1871.

a survey and plan of the necessary work and with an estimate of the cost thereof, which report shall be considered by said court on such reasonable notice to the persons interested, by publication in the newspapers or otherwise, as said court shall direct; if such plan shall be approved by said court, the said court shall proceed to appoint three commissioners to execute the same, who shall proceed to carry it out and to raise money by the issuing of bonds, if necessary, and to assess the cost upon the lands benefited by the improvement in proportion to the benefits received, and they shall proceed in making such improvement and assessment and in the raising money therefor, in the same manner as the commissioners appointed under this act to make the original improvement, and shall possess all the powers of the commissioners so appointed for the carrying out of said plan." *

From these provisions of the drainage laws it is evident that all improvements and repairs are to be made by the appointment of commissioners, who shall make the repairs in accordance with plans which are to be submitted to the Board of Managers of the Geological Survey for their approval, and the cost of the work is to be assessed upon the land-owners. The desirability of some further legislation continuing a commission in power in order to the maintenance of the improvements in any drainage work or the appointment of a representative body of the land-owners to care for and protect the same was referred to in the Annual Report for 1892 and again in 1893.† It may be added that the large land-owners are in favor of making these repairs and maintaining the work, but are not ready to ask for a new commission. Some simpler system of control on the part of the said owners, enabling them by their associated effort to do the work, seems to be wanted.

The full benefits of the improvement of the channel are not yet distributed over the whole tract as they ought to be, by a net-work of lateral ditches and intermediate drains. Ditches are needed along the border to catch the waters falling on the adjacent hillsides and flowing down these slopes to the meadows; others to carry these waters to the main stream are needed in addition to those already opened; others still are wanted to a more ready discharge of the surface-water and for holding, as it were in a reservoir, the excess of water in heavy showers and rain storms instead of its accumulation in broad

* Laws 1888.

† Annual Reports, 1892, pages 20, 21; 1893, pages 14-16.

shallow sheets on the surface and flooding the growing crops. The Dutch system of numerous open ditches is adapted to this tract. The work of opening such minor ditches should be that of the individual land-owner, although the plan for the same ought to be suited to the general drainage scheme. A small part of the tract is as yet improved and under cultivation; a large part is still wet pasture land. Nearly the whole of the meadows is naturally fertile and adapted to cultivation, and capable of producing large crops of potatoes, onions, corn, celery, &c. The profits of farming in some notable cases should be a stimulus to the reclamation of the whole tract. The hesitation on the part of the owners of some parts of the tract seems to be due to the obstructions in the main stream, and hence the importance of the work of clearing it out and keeping it cleared in order to the encouragement of all interested, to say nothing of the direct benefits afforded. The increased value of the land when fully improved, its ease of cultivation in comparison with the stony and rough hillsides, and the capital put in the improvements already made, are strong arguments for the maintenance of the same and for progress until the Great meadows shall have been fully reclaimed. The rich lands of the Quaker settlement, at the head of the meadows, are the naturally well-drained part of the old lake basin of the Pequest valley; the reclaimed wet lands, drained by human agency, are the lower part of the same topographic basin, or lake bed, and their drainage by man completes the work left unfinished by nature at the close of the glacial epoch.*

The great sanitary advantages of the drainage work already done are again stated. Malarial epidemics no longer occur in this valley, in fact, are unknown, whereas formerly they were common through the warmer seasons. The general healthfulness is as marked now as were the former unhealthy conditions due to sluggish streams, pools of standing water and decaying vegetation. The improvement here is suggestive of the benefits of drainage generally.

PASSAIC DRAINAGE.

Work on the Passaic drainage has been suspended for two years on account of want of funds for the continuation and completion, which, under favoring financial conditions, would have been possible by this

* Annual Report State Geologist for 1894, pages 34, 91.

time. The sale of bonds authorized by law for the payment of the expenses of the work has been affected by the general business depression and the consequent want of confidence on the part of capital. At the legislative session of 1894 relief measures in the way of collecting the assessments were secured, but the results were not as great as were anticipated, although they are important and suggestive of confidence to capital investing in these bonds.

The plan of drainage has been examined by a committee of the Board of Managers of the Survey, assisted by the consulting engineer and topographer, Mr. Vermeule, and the various propositions relating to the line of drainage channels, their size, capacity for delivering the stream flow, volumes of floods, and the possible effects of these various plans of drainage upon both the wet lands, above Two Bridges, and the river channel below Little Falls and through Paterson have been carefully considered in this examination, and the conclusions embodied in a report to the board made June 26th, 1894. The original plan was found to be the most practicable; effective for the drainage of the wet lands along the Passaic above Two Bridges and below Chatham, and not possibly capable of producing excessive floods along the lower reaches of the river, below Little Falls. The committee in its report recommended that the style of gates as proposed in the original plan be put in at Little Falls.

So much has been said in these annual reports on the Passaic drainage that it seems almost unnecessary to add to what has been published, and particularly the strong arguments for it by the late State Geologist, Dr. Cook, to whom the project was so dear on account of his interest in the valley where he was born and where the family home still remains, and because of the great advantages which were to come out of the completed work. Thus far the work is in the direction of a permanent and thorough drainage system, whatever modifications may be made in the style of gates or whatever changes in the height of the dam, or in the opening of new channels or widening and deepening existing waterways above the dam. It is well done and is effective. The rocks which obstructed the flow of the stream have been removed and the channel is adequate to the delivery of the largest volume of water which is practicable and consistent with conditions of safety down the stream. The dam is to be lowered by the Beattie Manufacturing Company, of Little Falls, and the gates are to be put in by the company conformably to the requirements of the agreement between them and the Commissioners and the original plan of drainage. This work is to be done as soon as the Commissioners are ready for it and have perfected their plans for the continuation of the channel enlargement above the dam. The need of funds stands in the way of progress in the carrying out of the whole scheme of improvement. The additional cost of the work in order to the relief of the lands overflowed in times of flood and by a more rapid discharge of the water through an enlarged and deepened stream-bed need not be so large as to make the assessments beyond the value of the lands improved. That the benefit to them would exceed considerably the cost per acre is accepted by those acquainted with the present conditions of the tract, the value of farm lands in the valley, and the extent of the work which is proposed to be done. The land-owners cannot take the bonds and furnish the money, hence the Commissioners are obliged to find sale outside of the valley for the remainder of the issue necessary to meet the cost of the work.

The extra-limital advantages of the Passaic drainage work are of so much importance that they are here stated briefly. The location, extent and the relations of these wet lands to the adjacent parts of the country—to the surrounding hills and mountains, and to the towns and cities near them—are shown on sheet 6 of the topographic maps and also on the geological map of the surface formations published in the last annual report. The latter shows the limits of the Lake Passaic of glacial times and the wet tracts, which are the undrained parts of that old lake. According to Professor Salisbury's observations, the pre-glacial outlet of the valley was through the gap at Short Hills and Milburn. The mass of earth and boulders left in the old river channel by the melting of the ice obstructed this outlet and closed the gap, and the depression in the trap-rock ranges at Little Falls and Paterson became the drainage way for the valley. The time necessary to cut down the reefs at Little Falls and at Two Bridges has not been long enough for the present river to do the work, hence the necessity of the removal of these obstructions and the improvement of the channel by man. This work partakes of a public character, and ought not properly and exclusively to be borne by the land-owners of the flowed lands, but by the State or part of the State within whose topographic limits it is essentially a characteristic feature and component. It is, however, impossible to determine the limits of such an affected district with accuracy and to apportion the costs of the improvements upon all who may be benefited, as the benefits are partly of a sanitary and partly of an æsthetic nature, whose limits are not capable of accurate location or definition. That these wet tracts with their shallow waters and their decaying vegetation after floods are the breeding places of malarial germs and the source of sickness, is well known. How far distant these malarial disorders may go is not known. The testimony of medical observers in this part of the State, and the best medical authorities, are opposed to the transmission of such disorders long distances. The existence of these nests of malarious disease is not, however, reassuring to the residents of the adjacent country or to any in the valley, since the indirect ill effects from such localities are felt much further away than the boundaries of the valley. It may be said that the health of the State and its reputation for sanitary conditions are affected by such plague spots within its limits. Paterson is only five miles away; Boonton, Morristown, Madison, Chatham, Essex Falls, Hanover and Caldwell are all in the valley. The Geological Survey has shown that the work is practicable. It has urged its progress, and it now emphasizes the importance of its completion in order that the benefits may be enjoyed by the residents of the valley, and the general sanitary conditions of this part of the State be improved.

No reference is here made to the value of improvements or the increase in ratables due to the drainage work, as that is, in part, offset by the cost to be assessed upon the landholders of the flowed lands. They are to pay for it. The encouragement of those outside of these assessed lands, and the support of the State in making the needful legislation, and the general confidence of the community is important and much to be desired by the commissioners who have charge of the work.

Reclamation of Tide-Marsh Lands.

The permanent improvement of the tide-marsh lands of the State by drainage and dyking, and the success in the reclamation of the lowlands of Holland were referred to in the report for 1892 and again in that for 1893. The description of the Dutch methods was given as an object lesson to all interested in the improvementof these wet lands.* The suggestions of the paper on the reclamation in the Netherlands have not led to any experiments here, and no work in the drainage of the

*Annual Report of State Geologist for 1892, pages 331–353.

tide-marshes has been done, excepting in small lots by individual owners. Along the Delaware river in Salem county and along the Cohansey creek in Cumberland county some of the drained lands have been allowed to revert to their original wet condition through the neglect of the dykes and sluice-ways. The general agricultural depression is no doubt the cause of part of this failure to maintain the improvements.

The broad belt of tide-marsh lands along the Hackensack river, between Jersey City and Newark, and between the latter city and Elizabeth along Newark bay, and the meadows along the Staten Island sound are so situated that their reclamation is a subject of vital importance and far-reaching influence. The prejudicial effect of the proximity of these marsh lands upon the healthfulness of the cities on their borders and on the salubrity of the adjacent country districts is the strong argument for their drainage and improvement. They are not only insalubrious, but also comparatively non-productive in an agricultural point of view. They are unsightly and mar the landscape, otherwise strong in its scenic elements of beauty. The possibilities of these meadows when drained and the sanitary advantages of their reclamation, aside from the æsthetic setting, make a strong impression upon all who have seen the rich and beautiful *polders* of Holland. The great importance of the subject has suggested a survey of Hackensack and Newark meadows to ascertain the proper lines of drainage and the advantages of the natural waterways and the contour lines of the land for a system of dyking and drainage for their reclamation. It is not, however, proposed to prepare plans of drainage, but to furnish information to be used by the engineer in his work of improvement. The topographic maps and the large-scale sun-prints of the original surveys show the location and extent of these lands and in part their composition and character.

NATURAL PARKS AND FOREST RESERVATIONS.

The subject of forest reservations, as related to the economic questions of tree-planting, timber-culture and protection, is referred to in connection with the surveys of the forest lands of the State.

There are in the State several localities and districts noted for their characteristic geologic features or their scenic beauty which should be reserved as natural parks, aside from their forested condition and importance in reference to the general question of forestry. The Palisades range is one of the most important of the districts which may be reserved as such natural parks for the use and enjoyment of the people. Its characteristic rock front and talus of tumbled blocks, its well-wooded top and its location within the metropolitan district of the continent are arguments for its preservation. The fact of so large a stretch of unbroken forest so near to New York and in a populous district is unique and noteworthy, and it seems fortunate that it should have been kept uncleared to this time, that now it may become a natural park for the benefit of the population around it. The Survey has had prepared a map on the scale of two inches to a mile, showing the topography and the forests, their location and composition. Copies of this Palisades map have been printed for the use of the Governor and legislative committees and the Palisades Commission. The surface features of the range were discussed in full by Professor Salisbury in his report for 1893.*

The Highlands contain many desirable locations for parks which are destined to become of importance on account of their lakes and streams and available water-supply for city use. The preservation of the forests and of the natural scenery is enforced by these advantages as gathering ground for public water-supply.

The facts relating to localities and districts are being ascertained by the Survey in the course of its more scientific work, and are to be given in a future report.

CHEMICAL LABORATORY.

The chemical investigations and analyses for the Survey have been made under the direction of Prof. A. H. Chester, of Rutgers College, and in the college laboratory at New Brunswick. The engagement for this division of work was made two years ago, that the necessary studies and examinations of the clays and other raw materials which are used in the brick and pottery industries might be had for the report on clays. It has been impossible to give all the time to this class of work on account of the necessity of making some special analyses of soils for the report on forests and the miscellaneous examinations of ores, minerals and other materials which are considered to be of importance and worthy of attention in the laboratory. The chemical work on the clays is still incomplete, and a great deal

* Annual Report State Geologist for 1893, pages 157–224.

remains to be done in making analyses and ascertaining their composition, and in fire tests to determine their practical values.

Professor Chester's report, which is here inserted, shows the miscellaneous character of the examinations made and also the extent of the work on the clays. The analyses are not here reported, except that of Caswellite, on which a special report has been prepared. It is given in another part of this report.

November 14th, 1895.

Prof. John C. Smock:

DEAR SIR—I send you with this, as you request, a complete list of the chemical analyses made at this laboratory for the Geological Survey of New Jersey during the current year. The total number of samples examined is seventeen, of which two are complete analyses. Classifying them, they are of the following kinds:

4 Soils.
6 Clays.
3 Marls.
2 Sands.
1 Lead Ore.
1 Iron Concretion.

All the work was done with the utmost care, and I am satisfied that the results reported can be relied on.

The work for 1895 only continued to July 1st, which accounts for the comparatively small number of analyses made.

The list of analyses is as follows, in the order reported:

Lab. No.	Description.		
81	Surface soil		East Plains, N. J.
83	"		" "
84	"		" "
86	"		" "
88	Green clay	I. D Gabel	Deans, N. J.
89	Brick "	"	" "
90	White "	"	" "
91	Lead ore		
92	Lime marl	G. A. Deane	Arkansas.
94	Clay	Hammell Farm	Robbinsville, N. J.
95	Greensand marl	Dr Price	Imlaystown, N. J.
96	" "	S. A. Fenton	" "
98	Clay	E. Olyphant	Tuckerton, N. J.
99	"		
100	Iron concretion		Southend, N. J.
101	Purple-sand		Asbury, N. J.
102	Redsand		" "

Yours respectfully,

ALBERT H. CHESTER, E.M., Ph.D.,
Professor of Chemistry.

SURVEY OF FOREST LANDS.

The surveys of the forest lands of the State have been carried forward in accordance with the terms of the act of the legislative session of 1894, whereby the sum of $5,000 was appropriated for this purpose.

In the northern part of the State the work has been in charge of Mr. Vermeule, who has been assisted by P. D. Staats, F. W. Bennett and H. Sproull. The northeastern part of the State has been surveyed in detail, and the composition of the forest, as to kinds and size, has been noted on the maps. The Palisades range, the valley of the Hackensack and nearly all of Essex county have been traversed, and the forest map prepared. The Highlands have been surveyed with reference to the extent of the forests upon the hill and mountain slopes, and the relation of the forested areas to the drainage has been studied. These areas have been colored on the topographic maps, and the extent and relation of the forest-covered part to the bare districts are in this way shown. The results of the survey are striking in the comparatively large percentage of the whole territory in woods, and particularly north of the moraine (terminal). South of that line or limit there is much less forest, and a larger part of the country is in farms and cleared. It is remarkable that there should have been so much land left in timber or uncleared so near the populous districts of the State and on that part of the Highlands whence the water-supply for these districts is obtained. This condition is most favorable to the gathering capacity and the quality of the water. The survey also shows that there is such a disposition of the forest as is conducive to the equable flow of the streams and to the retention of the moisture in the soil. The large part of the forest is on the slopes and not on the more nearly level plateaus and valley bottoms, and where it is most effective in helping to check the rapid discharge of flood-waters and prevent the streams from being loaded with silt or mud. The brooks flowing through a wooded country and through valleys in forest lands do not become so turbid as those of a country bared of trees and in farm lands. The soil is not washed down hill-sides and carried away by the streams, to be deposited in their lower reaches and in the more sluggish parts of their courses. Inasmuch as the cities are getting their supplies from the streams well up in the Highlands, and not below in the more nearly level or flat country, this wooded character of the slopes is of importance to the clear or transparent condition of the water. The superiority of water from a forest to that from a cleared and farmed district is well known, unless the district be largely in grass or pasturage, as that of the Croton water-shed in New York. The Highlands are therefore most valuable gathering-ground for public water-supply, and the State is fortunate in having this well-wooded hill country within its limits so near its large city population.

The maintenance of these conditions is also important. The survey has shown the topographic relation of the forest lands. The retention of these slopes in forest is desirable; the removal of the timber from and the clearing of the level parts is not to be feared as injurious. The surveys show where this clearing cannot be harmful or threatening. How the proper relation and conditions may be kept is a problem for the future. Individual owners cannot be expected to retain the forest for public good and to their loss, hence it seems to be a condition which may demand the action of the State in order to maintaining the forest cover where it is needed.

In the southern part of the State Mr. Gifford has been at work and has studied the question of forest fires and their origin and prevention. He has also given some time to the cedar swamps and to the general distribution of trees. By his efforts a more general interest in the protection of the forests from destruction by fire has been aroused, and the community at large has been affected in an educational direction and sentiment created to ask for help to arrest the ravages of these fires. A corps of observers have kept watch of fires and collected data about them. The results are given in Mr. Gifford's report. It is to be hoped that the work of observation and recording the number, origin, location, extent and destructive effects of forest fires can be continued, since the value of statistics is here of the first importance in showing the extent of the ravages. The statistics of fires are evidence of the need of more effective measures for protection than are now in use. Of these measures the most important and most practicable is the opening of fire lanes, and the separation of the great forested districts or territory into blocks thus isolated. The cleared borders along some of our railway lines are already to some degree effective as fire lanes. Were the clearings extended to all of the lines of railroad and along some of our more important wagon roads, the forested belt of the southeastern part of the State would be well divided into a system of blocks, and well situated for protection. The establishment of some such system of fire lanes seems to be necessary in order to enable the local authorities to contend successfully with the fires. A small map of the State is inserted in Mr. Gifford's report as an exhibit of lanes and blocks.

At the close of the season, in October, Mr. Gifford Pinchot, of New York, and consulting forester in charge of the forestry work at Biltmore, North Carolina, was engaged to prepare a report on the forestry question in the State and the adaptability of the several large divisions of the State to timber culture or scientific forestry. Mr. Pinchot made a few excursions into the principal forest districts, and he has incorporated his observations and suggestions in a special report, which is here submitted. Coming from an experienced forester and a practical administrator of a large forest plantation, and acquainted with our conditions and needs, his report is valuable and his suggestions are worthy of careful consideration.

The surveys in this division have been suspended on account of the appropriation for the work lapsing October 31st, and the want of further appropriation for completing them. There has not been time since that date to prepare a full report, particularly of the work done in the southern part of the State, and what is here given is a report of progress. The full report will be given to the Legislature at its coming session next year. It will contain the results of the work done, although necessarily incomplete in many details, because of want of time for making an exhaustive survey.

GEOLOGICAL ROOMS.

The work of arranging the collections of the Survey in the museum, which was begun in the winter of 1893–94 by Mr. Harry Landes, and was referred to in the last published administrative report, was terminated in the summer of 1894, and Mr. Landes left to engage in teaching. The collections have not been changed or materially increased since that time. The Columbian Exposition exhibit of the Survey has been received and stored in the basement, excepting the large relief map of the State, which has been set up in the central space in the museum. There is not room for the cases and the collections of this State exhibit in the museum, and they are therefore stored for the present. It is proposed to put in some of the minerals representative of the State in cases now occupied by rock collections, and thereby improve the appearance and add to the interest in the collection.

The Legislature, at its last session, passed an act creating a State museum and giving to it the Columbian Exposition exhibits as a nucleus of a general State collection or museum. Plans for the installation of these exhibits in the State-house are now in course of preparation. The consolidation of the Geological Survey museum with the other collections of the State in a well-equipped museum would add to the value and increase the interest of the public in the material which has been collected in illustration of the geologic structure and mineral resources of the State.

PUBLICATIONS.

The Annual Report for 1894 was the sole publication of the year.

DISTRIBUTION OF PUBLICATIONS.

The demand for the publications of the Survey is increasing steadily and they are distributed among a wide circle of inquirers outside of the State. The topographic maps are sold at twenty-five cents a sheet. The sales for the year will amount to about $400. The requests for reports are granted as far as possible. The restriction upon Volume I. of the Final Report has been made necessary by the small number of volumes in stock. They are supplied to libraries and to fill sets. The cost of carriage by mail or by express is paid by the recipient, excepting State officers, libraries, newspapers and correspondents whose names are on our list of exchanges. The plan of a wide distribution is followed in the case of all the publications which are in stock.

Besides the regular series of topographic maps, on the scale of one inch to a mile, sun-print copies of the original topographic projections, and on the scale of three inches to a mile, are sold to parties desiring so large sheets, at the rate of twenty-five cents per square foot, or thirty-five cents if mounted.

New editions of three of the atlas sheets have been published since the last administrative report was issued.

STAFF OF THE SURVEY.

PROFESSOR ROLLIN D. SALISBURY is in charge of the survey of the surface formations. He has had G. N. Knapp as assistant geologist and P. D. Staats as topographer for a part of the season.

CLARKSON C. VERMEULE, consulting engineer and topographer, has had charge of the surveys of forests in the northern part of the State. P. D. Staats has been assistant during the field season of 1895.

IRVING S. UPSON has charge of the sale of topographic maps, from New Brunswick. He is also the disbursing officer of the Survey.

JOHN GIFFORD has had charge of the forestry work in the southern part of the State.

In co-operation with the United States Geological Survey, DR. J. E. WOLFF, of Harvard University, Cambridge, has directed the surveys in the region of the Highlands. LEWIS G. WESTGATE assisted in the survey.

PROFESSOR WILLIAM B. CLARK, of Johns Hopkins University, Baltimore, has charge of the work in the Cretaceous and Tertiary formations. R. M. Bagg is his assistant.

DR. HENRY BARNARD KÜMMEL, formerly assistant to Professor Salisbury in the surveys of the surface formation, is making a survey of the red sandstone belt of the State.

ALFRED A. CANNON is clerical assistant to Mr. Upson at New Brunswick.

HATFIELD SMITH is general assistant in the office in Trenton.

UNITED STATES COAST AND GEODETIC SURVEY OF N. J., 1894.

BY EDWARD A. BOWSER.

In the month of April a reconnaissance was run on the lines Burden to Bridgeton and Burden to Pine Mount to determine the height that would be necessary for the observing signals at Burden, Bridgeton and Pine Mount. It was ascertained that, with a sixty-four-foot observing signal at each of the stations, Burden and Bridgeton, and with the opening of short vistas through the tree tops on this line, the two stations would be intervisible.

On July 5th field work was resumed. An observing tower sixty-four feet high was built at Burden to enable us to see over the tall timber to Bridgeton and Pine Mount. On July 18th the tower was completed, and on July 19th, 20th and 23d observing signals were erected at Colsons, Bridgeton and Lippincott, fifty-five, sixty-five and forty-eight feet in height, respectively.

On July 25th the theodolite was set up at Burden. A search was then made for the underground mark at Pine Mount, which had been buried there in 1839. On August 2d this mark was found; it was an earthenware cone containing two cracks extending its whole length. Careful measurements were taken to secure its position against its possible removal before we should visit it again. On the next day an observing signal sixty-one feet high was erected over this cone. The measurement of the horizontal angles at Burden was begun on August 4th.

On August 29th Pine Mount was re-marked. The cracks in the cone were cemented; the cone was sunk to the depth of four and one-half feet to its lower base, and a granite monument was put over it, which is three and one-half feet long, dressed six inches square, with the letters "U. S." cut in each of its four sides, and a triangle on the top. This monument was set in hydraulic cement to within six inches of the top, and a full description, with sketch, was made. On September 3d the measurement of the angles at Burden was completed, and on the next day the instruments were shipped to New Brunswick.

On September 1st, a reconnaissance was run on the line Bridgeton-Pine Mount, to ascertain the height of the trees along the line, and it was found that a forty-eight-foot scaffold at Bridgeton would see over the woods to a fifty-five-foot signal at Pine Mount.

In the latter part of September the latitudes and longitudes were computed of the primary station Burden, and the four tertiary points—Salem Church spire, Port Penn range light, Finns Point range light, and Quinton Church spire.

The next stations to be occupied are Bridgeton and Kellogg. The first work to be done is a reconnaissance southeasterly of Bridgeton to determine two primary stations to take the places of Fairton and Muskee Hill.

SUPPLEMENTARY.

UNITED STATES COAST AND GEODETIC SURVEY OF NEW JERSEY, 1895.

BY EDWARD A. BOWSER.

In the month of April a reconnaissance was run on the lines Bridgeton to Newfield and Bridgeton to Kellogg to determine the heights that will be necessary for the scaffold at Bridgeton and the signals at Newfield and Kellogg. It was found that a forty-eight-foot observing signal at Bridgeton will be required to see forty-foot signals at Newfield and Kellogg.

As the allotment for New Jersey was exhausted, and as there was none made for the fiscal year beginning July 1st, 1895, the work was discontinued for the remainder of the year.

ON CASWELLITE, AN ALTERED BIOTITE FROM FRANKLIN FURNACE, N. J.

BY ALBERT H. CHESTER.

The mineral under consideration was first noticed at the Trotter Mine, by Mr. F. L. Nason, in January, 1893. During the following summer he collected a considerable amount of it, which he kindly sent to me, and which has been examined at the laboratory of the State Geological Survey. At my request he has written the following account of its occurrence and association:

"The limestone formation of Orange County, New York, extends southward into Sussex county, New Jersey, includes the zinc deposits at Franklin Furnace and Stirling Hill, and as a continuous deposit terminates a little north of the village of Sparta.

"At Franklin Furnace the white limestone is injected with numerous dikes of granite. These granites can be seen to good advantage in the furnace quarry at Franklin and in the Trotter Mine at the north end of Mine Hill. At the furnace quarry the eruptive origin of the granite is shown (*a*) by its thin tongues reaching out into the enclosing limestone from the main body; (*b*) by its cutting across the strike of the limestone; and (*c*) by the large development of contact minerals, among the most prominent of which are tourmaline and chondrodite.

"The granite here is peculiar in that the mineral allanite is so prominent that it may properly be called an allanite granite.

"As might be expected, when this granite cuts the zinc vein, which it does, as proved by mining, interesting contact minerals are developed. On the surface the dike appears at a point known as Double Rock. Great masses of garnet here are found on the suface. In the limestone adjoining, the garnets appear abundantly in beautiful clusters of crystals. In the mine two hundred feet from the surface and from the surface down to this point the granite is encountered. In connection with this dike the rarer minerals found at Franklin occur. Allanite is found in large crystals usually in the coarse granite in contact with either the limestone or with the vein matter.

"Axinite, usually massive, but frequently in pockets, lined with small but brilliant crystals occurs.

"Large crystals of Amazon stone very perfect in form also occur. One large crystal formerly in the possession of Mr. W. W. Pierce, weighed about twenty pounds.

"Rhodonite, both massive and in beautiful large crystals.

"Zircon, a specimen in the cabinet of Mr. Thos. Long, of Ogdensburgh, one-quarter inch across the prism face, and one and one-half inches long.

"Zincite; massive tephroite; tephrowillemite in fine crystals; sussexite, rarely found; desaulesite; niccolite, in crystals occasionally; rammelsbergite, in crystals; rhodocrosite; fluorite; asbestos.

"The most abundant minerals are, however, massive rhodonite and polyadelphite. It is in immediate connection with this latter mineral that the recently observed mineral is found. It occurs in thick plates and scales with biotite, into which this passes or from which it is apparently derived by alteration.

"The writer has been at the mines frequently during the past five years, and this is the first time that this mineral has been known to be observed, and it can thus probably be safely recorded as a new mineral from this locality."

The new mineral is of a peculiar flesh, or light copper-red, color, with a bronzy lustre and micaceous structure, closely resembling light-colored clintonite, for which it was at first mistaken. Its hardness is 2.5-3, and its specific gravity is 3.54. It is completely decomposed by hydrochloric acid, with the separation of gelatinous silica. It has entirely lost the elasticity of the original biotite and is quite brittle, so that while it still cleaves easily it has not the eminent cleavage of mica. It occurs in most intimate association with massive yellow garnet, granular rhodonite, and a somewhat altered dark brown biotite, with which last it is most closely connected, in many instances the same plate of mica showing a gradual change from nearly black biotite at one end to caswellite at the other. It, therefore, is found in all stages of alteration, and varying in color from almost black to the bronze-red or pink described above.

The analyses made result as follows:

	1.	2.	Average.
Ignition loss	4.64	(4.64)	4.64
$Si\,O_2$	38.68	38.80	38.74
Fe_2O_3	6.85	(6.85)	6.85
Al_2O_3	6.45	6.71	6.58
Mn_2O_3	15.80	16.11	15.95
$Ca\,O$	22.68	21.92	22.30
$Mg\,O$	5.43	5.60	5.52
	100.53	100.63	100.58

The molecular ratios, calculated from the average of these analyses, are:

$Si\ O_2$	.643	.643	3.09
Fe_2O_3	.043		
Al_2O_3	.064	.208	1.00
Mn_2O_3	.101		
$Ca\ O$	.398	.536	2.57
$Mg\ O$	.138		
H_2O	.258	.258	1.24

Showing a ratio of $Si\ O_2 : R\ O : R_2O_3 : H_2O = 6 : 2 : 5 : 2.5$.

This does not suggest any very probable formula, a result to be expected from the way in which the mineral was produced.

Mr. Heinrich Ries, Fellow in Mineralogy at Columbia College, who made optical examinations of this mineral and of the associated biotite, writes as follows: "The new mineral is very feebly doubly refracting, and shows, apparently, no pleochroism at right angles to the base. It is more strongly bi-axial than the biotite from which it has altered, but it is so feebly refractive that no image could be obtained. With the quartz wedge it acts like an isotropic mineral. The biotite with it shows a slight divergence of the optic axis, probably not more than five degrees. A flake was struck with a sharp point, to obtain the percussion figure, and the leading ray of the latter was parallel to a line joining the loci of the optic axes, proving it to be a mica of the same order as biotite." A very dark red mica with brilliant lustre, from the same mine, and associated with similar minerals, was also examined optically, and proved to be a fresh, unaltered biotite. Chemical examination showed the presence of potash in considerable proportion in this unaltered biotite, while it is found in slight amount in the biotite occurring with the Caswellite, from which latter it has wholly disappeared, as shown by the analyses quoted. The fresh biotite also shows much magnesia and little or no lime, differing thus from Caswellite.

These facts show that there is an unaltered manganesian biotite among the minerals found at the Trotter mine, which at least at one place has been altered by the loss of its alkalies, and probably by other changes in its composition, so that it has practically become a new mineral. This idea is strengthened by the fact that the mineral has been found only at one place in the mine. Though nothing is on record of its occurrence, its position and distribution in the dump show that it was of local occurrence. It seems to indicate an influx at some point of water carrying with it manganese and calcium compounds, and perhaps helps to explain the finding of such a variety of minerals at this most prolific locality.

Inasmuch as these results seem to justify the view that it is a new mineral species, I propose for it the name *Caswellite*, after Mr. John H. Caswell, of New York, well known among the mineralogists of this vicinity.

PART I.

SURFACE GEOLOGY.

REPORT OF PROGRESS

BY

ROLLIN D. SALISBURY.

SURFACE GEOLOGY—REPORT OF PROGRESS.
1895.

BY ROLLIN D. SALISBURY.

During the spring and early summer of 1895 I spent a little more than two months in the field in a reconnaissance of the southern portion of the State, and during the summer and autumn Mr. Knapp spent about five months in detailed surface mapping. My reconnaissance covered that portion of the State which had up to that time been studied but little, and concerned parts or all of the following counties: Monmouth, Ocean, Burlington, Camden, Atlantic, Gloucester, Cape May and Cumberland. Stated in other terms the reconnaissance had to do especially with the wooded portion of south-eastern New Jersey, and with the more fertile belt in the southwestern part of the State.

While the reconnaissance did not settle all questions involved within the area studied, it served to bring out many general relations, and forms a proper basis for the more detailed work which is to follow. Certain general results may be briefly stated without entering into a discussion of them.

THE MIOCENE.

The Beacon Hill (Miocene) formation which it has been found necessary to study in connection with the younger formations, maintains, to the southward, the general characters and relations which have already been set forth in earlier reports. In general it is found to correspond in direction of dip with the Cretaceous beds on which it lies. But, on the other hand, the study of the broader area has made its unconformity with the Cretaceous more striking than earlier work had done. While over considerable areas to the north and northeast it is found to rest upon the Middle Marl, and upon this formation only, this relation does not hold throughout the State. In the Sand Hills, north of Monmouth Junction, it rests on the Raritan Clay. In other places it rests on the Upper Marl, thus demonstrating its unconformity with the Cretaceous beds.*

Traced along the strike of the Cretaceous beds the base of the Miocene is found to depart notably from horizontality. It is highest in the vicinity of Clarksburg and Perrineville (about 270 feet), declining thence slightly to the Navesink Highlands (about 180 feet) on the northeast, and more notably to the southwest. At Mount Holly its base has an elevation of only about 150 feet. Still further west at Point Airy, a mile northeast of Woodstown, its base has declined to about ninety feet (including the astringent clay), and at the Big Mannington hill, five miles further in the same direction, to forty or fifty feet, while near Alloway and Quinton it reaches sea level. These relations serve to emphasize the general conclusion which has heretofore been stated, that there has been deformation of the southern portion of the State since the deposition of this formation. The axis of disturbance probably ran west of north and east of south, and suffered uplift relative to the areas on the northeastern and southwestern sides, respectively, while the relative depression of the two sides was unequal, being greater on the southwest. Along this axis the deformation was probably greatest in the vicinity of Clarksburg and Perrineville. The figures of the preceding paragraph make it clear that the decline of the base of the formation to the southwest is not uniform, being very much less per mile between Mount Holly and Woodstown than between Perrineville and Mount Holly, or between Woodstown and Quinton.

The decline or dip of the base of the Miocene along lines at right angles to the strike, is not uniform. The dip as determined by Mr. Knapp, along six lines, is as follows: 1° From Pine Hill, near Clarksburg, Monmouth county, to Ely, about 32 feet per mile; 2° Stone Tavern (Mechanicsville), Monmouth county, to Burksville, about 32 feet per mile; 3° Southeast of Prospertown for 2½ miles, 28 feet per mile; 4° Ellisdale, Burlington county, to Brindletown, Ocean county,

*The reference of the sand and gravel over the Raritan Clay near Palmyra (Hylton's pits) to the Miocene (Annual Report for 1894, page 99) seems now to have been an error. The beds in question seem to belong to the Raritan formation, which in this part of the State contains much sand and gravel. This is shown by various well records (Annual Report for 1893, pages 405–9), as well as by data gathered during the summer of 1895.

18½ feet per mile; 5° Mount Holly to Retreat, 18 feet per mile; 6° Mount Laurel, three miles southeast of Moorestown, to a point 2½ miles further southeast, about 19 feet per mile.

It is not necessary to suppose that all this variation is the result of post-Miocene deformation. A part, and perhaps a large part, may be the result of deposition on an uneven base.

The reconnaissance made it clear that the "astringent" clay * of the southwestern portion of the State, especially well exposed in Salem and Gloucester counties, near the southeastern margin of the Cretaceous, lies below the sand and gravel which are a continuation of the upper part of the Beacon Hill formation further north. Even to the north and northeast, however, the Beacon Hill formation is found to become more or less clayey at its base, often containing considerable layers which have been used to a limited extent for brick. It is believed that the "astringent" clay of Salem and Gloucester counties is but a greater development of the clayey layers which characterize the formation more or less generally throughout its course. The glass sands about South Vineland are believed to belong to this formation, being referable to its upper horizons.

The wider study of the year has brought out the fact that the formation has a greater range of material than was at first supposed. In the vicinity of Farmingdale it seems to include the following phases: (1) Coarse, gritty sand and fine gravel of the Shark River type; (2) orange to salmon-colored sand, very sticky from the presence of clayey matter, generally lying below the preceding; (3) greyish clay such as that seen at Southard, often lying just over the marl of the region, as seen at various points near Farmingdale. Seams of similar clay, however, occur well up in the formation; (4) light grey micaceous sand. This is often associated with No. 2 in thin bands, but occurs below it as well. This and all sands of the formations are very likely to be streaked more or less with clay. In other portions of the State the variety of sand becomes much greater, the "astringent" clay is added, and, at a few points near Woodstown, thin layers of a fine white, or whitish substance, which has somewhat the appearance of soft talc.

In the southern and southwestern parts of the State, as at Millville, and at many points between Woodstown and Mullica Hill, at Clementon, south of Marlton, at Arney's Mount, at Fountain Green,

* Cook, Annual Report of 1886, page 182.

and at various points in the vicinity of Clarksburg, the sand has in a marked degree the peculiar quality which has been designated "fluffiness." The fluffy sand is often very delicately and beautifully mottled and streaked with pale shades of various colors. This delicate streaking and mottling is exceedingly characteristic of the formation throughout its southern extension. Very thin seams of clay in the sand are also characteristic. Nearly everywhere the formation contains gravel, some of which is coarse. Cobbles up to three or four inches in diameter occur not rarely, and they are often remarkably clean and hard, especially where they are of quartz. The gravel is more likely to occur in abundance near the upper part of the formation, though not confined to this horizon. It is sometimes found in pockets, which may affect any horizon. There is very likely to be a seam or thin layer of gravel at the very base of the formation, along the plane of its junction with the underlying Cretaceous.

There would seem to be little doubt that one of the post-Cretaceous formations, presumably the Miocene, once extended northward so as to cover the Sourland mountain, either in whole or in part. Very meager remnants of gravel, consisting indeed of no more than scattered pebbles, have been found at numerous points west of Plainville, in Somerset county. The mere existence of scattered pebbles of quartz which resemble those of this formation might not be thought to be a fact of much significance. The long period which various portions of the State have been under cultivation, and the possibilities which might be thought of in bringing about the transportation of occasional pebbles in connection with human activities, would lead one to attach little importance to occasional pebbles in most situations. But the pebbles referred to were found in such situations as to make any explanation of their origin, other than a natural one, improbable. Of especial significance were the pebbles of quartz found in forest regions which have never been cultivated, about the heads of gullies and ravines, where erosion had freshly exposed them. They were seen in such positions in several places, and in such numbers as to leave no possible doubt as to their being in a natural position. There would seem then to be no alternative but to suppose either that some formation younger that the trap once extended northward over the mountain; or, second, that the conglomerate beds of the Trias had at some time extended over this region. Of these two possibilities, the former seems the more probable, and since the pebbles found agree in kind with those characteristic of the Beacon Hill formation, and since their position agrees with the position which this formation must have had if it once extended northward, it seems reasonable to suppose that this formation once covered or lapped up on to the mountain. In this connection it is to be remarked that similar suggestions of the former extension of a similar formation were found some time since on the Watchung mountains.*

PENSAUKEN FORMATION.

The Pensauken formation probably covers most of the area southeast of the Cretaceous belt, and considerable parts of the area where that formation occurs. Generally speaking, it may be stated that the base of the greater part of this formation declines to the southeast in harmony with the dip of the underlying formations. There is some evidence, however, that the decline in this direction is even less regular than in the case of the Miocene, upon which it is distinctly unconformable. Like the Miocene, too, though much more distinctly, the base of this formation declines toward the Delaware river, so that there is a narrow belt next this stream where the base of the formation declines to the westward. The unconformity of the Pensauken on all subjacent formations is distinctly shown by the fact that in one place or another it rests upon every member of the Cretaceous series, as well as on the Miocene. Not only this, but unconformable contacts between it and the Miocene are shown at many points. Two such contacts were seen in the vicinity of Millville, one in the section exposed by the trolley line just south of the pond, and the other in the section along the tramway in the pit two miles or more south of Millville, on the west side of the river.

As in the case of the Miocene, the wider study of this formation has led to the belief that it is somewhat more complex in constitution than earlier studies indicated. Where identified heretofore, it is made up largely of arkose sand and of gravel, containing as distinctive elements soft chert, bits of Triassic shale and sandstone and pebbles of thoroughly decomposed granite. The general absence of certain other elements, which enter into the constitution of associated formations, is also a diagnostic mark of the Pensauken.

These characteristics are found to hold, though not without modi-

*See Annual Report for 1893, page 48.

fication, to the southernmost exposures of the formation seen, viz., those at Millville and near Tuckahoe. To the southward the granite and gneiss pebbles characterizing the formation about Trenton, Hightstown, Old Bridge, *et al.*, and appearing to have come from the north, are replaced by gneissic and schistose materials of a different character, derived apparently from gneisses and schists like those of Philadelphia.

In addition to these changes in the gravel, which seem to be the result of geographic position, the coarse sand becomes less arkose, and therefore cleaner, to the south and southeast. Toward the south, too, it appears that the Pensauken contains much more clay in the form of distinct seams, though there is less clayey matter distributed among the sand and gravel. Seams of clay a few inches to a few feet in thickness have been seen not rarely in typical exposures of the formation at various points. One of the best defined and most clearly exposed of these seams of Pensauken clay was seen in the pit a mile south of Millville, on the west side of the river. Similar seams have, however, been seen at many points. If present interpretations be correct, considerable beds of clay which are worked for the manufacture of brick and tile, are to be referred to this formation, notably those at Fish House. It is not to be inferred from this statement that all the clays used for brick, tile, &c., in the southern part of the State are Pensauken. It seems probable that some of them, *e. g.*, those about Farmingdale, are Miocene; some of them, as noted above, are Pensauken; while others, *e. g.*, those about Winslow Junction, are still younger.

In the southeastern portion of the State, the discrimination of the Pensauken from the Miocene has thus far been a matter of some difficulty. To put the matter in another way, there is in the southeastern part of the State, along the line of the New Jersey Southern railroad, and extending thence westward for some distance and eastward to the ocean, a very widespread bed of coarse, gritty sand, often used for moulding purposes, the classification of which has not yet been placed beyond question. Approached from the north, the relations of this sand seem rather to favor its reference to the Miocene, while approached from the west, and especially from the latitude of Camden or below, its relations seem rather to favor its classification with the Pensauken.

Through most of the wooded area of southwestern Jersey, this is the formation exposed wherever sections more than four or five feet in depth are formed. On the whole, the evidence now in hand seems to favor its reference to the Pensauken, rather than to the Miocene. If it be Pensauken, it is, on the whole, freer from gravel, and freer from the clayey and earthy elements than the Pensauken further north and west. It is often highly ferruginous, and in many places the ferrugination has gone to the point of cementation. It is from the horizon of this sand that the highly ferruginous sandstone of the southeastern part of the State is won. There is rarely quarrying in any proper sense of the term, but there are many places where layers have been discontinuously cemented to such an extent that by digging over a hillside, considerable quantities of stone may be secured.

Good exposures of the formation in question are shown at numerous cuts and pits about Lakewood; at Richland; at the pits near Woodmansie, where excellent road material is had; at Island Heights; and near Staffordville, where there is an extensive pit likewise worked for road material.

There can be little doubt that detailed work from the west to the east, with careful study of the changes which the formation undergoes in this direction, will clear up all the difficulties which have heretofore arisen.

The detailed work of Mr. Knapp has been along the Delaware river in the broad fertile belt which embraces the western part of Salem, Gloucester, Camden and Burlington counties. His earlier work had been in an area further north, and had reached as far south as Rancocas creek. His work during the present season has carried the river belt as far south as Salem, and in general terms, eastward to the timbered region. His work has brought out many interesting and significant points in connection with the Pensauken formation. Within the larger part of the area outlined above, the Pensauken is found to exist in remnants only, though to the eastward near the eastern limit of the cultivated belt, it becomes essentially continuous. Its distribution within the area studied by Mr. Knapp is shown on the accompanying map, Plate I.

One of the significant things in its distribution in the southwestern part of the State is the fact that it occupies divides, and another that its remnants, especially to the westward, are disposed in linear belts parallel to the strike of the Cretaceous beds. In the central portion of the State, that is, in the area north of 40° 10′, there is little that is striking in the distribution of the Pensauken patches. They are relatively large, and overlie formations of various sorts, including the Triassic, both trap and shale, the Raritan clay, and the Clay Marl.

South of the latitude of Trenton, however, the linear arrangement of the Pensauken remnants is apparent. The most considerable line of them lies on the Clay Marl belt, a little southeast of the line of its junction with the Raritan clay. This line or belt of Pensauken remnants lying on the Clay Marl extends from New Sharon, near the west line of Monmouth county, southwestward through Crosswicks, Bustletown, Deacon's, Rancocas, Hartford, Moorestown, Cooperstown, Haddonfield, Mount Ephraim, Woodbury, Mickleton, Swedesboro to Auburn and beyond. It rarely has a width of more than three or four miles. East of this belt and parallel to it, there is a wider one in which Pensauken remnants are notably fewer and smaller. This belt may be said to run from Recklesstown, Burlington county, southwest through Mount Holly, Marlton and Wenonah, to Mullica Hill and Woodstown. This belt is of very unequal width. Southeast of it Pensauken remnants again become more abundant, and still further in this direction the formation becomes continuous, and probably underlies the whole of the southeastern part of the State.

This eastern belt of remnants, which are really outliers of the continuous portion of the Pensauken lying further southeast, runs through Camden, Gloucester and Salem counties, along a line extending from Gibbsborough, through Clementon, Point Pleasant, Prosser's Mills and Pitman Grove, to Yorktown three or four miles south by southeast of Woodstown, and is approximately coincident with the northwestern edge of the Miocene formation as it now exists. In other terms, the Pensauken remnants are abundant on the northwestern edge of the Miocene, and further west on the Clay Marls, but not on the intermediate members of the Cretaceous series.

There is another very subordinate row of Pensauken patches, northwest of the Clay Marl belt already referred to. It extends from Bridgeborough, near Riverside, to Bethel and Merchantville. This row of Pensauken remnants lies on the Raritan formation, and is but narrowly separated from the belt first described. Mr. Knapp has made out a number of subdivisions of the Clay Marl series, and finds that the outcrop of the lowermost of these subdivisions is essentially coincident with the Pensauken free belt lying between that belt of Pensauken patches which rest on the middle and upper portions of the Clay Marl (New Sharon to Auburn), and the subordinate belt on the Raritan formation (Bridgeborough to Mechanicsville).

Certain general facts of significance in connection with the constitution of the Pensauken of this part of the State, as brought out by Mr. Knapp's work, may be briefly stated. The western belts of patches, that is, those lying on the Clay Marl and Raritan beds, and occupying for the most part divides, preserve much better than the Pensauken lying further east, the characteristics possessed by the formation further north. But even along the Clay Marl belt, the Pensauken undergoes some change from northeast to southwest. As far south as Cooper's creek (Camden), the characteristics which it has held to the northeast near Trenton, Hightstown, Old Bridge, &c., are essentially constant. To this point there is usually present a small amount of granitic material of northern origin, a small amount of red shale, some chert now in a soft condition, and more or less arkose sand. South of Cooper's creek, the formation as a whole becomes more sandy, and the granitic material of northern origin seems to drop out, being rarely if ever seen southwest of the Timber creeks, four miles below Camden. At the same time that these changes take place, a small amount of gneissic material which may well have been derived from the formation about Philadelphia, makes its appearance in the gravel. It is sufficiently unlike the granitic material of the northern part of the Pensauken formation to be readily distinguished from it. South of the Timber creeks, too, a considerable amount of vein quartz appears, such as affects the Philadelphia gneiss at various points. At the same time that the change in the crystalline material takes place, the Triassic constituent of the gravel seems to undergo a change, as if it came from another and different portion of the formation.

It is worthy of note that these changes occur opposite the point where the Schuylkill joins the Delaware. South of Cooper's creek the arkose element becomes notably less prominent, and the sandy portion rather freer from earthy materials. At the same time the sandy and the gravelly portions of the formation are somewhat less distinct from each other, there being rather less of the latter and more of a tendency to mixture of the two grades.

In lithological characters the belt lying further southeast is somewhat different, especially in that it contains a larger amount of soft chert, and a smaller variety of sandstone. The former is fossiliferous, the most abundant species being paleozoic corals, and is probably the contribution of the Beacon Hill formation. Like that further west, it contains material from the Philadelphia gneiss, as also material derived from the Triassic formation. It also contains, at some points, bowlders and smaller pieces of sandstone or quartzite derived from the "Lime Sand" of the Cretaceous. These bowlders are of especial interest, since to have attained their present position they must have been carried southeastward from the Lime Sand outcrop over the Upper Marl and out on to the Miocene. Since the last formation lies much higher than the Lime Sand, this distribution of the bowlders from the latter becomes significant. Their position would seem to mean that the higher (topographically) beds of Pensauken, lying on the Miocene, must have been deposited when topographic relations were unlike the present. Further discussion of this point is deferred until fuller study of the areas and questions involved has been carried on.

From a lithological standpoint, the lithological variations in the Pensauken are such as might be expected from its varying geographic relations to older formations.

South of Cooper's creek, the southeastern belt of Pensauken remnants, as well as the northwestern edge of the continuous area beyond, is considerably higher than the northwestern, so that they seem in places to be somewhat distinct topographically. This is shown by the accompanying sections, especially 2, 3 and 5, Plates II. and III. The meaning of this topographic diversity is not at once evident. The base of the Pensauken in the Clay Marl belt (New Sharon to Auburn) rises slightly toward the southeast, as shown by sections 3, 5 and 6, while in the Miocene belt (Gibbsborough to Yorktown) it sometimes rises slightly to the northwest. From sections 2, 3 and 5 it would appear that the Pensauken might be a bifold formation, the lower portions (*a a*) representing one subdivision, and the higher (*b b*) the other, with an erosion interval intervening.

The same sections might suggest another interpretation, viz., a northeast-southwest fault just southeast of the belt of Pensauken remnants lying on the Clay Marl. If such a fault had occurred, and if the surface to the eastward had been elevated, erosion might well have removed the Pensauken from the belt where it is wanting. Such fault should have shown itself in the displacement of the Cretaceous beds, and of such displacement Mr. Knapp has not found evidence.

Sections 5 and 6, on the other hand, allow of another interpretation, viz., that the Pensauken and underlying formations have suffered deformation in post-Pensauken times, resulting in uplift (not faulting) along the line of the marl outcrops (Recklesstown to Woodstown). The greater elevation of this belt would have led to increased erosion along it, and so to the removal of the Pensauken, which, on this interpretation, must once have covered the belt between the two lines or series of existing remnants. Indeed, on any interpretation, the original continuity of the Pensauken across this belt seems certain, for occasional small remnants of it are still found. If a low anticlinal axis such as this suggestion would necessitate, really exists, accurate measurements of the dips of the various beds involved, should discover it. Between these various hypotheses fuller details will probably decide.

North of Cooper's creek, the Pensauken patches of the Clay Marl belt are higher than the Pensauken-free territory immediately to the east, but not so high as the Pensauken lying still further in this direction. The absence of the formation here would likewise appear to be the result of erosion, favored by accessibility to streams, rather than by greater elevations.

THE JAMESBURG FORMATION.

Relatively little that is new concerning the Jamesburg formation has come to light during the summer. It is certain that such representation as this formation may have in the southeastern part of the State is rather meager or very indistinct. Whatever material is to be referred to the Jamesburg must have been derived principally from the underlying beds, without the addition of much extraneous material. While, therefore, it is believed to be very generally present, it is often difficult to distinguish it from the underlying formation, in the general absence of exposures, and the absence of exposures is the rule rather than the exception throughout the wooded portion of southeastern Jersey. Positive data are not wanting, even if too meager to be altogether satisfactory, that the Jamesburg formation is widespread, probably nearly universal, in this part of the State. If present interpretations be right, the only exceptions to its presence are places where erosion has removed it, and such places are not extensive areally.

If the low formations about the coast are to be connected with what has heretofore been referred to as the "Low-level Jamesburg," as now seems possible, the total area of the low and high-level Jamesburg is great.

It should perhaps be stated that the existence of the Jamesburg has been called into question at many points. Lithologically it so closely resembles what might be produced from the weathering of the underlying beds, that at many points and over considerable areas, its existence could not be affirmed on the basis of facts there represented. But there are various points, on the other hand, and these widely distributed, where the Jamesburg formation is represented by a thin stratum which could not by any possibility have been derived from the underlying formations, and the certain presence of the Jamesburg in such places is sufficient to carry the doubtful areas so situated that they cannot have escaped the influence of the agencies which made the deposits about the interpretations of which there is no doubt. As examples of the Jamesburg in such critical locations may be mentioned the capping of the isolated hill 181 feet high, two miles southwest of Marlton, in Burlington county, various sections in the vicinity of Millville, and sections in the vicinity of Fountain Green, Burlington county. The phenomena at these and other places seem to necessitate belief in the general submergence of the southern portions of the State in post-Pensauken time.

Various facts gathered in the great forest area of the southeastern portion of the State, led to the suspicion that the barrenness of that region is due to the presence of the Jamesburg formation. Further north, it is true that the Jamesburg is predominantly loamy. But the underlying and adjacent formations from which it was derived were more clayey, or more arkose. To the southeast, where the Pensauken becomes more sandy, as already noted, its derivatives must necessarily have been influenced in the same way. It is believed to be possible, therefore, that the peculiar quality of the soil to which the relative barrenness of southeastern New Jersey is due, may be the result of its last submergence. Beneath this thin stratum, which is often but two to five feet thick, the formation is of such a nature that it might have given rise to the uppermost three to five feet, by the removal of its more earthy constituents.

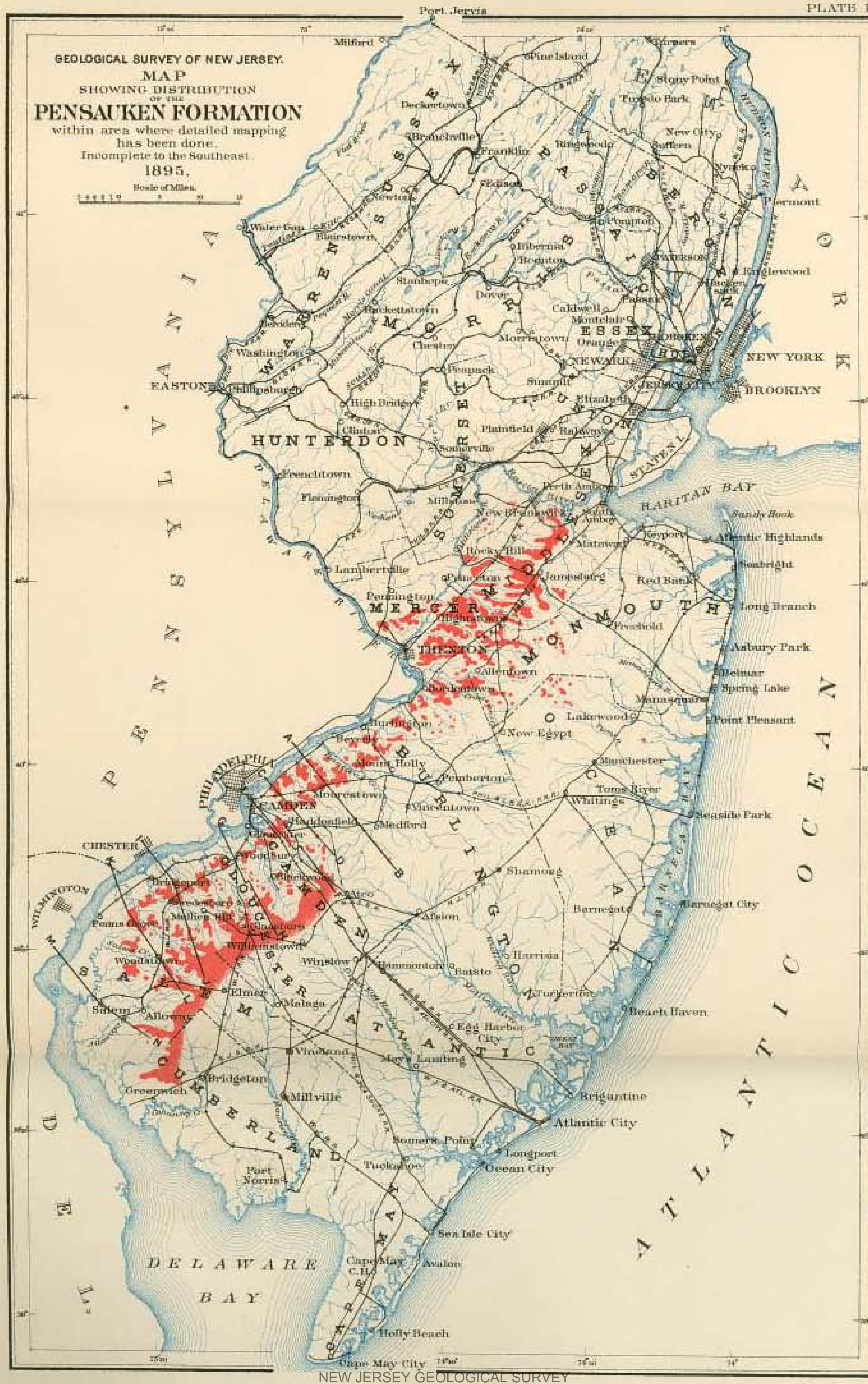
The topography which has heretofore been found to characterize the Jamesburg in the regions which have been especially studied, seems to be co-extensive with the formation itself, though not equally well developed at all points. The special feature here referred to is the shallow sinks. They are found in as widely separated localities as Colt's Neck (Monmouth county), Manchester and Toms River (Ocean county), Vineland (Cumberland county) and Alloway (Salem county). Furthermore, they are found to characterize the low coastal lands below the level of forty and fifty feet nearly everywhere. They affect the whole of Cape May county, as well as the low country facing Delaware bay and the Atlantic ocean.

While it seems probable that the surface formation over the whole of the lowland from Raritan bay on the northeast to the mouth of the Delaware river on the southwest, are of the same age, it seems very certain that the thickness of the youngest formation represented along the coast is much greater about Cape May and further west on the south coast, than along the eastern coast, or along some parts of Delaware bay. It would appear that the whole of Cape May, at least as far north as the Great Cedar swamp, belongs to the youngest formation which is represented in southern New Jersey. No evidence was here seen of anything above sea-level, as old as the Pensauken. On the other hand, in the vicinity of Tuckerton, and from there to Toms River and further north, the coastal formations, barring a relatively thin superficial covering, appear to be older, though there may be some question as to whether they are referable to the Pensauken or the Miocene. Further work will doubtless clear up the present uncertainty.

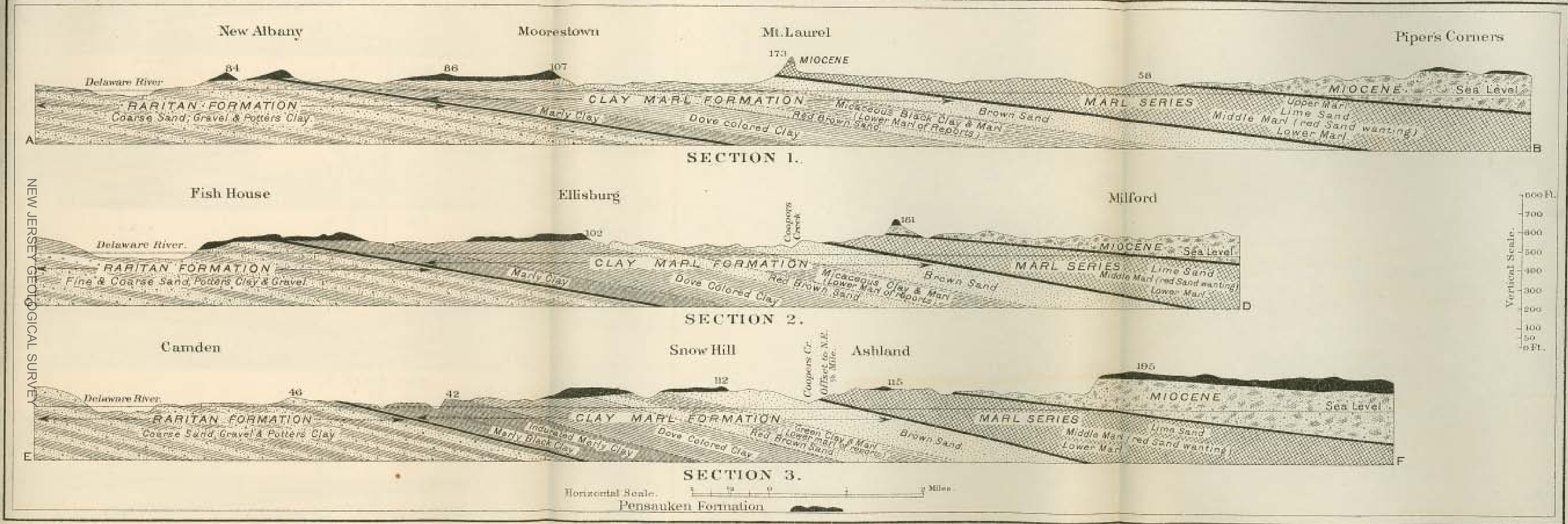
The time relations of the "high-level" and "low-level" Jamesburg cannot be said to be as yet determined beyond question. It seems probable that the low-level areas about the coast, or at least their uppermost covering, corresponding probably to the "low-level Columbia" of the regions south of New Jersey, are very young, being in part contemporaneous with the Trenton gravel, and so with the last glacial epoch. This would appear to be indicated by the fact that, along the Delaware, the "low-level" Jamesburg is harmonious in elevation with the Trenton gravel formation, with which it appears to be continuous laterally, and that it extends up the valleys tributary to the Delaware, at elevations accordant with those of the Trenton gravel formation or its equivalent, at the junction of the valleys. In these tributaries the "low-level" Jamesburg rises gradually with the valleys, and finally attains a considerable elevation toward the heads of the more considerable streams. The relations of the high-level Jamesburg to the lower have not been certainly fixed.

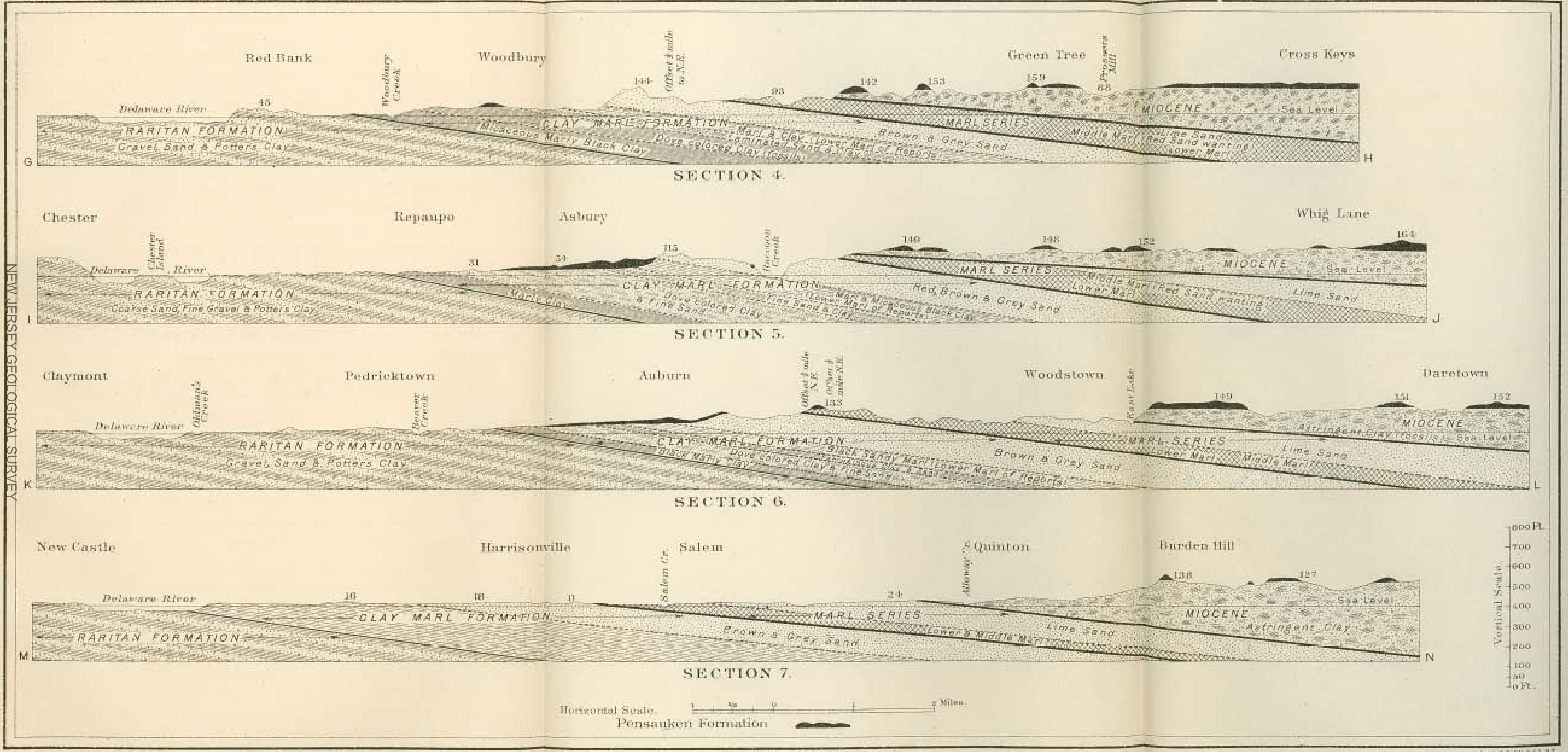
EXPLANATION OF PLATES.

Plates II. and III. represent a series of sections taken along the lines *a b*, *c d*, *e f*, *g h*, *i j*, *k l*, and *m n*, Plate I. They are designed to show the topographic and stratigraphic relations of the Pensauken. The formation colored black is the Pensauken. The numbers at various points along the surfaces of the sections represent elevations above sea-level. The sections also show the subdivisions of the Clay Marl series in the southwestern part of the State, and the relations of the overlying strata up to the Pensauken.



GEOLOGICAL SURVEY OF NEW JERSEY.
MAP
SHOWING DISTRIBUTION
OF THE
PENSAUKEN FORMATION
within area where detailed mapping
has been done.
Incomplete to the Southeast.
1895.
Scale of Miles.
Port Jervis
HUNTERDON
MERCER
MONMOUTH
BURLINGTON
CAMDEN
GLOUCESTER
ATLANTIC
CUMBERLAND
ESSEX
HUDSON
NEW YORK
BROOKLYN
PHILADELPHIA
CHESTER
WILMINGTON
EASTON
TRENTON
HARITAN BAY
DELAWARE
BAY
ATLANTIC OCEAN
Atlantic City
Cape May City


New Albany
Moorestown
Mt. Laurel
Pipers Corners
84
86
107
173
MIOCENE
58
Delaware River
RARITAN FORMATION
Coarse Sand, Gravel & Potters Clay.
Marly Clay
CLAY MARL FORMATION
Dove colored Clay
Red Brown Sand
Micaceous Black Clay & Marl (Lower Marl of Reports)
Brown Sand
MARL SERIES
MIOCENE
Sea Level
Upper Marl
Lime Sand
Middle Marl (red Sand wanting)
Lower Marl
A
B
SECTION 1.
Fish House
Ellisburg
Milford
Delaware River.
102
Coopers Creek
161
RARITAN FORMATION
Fine & Coarse Sand, Potters Clay & Gravel.
Marly Clay
CLAY MARL FORMATION
Dove Colored Clay
Red Brown Sand
Micaceous Clay & Marl (Lower Marl of reports)
Brown Sand
MARL SERIES
MIOCENE
Sea Level
Lime Sand
Middle Marl (red Sand wanting)
Lower Marl
D
SECTION 2.
Vertical Scale.
800 Ft.
700
600
500
400
300
200
100
50
0 Ft.
Camden
Snow Hill
Ashland
Delaware River.
46
42
112
Coopers Cr.
Offset to N.E. ½ Mile.
115
195
RARITAN FORMATION
Coarse Sand, Gravel & Potters Clay
Marly Black Clay
Indurated Marly Clay
CLAY MARL FORMATION
Dove Colored Clay
Red Brown Sand
Green Clay & Marl (Lower marl of reports)
Brown Sand
MARL SERIES
Middle Marl
Lower Marl
Lime Sand
(red Sand wanting)
MIOCENE
Sea Level
E
F
SECTION 3.
Horizontal Scale.
Miles
Pensauken Formation


Red Bank
Woodbury
Green Tree
Cross Keys
Delaware River
Woodbury Creek
Offset ½ mile to N.E.
Prossers Mill
RARITAN FORMATION
Gravel, Sand & Potters Clay
CLAY MARL FORMATION
Micaceous Marly Black Clay
Dove colored Clay (fossils)
Marl & Clay (Lower Marl of Reports)
Laminated Sand & Clay
Brown & Grey Sand
MARL SERIES
Middle Marl
Lime Sand
Red Sand wanting
Lower Marl
MIOCENE
Sea Level
G
H
SECTION 4.
Chester
Repaupo
Asbury
Whig Lane
Delaware River
Chester Island
Raccoon Creek
RARITAN FORMATION
Coarse Sand, Fine Gravel & Potters Clay
Marly Clay
CLAY MARL FORMATION
Dove colored Clay & Fine Sand
Marl & Micaceous Black Clay
(Lower Marl of Reports)
Fine Sand & Clay
Red, Brown & Grey Sand
MARL SERIES
Middle Marl (Red Sand wanting)
Lower Marl
MIOCENE
Sea Level
Lime Sand
I
J
SECTION 5.
Claymont
Pedricktown
Auburn
Woodstown
Daretown
Delaware River
Oldman's Creek
Beaver Creek
Offset ½ mile N.E.
East Lake
RARITAN FORMATION
Gravel, Sand & Potters Clay
CLAY MARL FORMATION
Black Marly Clay
Dove colored Clay & Fine Sand
Black Sandy Marl (Lower Marl of Reports)
Brown & Grey Sand
MARL SERIES
Lower Marl
Middle Marl
Lime Sand
MIOCENE
Astringent Clay (fossils)
Sea Level
K
L
SECTION 6.
New Castle
Harrisonville
Salem
Quinton
Burden Hill
Delaware River
Salem Cr.
Alloway Cr.
CLAY MARL FORMATION
RARITAN FORMATION
MARL SERIES
Brown & Grey Sand
Lower & Middle Marl
Lime Sand
MIOCENE
Astringent Clay
Sea Level
M
N
SECTION 7.
Horizontal Scale.
2 Miles.
Pensauken Formation
Vertical Scale.
800 Ft.
700
600
500
400
300
200
100
50
0 Ft.
JULIUS BIEN & CO. N.Y.

PART II.

REPORT ON
ARCHEAN GEOLOGY

BY

J. E. WOLFF.

REPORT ON ARCHEAN GEOLOGY.

BY J. E. WOLFF.

The areal mapping of the Archean area of the Highlands by the United States Geological Survey, in co-operation with the State Survey, has progressed steadily since the last report.

The field work is completed for the Lake Hopatcong sheet of the atlas of the United States, as published by the United States Geological Survey, which includes that part of the State topographical sheet of the "Central Highlands" enclosed between Woodport and a little south of Mendham, from north to south; and from the west edge of Morristown to Budd's lake, from east to west—a total area of 233 square miles, on the same scale of an inch to the mile. During the coming winter this sheet with the descriptive text will be prepared for publication.

After the completion of the above sheet, work was begun on the Franklin sheet, which has the same area, and extends between Libertyville to south of Sparta in a north and south direction, and from Stockholm to Branchville in an east and west direction. The field work of thirty-five square miles of this sheet has been completed.

By the work already done on this part of the Franklin sheet, the existence has been proved of large areas of eruptive granite along the west edge of this part of the Highlands, which extends the occurrences described by Mr. Nason in the report of 1890 in the foothills east of the white limestone belt.

The larger area so far defined lies between Franklin and Stockholm, and has been traced five miles from its northern end, near the "Mud Pond," in a southwesterly direction, with a width of about a mile and a quarter; the southern limit not having been yet reached in the progress of the work.

Accompanying this report is a paper by Mr. Lewis G. Westgate on the geology of the northern end of Jenny Jump mountain, in Warren county, with accompanying maps, which represents the results of a very careful and detailed study of this area, which is an interesting one on account of the presence of white limestone there, much like that of the Franklin region in Sussex county. It will be observed that his conclusion as to the age of the white limestone here differs from that reached in the report of 1890 for the Sussex white limestones, in that he considers the Jenny Jump crystalline limestones to be pre-Cambrian and older than the blue (Cambro-Silurian) limestone adjacent to them.

CAMBRIDGE, Mass., Nov. 25th, 1895.

THE GEOLOGY OF THE NORTHERN PART OF JENNY JUMP MOUNTAIN, IN WARREN COUNTY, NEW JERSEY.

BY LEWIS G. WESTGATE.

INTRODUCTION.

The following paper is a report upon field work done in the State of New Jersey during the summers of 1891 and 1895, under the auspices of the United States Geological Survey, and of the Geological Survey of New Jersey. The work has been under the direction of Dr. J. E. Wolff, of Harvard University, to whom the writer wishes to express his thanks for advice and encouragement during its whole progress.

The area under consideration embraces the northern half of Jenny Jump mountain, in Warren county. This mountain lies along the northwestern border of the Highland area, and is a sort of outlier or peninsula reaching into the later Paleozoic rocks. As is true of all northern New Jersey, the geology and topography of the area are closely connected. The hard gneisses form the mountain, and the softer Paleozoic limestones and shales form the floor of the Kittatinny valley, from which the mountain rises. The geological boundary between the two rock formations is also the topographic boundary between hill and lowland. The mountain is nine miles in length, two miles in width in its widest part, and lies, like the other ridges of the Highlands, in a northeast and southwest direction.

For convenience in description the area surveyed may be divided into two portions; one, an area mainly of gneisses, forming the main ridge of the mountain; and the other, a smaller area of limestone, diorite and other rocks, at its extreme northeastern end.

THE GNEISSES.

DISTRIBUTION AND PETROGRAPHICAL DESCRIPTION.

The areal distribution of the gneisses is shown on the map. They are of different varieties, and occur in northeast and southwest belts, parallel to the general trend of the mountain.

Granitoid biotite-hornblende-gneiss.—This is a medium-coarse granitoid gneiss, and is found in two belts, one along the northwest side of the mountain, with an average width of a third of a mile, the other a more irregular belt on the southeast side of the mountain. Many of the outcrops are quite massive. In perhaps half of the outcrops of the first belt there is a more or less distinct banding. The average of the strike and dip of the banding in those outcrops is: strike N. 50° E., dip 65° S. E. The terms "dip" and "strike" are used here and elsewhere wholly independently of any theory of the origin of the banding in the gneiss. This banding may be the result of sedimentation, or, as seems more probable, may be a secondary structure produced by dynamic metamorphism. The same terms may be conveniently used to describe certain geometric relations in rocks, whether the relations are those of sedimentary beds, or of parallel bands of eruptive rock. (Of course the value of the observations would be very different in the two cases.) The dip is always to the southeast, the different measurements varying between 50° and 80°. The rock of the southeast belt is more massive.

Microscopically this rock is a medium-coarse-grained, light-colored, often brown, granitoid gneiss, of uniform character. It consists principally of feldspar and quartz, but contains abundant hornblende and biotite, usually scattered irregularly through it, though sometimes showing a more or less parallel arrangement. In some outcrops the hornblende is the more abundant, in others the biotite. The rock is a biotite-hornblende-gneiss, and either mineral may locally prevail. It usually weathers to a characteristic brownish, crumbling rock. In many places the grain becomes coarser and the rock assumes the facies of a pegmatite. In a few cases it is finer grained, and approaches in character the pyroxene gneiss described below.

At several points to the northwest and south and southeast of Davis mine, the gneiss is garnetiferous. The garnet occurs in small irregular masses scattered through the rock, and is especially noticeable on the weathered surface, showing as reddish-brown patches and dots against the lighter rock. In some outcrops the gneiss is in part garnetiferous and in part not. Garnet is especially abundant, and occurs in larger patches, in the irregular masses of coarser pegmatite which are found in these outcrops. This garnetiferous gneiss seems to be a local variation; it cannot be traced for any distance as a definite horizon.

Microscopically the rock is a medium-coarse gneiss. Parallel structure of the minerals is almost wholly wanting, being only faintly developed in a single slide, where there is an obscure parallelism in the biotite flakes. Quartz and feldspar are the predominating minerals. Of the feldspars, microcline occurs in all the slides, and is the most abundant mineral in each. Microperthite is abundant. Orthoclase occurs frequently, and plagioclase infrequently. The gneiss of the southeastern belt contains more of the orthoclase and plagioclase, and less of the other feldspars, than the northern belt. Quartz occurs in irregular grains, and as rounded inclusions in the feldspar. Biotite and hornblende are present in the rock, the former in the greater abundance. Brown biotite is scattered through the rock in irregular flakes which show no parallel structure. The hornblende occurs in scattered irregular grains, which show no development of crystal faces. Apatite and magnetite occur as accessories. Green monoclinic pyroxene is present in a single section. The rock is a typical gneiss in the irregularity of the different minerals and their lack of crystal boundaries, and in the common mutual inclusions of the different minerals, especially quartz and feldspar.

Bands of dark hornblende gneiss occur within the area occupied by this gneiss, but they will be treated more fully below.

Hornblende-pyroxene-gneiss.—This rock occurs in a northeast and southwest belt, forming the main axis of the mountain. This belt has a breadth along the middle of the mountain of from 1,300 to 1,400 feet, but narrows somewhat at the north.

The rock is a light-colored, usually greenish, medium-grained gneiss. In many outcrops it is massive, but in the greater number it is more or less banded; often conspicuously so where hornblende rock or pegmatite are present. In many cases bands of dark hornblendic rock are the only evidence of banding found in the outcrop, and in such cases the dip and strike of the banding have been taken from these. If these dark bands are, as seems probably, of eruptive origin, such measurements would not necessarily be the true dip and strike of the rocks. In that case their general parallelism is probably conditioned by their following banding planes of the gneiss. So that the plane of these hornblendic sheets is probably in most cases that of the banding of the gneiss. Wherever there is banding of the gneiss in the same outcrop with the hornblendic bands, the two are parallel. The strike averages N. 50° E. The dip is always to the southwest, between 40° and 90°, usually about 70°. The general direction of the strike as mapped coincides with the direction of the gneiss belt.

Microscopically, the rock consists principally of feldspar and quartz, with hornblende or pyroxene, or both. Both plagioclase and orthoclase feldspars occur, the former in greater abundance. Microline occurs sparingly, never as the principal feldspar. Microperthite is absent. Quartz is usually present in abundance in irregular grains, and as rounded inclusions in the feldspar. Hornblende and pyroxene occur, often very abundantly. The pyroxene occurs on the whole more abundantly than the hornblende. Biotite occurs rarely, in small amounts. These colored constituents occur in irregular grains, and rarely develop crystal planes. Titanite, magnetite, and apatite occur commonly, and sometimes abundantly, as accessory minerals. Of these, titanite is perhaps the most common. In many hand-specimens it may be seen, even by the naked eye, as numerous small, rounded, brown grains. The structure of the sections is typically gneissic. The minerals have the irregular boundaries characteristic of gneiss, and mutually enclose one another.

Under the microscope, the rock always appears massive. There is no evidence of banding, and little or no parallel arrangement of the hornblende or pyroxene.

There are three well-marked varieties of this gneiss, depending on the presence, character, and abundance of the dark-colored silicates:

1. White or feldspathic gneiss, in which there are no primary dark-colored silicates;

2. Hornblende-gneiss, in which dark-green monoclinic hornblende prevails;

3. Pyroxene-gneiss, in which light-green monoclinic pyroxene is most abundant.

Of these three varieties, the first is less common. The second and third occur with about equal frequency. Sometimes biotite is present, but rarely in sufficient quantity to make a typical biotite-gneiss. These three varieties grade into each other completely. There appears to be no regularity in their distribution throughout the belt in which they occur.

There appears to be a distinct mineralogical contrast between the granitoid biotite-hornblende-gneiss first described and this rock. In the former the prevailing feldspar species are microcline and microperthite; hornblende and biotite occur in about equal abundance, and pyroxene is almost wholly wanting. It is coarser grained, more massive, and weathers readily to a brownish decomposed rock. In the latter, plagioclase and orthoclase are nearly always the only feldspars present, microcline occurring only occasionally and in small infrequent grains; pyroxene is the most common dark-colored constituent, hornblende is next in abundance, and biotite occurs but rarely and in small amounts. The quite general presence of titanite as an accessory is also characteristic of this rock. It is finer and does not weather in a characteristic manner, like the gneiss first described.

The pyroxene gneiss lies next the western band of the biotite-hornblende-gneiss, but does not approach the eastern band. The boundary line between the outcrops of the two has been traced in nearly a straight line for over three miles; so that it is clear that we are dealing with two belts of rock, and not with two varieties of one rock which occur irregularly throughout a single belt. No outcrops show the two rocks in sharp contact. Near the boundary line the biotite-hornblende-gneiss is sometimes seen in the field to approach the pyroxene-gneiss in character; and it is probable that the rocks of the two belts grade into each other at their contact.

Biotite-gneiss.—Immediately southeast of the hornblende-pyroxene-gneiss just described lies a comparatively narrow band of gneiss less than 500 feet in breadth. It runs parallel with the other gneiss belts, and agrees with them in the dip and strike of its banding. This gneiss is a medium to fine-grained, generally light, but sometimes dark-colored, biotite or biotite-hornblende-gneiss, and in the outcrops is usually banded. In microscopic sections it is seen to be mainly composed of feldspar, quartz and biotite. Both plagioclase and orthoclase are present, and in nearly equal abundance. Microcline occurs in one slide in small grains. Quartz is commonly present in irregular grains, and as rounded inclusions in the feldspar. In typical specimens of this rock, brown biotite is the only primary colored constituent present. Magnetite and apatite occur as accessories. The rock structure is typically gneissic, and banding, although seen in the field, and sometimes even in hand-specimens, is noticeable, microscopically, in but a single slide.

At some localities the rock is a garnetiferous biotite-gneiss. The garnet is of a reddish-brown color, and occurs scattered through the gneiss in small irregular masses, which usually hold more or less of the other minerals of the rock as inclusions.

Along the contact between the biotite-gneiss and the hornblende-pyroxene-gneiss described above, there are, in some places, alternating bands of the two, indicating a gradual transition from the one to the other.

These three varieties of gneiss which have been described, while showing constant minor differences, are all alike in certain important petrographical characteristics. They are light-colored rocks, in which the feldspar and quartz are the prevailing, in some cases the only, minerals; while the dark-colored silicates play a subordinate part. They show a more pronounced gneissic micro-structure than the rocks to be described below. Further, they are usually massive, or only faintly banded. A banding may be noticeable when an outcrop as a whole is examined, but hand-specimens rarely, and microscopic sections almost never, show it. They are massive, typically gneissic acidic rocks, and are sharply marked off from the more basic, hornblendic rocks which follow. They may also differ from them in origin, but of that it is not possible to speak with certainty.

Dark biotite-hornblende-gneiss.—This is a dark, sometimes black, usually well-banded gneiss, in which hornblende largely preponderates, although biotite is common but less abundant. It occurs in two large and several smaller areas. The largest of these occupies the depression between the high western and lower eastern ridge of the mountain, and can be followed along the whole northern part of the mountain, parallel to the other gneiss belts. It is along this belt that the mines in this region, besides many small prospecting openings, are located; none of these iron mines are now worked, with the possible exception of the Kishpaugh mine, which is outside of the area surveyed, but is probably located on the southwest extension of this belt.

A second important belt occurs along the east side of the north end of the mountain, between the eastern band of granitoid biotite-hornblende-gneiss and the crystalline limestones. Several smaller bands occur in different parts of the main mass of the mountain, as may be seen from the map. The description of the rocks, lithologically identical with these, which are associated with the limestones in the low hills east of the north end of the mountain, will come later.

The rocks of the first belt will be first described. They are best shown along their eastern border. As already indicated, they are typically dark, sometimes black, rocks, which usually are well banded in their outcrops, and with these distinctive characteristics the belt can be traced almost uninterruptedly through the whole northern half of the mountain. The usual strike of the banding is N. 50° E.; the dip, 50° or more S. E. North of Davis mine the direction of the belt as a whole, and of the banding, becomes more northerly.

Microscopically the rock is seen to be composed of feldspar, dark-green monoclinic hornblende and, less abundantly, biotite. Both plagioclase and orthoclase feldspars occur, sometimes in equal abundance, but plagioclase often preponderating. Quartz may or may not be present; when present it is usually in small amounts. Magnetite and apatite occur as accessory constituents. Magnetite is sometimes quite abundant, as might be surmised from the many openings for ore along the belt. The rock is massive, the banding which is clearly seen in the outcrop not being recognized microscopically. The minerals are allotriomorphic, showing usually a polygonal granular facies which is not seen in the lighter colored gneisses of the region.

In passing westward across this belt, near the northern end of the mountain, the dark or black hornblende-gneiss passes gradually into a greenish well-banded gneiss. This variety has not been studied microscopically, but examination in the field indicates that it is simply an altered form of the hornblende-gneiss, and that its green color is due to the development of large amounts of secondary epidote, bands of which, parallel to the rock-banding, show conspicuously on the weathered surface. The feldspars have generally a red color, so that the rock has a red or green shade, according as the feldspar or hornblende prevailed in the original rock. Often where less altered the rock is a dark gneiss, similar to the hornblende-gneiss east of it; and it is here regarded simply as a variety of the dark hornblende-gneiss. These two gneisses, the black and its brighter colored variety, can be traced for a considerable distance in their respective positions, both north and south from the old silver mine, where they show most distinctly.

Further south, along the middle of the mountain, in probable continuation of this belt of weathered hornblende gneiss, the rocks are much-weathered medium-grained gneisses, consisting principally of plagioclase and orthoclase feldspar, with biotite and hornblende as dark-colored silicates, and, less commonly, augite. The rock structure is more typically that of gneiss. They are mapped here, however, with the dark hornblende rocks, because they lie in the southern extension of the belt of greenish weathered rock, which seems to be simply an altered hornblende-gneiss, because they are much weathered, like the corresponding rocks further north, and because there are not enough outcrops to show that there is a distinct belt of rocks between the dark hornblende-gneiss and the biotite-gneiss to the west.

For half a mile at its north end the steep eastern face of the mountain is covered by a dark or black medium-grained hornblende-gneiss, which is continued as a narrow belt to the extreme north end of the mountain. It lies between the coarse granitoid biotite-hornblende-gneiss on the west and the crystalline limestone on the east, except where it runs beneath the alluvium of Pequest meadows. The rock was not examined microscopically, but to the eye it is not different from the dark hornblendic gneiss already described. The strike of the banding is a little east of north, agreeing with the direction of the belt as a whole; the dip is 40° to 60° E. The slope of the mountain is here steep towards the east, nearly as steep as the dip of the banding of the gneiss; so that the gneiss band probably is not as thick as the mapping would seem to indicate, and may only form a cover to the sloping mountain side.

Several smaller bands of this dark biotite-hornblende-gneiss are indicated on the map. Two of these occur within the western band of granitoid biotite-hornblende-gneiss; a third occurs just west of the eastern band of the same granitoid gneiss, south of the Stinson Mine. In each of these the rock agrees both in field and microscopic character with the rocks of the larger areas already described. The direction of the belts as a whole, and the strike of their banding, is parallel to the other larger gneiss belts.

Two other outcrops which are mapped as dark hornblende-gneisses require special mention. These occur east of the limestone, along the middle of the mountain. In the northernmost of these two outcrops, the rock is a well-banded gneiss, somewhat varied in character. In places it is a greenish weathered basic rock; again it is a greenish hornblende-gneiss, with some green pyroxene, and the polygonal-granular facies characteristic of the dark hornblende-gneisses already described. A little more than a mile southwest, where the road crosses the limestone, the rock east of the limestone is a greenish well-banded rock, which the microscope shows to be an aggregate of quartz and epidote grains. Weathering has completely obscured the original character of the rock; but it is not improbable that it was a basic hornblende-gneiss, like the rock just described as occupying a corresponding position east of the limestone to the northeast, and which has undergone a process of alteration similar to that suffered by the dark hornblende-gneisses of the first belt described. The banding of the gneiss at these two localities dips to the northwest, apparently conformable to the limestone west of it.

Rocks associated with the preceding gneisses.—There are several different rock varieties occurring in the area occupied by these gneisses, which deserve attention.

1. *Pegmatite.*—This is essentially a coarse mixture of feldspar and quartz, usually with more or less green monoclinic hornblende, and often with considerable amounts of magnetite. It occurs in irregular patches and in dike-like masses. Often the pegmatite occurs in long, narrow bands, or lenticular masses, parallel to the banding of the gneiss. There is then nothing, except perhaps the sharpness of the boundary between the gneiss and these bands, to indicate that they are not regular members or bands of the gneiss, of somewhat different lithological composition from the rest, and coarser grained. Often, however, they may be seen to cut the gneiss irregularly across the banding. In that case they are clearly of later age than the gneiss. The material in these dikes is always massive, and never suggests a vein origin for the rock. The bands parallel to the banding in the gneiss do not differ from the others except in direction, and are considered to have a similar origin. We may therefore class them as eruptives.

These pegmatite bands are present everywhere in the gneiss. Along the eastern border of the biotite-gneiss, between it and the dark hornblende-gneiss, white or red pegmatite is developed more abundantly than in any other part of the field, forming a broken band sometimes many feet in width.

2. *Epidote rock.*—The large amount of "epidotization" to which some of the dark hornblende-gneisses have been subjected, has already been mentioned. Apparently it results here from the decomposition of the hornblende, or from the interaction between hornblende and plagioclase; both of these original minerals being much weathered. Bands and patches of greenish rock, rich in epidote, occur very frequently in the pyroxene-gneiss. These bands are generally but a few inches in width, and as often cut the banding of the gneiss as run parallel with it. They appear to be veinlike in their nature. Sometimes they are wholly greenish, fine-grained aggregates of epidote; at other times these veins are mainly quartz, with a border of epidote. Under the microscope this rock is seen to be composed wholly of quartz and epidote. The quartz occurs in extremely irregular, interlocking grains, with a wavy extinction, and looks like vein quartz. The epidote is present in large quantities in grains and granular aggregates, and probably results from the decomposition of the pyroxene in the enclosing gneiss. These epidote bands are then the filling of cracks by deposits of silica and secondary epidote, derived from the decay of the pyroxene, and possibly also, in part, of the feldspars, in the gneiss. The feldspar is, however, usually fresh. Pyroxene occurs abundantly through the gneiss, and is very generally more or less weathered, resulting in the production of secondary minerals, often in large amounts, prominent among which is epidote.

3. *Amphibolites.*—The large areas of dark or black hornblendic rocks have already been described. Besides these larger areas, narrow bands of dark, granular hornblendic rock are very common in the different gneisses. They consist essentially of an aggregate of dark-green monoclinic hornblende and plagioclase, but sometimes contain biotite. They form long and narrow bands, generally parallel to the banding of the gneiss, their width being usually from one or two feet down to a few inches. In one case the band is itself banded.

Lithologically these rocks are not different from certain hornblendic rocks at the north end of the mountain, some of which are shown to be eruptive by their field relations, and which will be described later. Their general arrangement parallel with the strike would seem to indicate that they are interbedded gneiss. But as an eruptive rock would follow the lines of weakness in the rock into which it was injected, and as these lines or planes would be, other things equal, the planes of banding or lamination, it seems that this apparently interbedded arrangement would be the one most likely to occur in case the hornblende rock was an eruptive through a previously banded gneiss. While then there is no demonstrable evidence that these hornblendic bands in this part of the mountain are eruptive, this consideration, in connection with the occurrence elsewhere of lithologically similar rocks which are known to be eruptive, inclines us to suppose that such is their probable origin. Similar rocks have been described from many other crystalline areas, under the terms "hornblende-gneiss," "diorite-schists," "amphibolites," and "metamorphic diorites," and have been regarded by geologists as of eruptive origin.* By Cook † they were considered as true gneisses and metamorphosed sedimentary beds. By Britton ‡ they were considered metamorphic, where occurring in layers parallel to the banding in the gneiss. By Wolff § some similar rocks in New Jersey are considered eruptive, while it is held unsafe to assign a common origin to them all. But similar rocks are also described by the same writer ‖ from Massachusetts and Vermont, where they are generally parallel to the banding of the schists, but in some cases cut it obliquely, and all are referred to an eruptive origin.

4. Diabase.—Dikes of dark, compact, fine-grained diabase occur in several places, cutting both the gneisses and the limestones, and the gneissic and hornblendic rocks associated with them, at the north end of the mountain. As the largest of these dikes cuts the gneisses which have been described, they may as a whole be considered here. The largest dike is fifty feet or more in width, and can be followed for a mile and a half in a northeast and southwest direction. It was found on the west side of the summit, near the southern edge of the area mapped, and traced thence down the face of the hill to a point one-third of a mile northeast of the Stinson mine. It may extend beyond this point, but was not traced further. The course of the dike is nearly straight, and it does not often give off branches into the surrounding gneiss. At one or two points, however, it does, and in one instance was seen to include a "horse" of gneiss several feet in length. Long diabase dikes occur cutting the limestone and

* Van Hise, Bulletin United States Geological Survey, Archean and Algonkian, page 384.

† Geological Survey of New Jersey, various reports.

‡ Geological Survey of New Jersey, Annual Report for 1886, page 104.

§ Geological Survey of New Jersey, Annual Report for 1893, page 363.

‖ Mon. XXIII, United States Geological Survey, Geology of the Green Mountains in Massachusetts, page 65.

associated rocks at several points at the northeastern end of the mountain, as shown on the map. They cut both the limestone and other rocks in an east-northeast direction. Throughout this northern limestone-diorite area smaller dikes of diabase are of frequent occurrence.

Microscopically the rock is a typical diabase. Plagioclase occurs in large rectangular prisms, several times longer than broad. They are permeated with secondary muscovite and granular products. Colorless monoclinic pyroxene occurs throughout the slide in irregular grains and crystalloids. In many cases it is weathered to a greenish chlorite, with other earthy decomposition products. The plagioclase and pyroxene occur porphyritically developed in a finer grained ground mass consisting of an interlocking aggregate of prisms of pyroxene and feldspar, in which lie granular masses of pyroxene and magnetite.

In microscopic character these diabases resemble the Triassic diabases of New Jersey and Connecticut. They are the youngest rocks of the Highland area, for they cut all the other rocks. It is probable that they are of the same age as the similar diabases occurring in the Triassic rocks to the east, although there is no proof of this, in the region under discussion.

The intrusion of these diabases does not appear to have metamorphosed the rocks through which they pass, to an appreciable extent. The other rocks show no alteration at their contact with the diabase dikes. The diabase cannot be considered an agent in the metamorphism of the white limestone, but was probably injected into it after it had become thoroughly crystalline.

5. *Crystalline limestone.*—At several places crystalline limestone occurs in close association with the dark hornblendic gneisses already described. These will be considered in detail below.

General character of the gneisses.—The general character of the gneisses of the main part of the mountain (with the exception of the dark hornblendic gneisses) is markedly granitic. H. D. Rogers,* in 1840, described the crystallines of the New Jersey Highlands as "consisting of gneiss under all its forms, the granitoid variety predominating. Innumerable small veins of feldspathic granite, syenite, greenstone, &c., penetrate the gneiss. Mica is deficient, the usual mixture being either feldspar or quartz with a little mica, or these

*Summarized by Van Hise, Bulletin United States Geological Survey, Archæan and Algonkian, page 399.

minerals with an excess of hornblende, and hornblende and magnetic oxide of iron, the latter being so abundant as to be a characteristic constituent. The massive granitoid gneisses of the Highlands are in striking contrast with the gneiss belt of New York and Staten Island, which is distinguished by a schistose structure or the thinly bedded character of ordinary gneiss." This description applies perfectly to the limited area under consideration. The gneisses are granitoid, and generally massive. Hornblende is the most abundant of the dark-colored silicates present. The gneisses are cut by masses of pegmatite, diabase, and hornblendic gneiss or amphibolite. There is a conspicuous absence of schistose rocks of all kinds. There is an equally noticeable absence of that crumpling and contortion of the banding of the rock which characterizes crystalline rocks in many places; as for example, in the crystalline area of Western Massachusetts. The banding in single outcrops and over wide areas is very uniform. There is a general northeast and southwest strike, and an almost universal dip of 60° to 90° S. E.

THE ORIGIN, STRUCTURE AND AGE OF THE GNEISSES.

The origin of the gneisses.—Very little can be said to be known about the origin of these gneisses. When the lighter colored feldspathic varieties are studied microscopically, no evidence can be found that they are of detrital origin. Examination in the field throws little light upon the problem. The uniformity of their banding indicates, possibly, that it is a secondary structure. At any rate, the mere presence of banding in the gneiss is certainly no proof, perhaps not even an indication, of sedimentary origin; for banding in gneisses has been repeatedly shown to be of secondary origin. On the other hand, the massive character which some of the granitoid gneiss assumes, suggests an eruptive origin, and that a part at least of the gneiss is a metamorphosed granite.

The origin of the dark hornblendic gneisses is equally a matter of conjecture. They occur interbanded with the other gneisses, as if all were conformable members of one series. Their banding also may be a secondary structure. They agree in lithological character with certain dark banded hornblendic gneisses associated with the limestones, and which will be described below; and there is reason to believe that some of these hornblendic gneisses associated with the limestones are of eruptive origin. But it would not be safe, for this reason, to conclude that all the areas of dark hornblende-gneisses are eruptive. For the present we can only speculate as to what the origin of these gneisses may have been; the facts are not yet known which will enable us to settle the problem—perhaps they never will be.

The structure of the gneisses.—From what has already been said concerning their origin, it will be inferred that no structure has been made out for the gneisses on Jenny Jump mountain. If they showed structure—definite horizons and beds thrown into folds—the sedimentary origin of the series would naturally be inferred. The gneisses occur in northeast and southwest belts, which for the most part run parallel to each other along the whole length of the mountain. Some of these different bands are of the same lithological character. It has not been possible to trace into each other any of these different belts which agree in lithological character. A general northeast pitch of the rocks of the Highland area has been noted by various writers; and if these similar belts of rock are the same band, in different parts of a northward pitching synclinal or anticlinal fold, they should swing around and join, either on the south or on the north; but they do not do this. When traced to the north end of the mountain they continue parallel until they disappear below the later blue Paleozoic limestone. In spite of inability to connect any of the different belts in the field, upon the supposition that they are parts of the same formation, it would be possible to invent synclines or anticlines to explain their recurrence and their relations to the other rocks. To do so, however, would be useless, as the facts are wanting to support any such theory.

It may be noted here that little help can be obtained in deciphering any possible system of folds in these gneisses, from minor plications (a method which has been of great value in the study of the crystalline rocks of Western Massachusetts) for such a system of smaller secondary and tertiary folds superposed upon the larger folds of the region is wholly wanting here.

The only published account of a definitely determined structure in the Highland gneisses of New Jersey, is the fold occurring in the Hibernia region, which has been described by Dr. Wolff.*

Two cross-sections, one across the middle, the other across the north end of the mountain, are here inserted, to show graphically the relations of the gneisses and limestones. The second and more northerly of the two is extended eastward to cross the area, mainly of limestones, which will be described below.

*Geological Survey of New Jersey, Annual Report for 1893, The Geological Structure in the Vicinity of Hibernia, N. J., page 359.

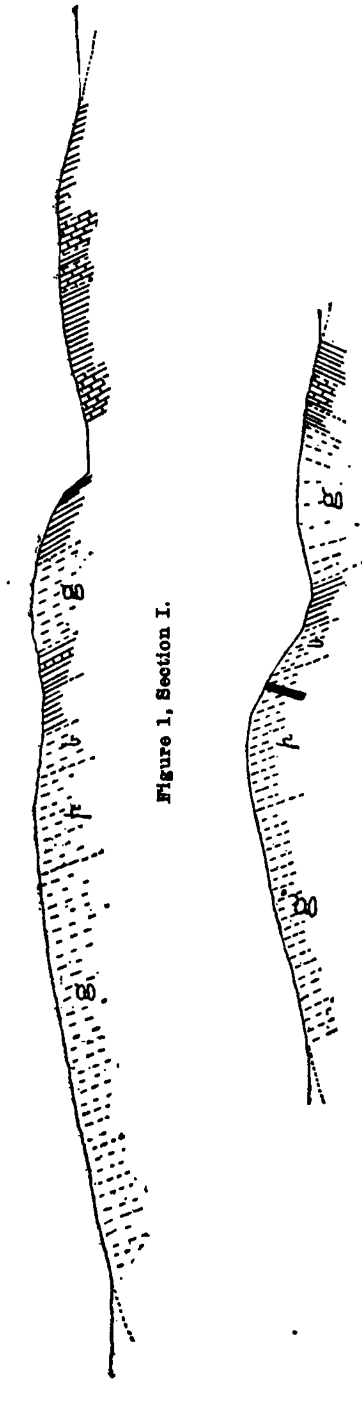


Figure 1, Section I.

Figure 2, Section II.

Lighter feldspathic gneisses; *g*, granitoid biotite-hornblende-gneiss; *p*, hornblende-pyroxene-gneiss; *b*, biotite-gneiss. Dark hornblendic gneiss.

Crystalline limestone. Diabase.

Vertical and horizontal scale: 1 inch = 1,760 feet.

Age of the gneissic series.—These rocks have always been referred to the pre-Cambrian series—to Primary, Azoic, or Archean, according to the nomenclature in use at the period of writing. It is the usage of the United States Geological Survey to restrict the term Archean to the most ancient crystalline rocks which formed part of the original crust of the earth, and which underlie and antedate the oldest sedimentary rocks; and to classify as Algongian all sedimentary rocks up to the base of the Cambrian.* While the presence of limestone belts closely associated and perhaps interbanded with these gneisses, and of magnetic iron ore, suggests a detrital origin for a part at least of these rocks, at present there is not sufficient evidence to refer them certainly to the Algonkian. They must be classed simply as pre-Cambrian.

THE WHITE OR CRYSTALLINE LIMESTONE.

DISTRIBUTION AND PETROGRAPHICAL DESCRIPTION.

The crystalline limestone along the southeast border of the mountain.—The most southerly outcrop of white or crystalline limestone is at a marble quarry just south of the road from Hope to Danville, near the bottom of the map (Map 1). It is here a pink, coarsely crystalline, nearly massive rock, holding abundant basic impurities, principally pyroxene and biotite, which are often collected into dark-green or black aggregates of considerable size, and do not appear to lie in planes corresponding to the banding planes of the limestone. The banding of the limestone is very faintly developed, and appears to be: strike N. 27° E., dip 60° N. W. East of the limestone is a finely banded quartz-epidote-gneiss, the banding striking N. 50° E., and dipping 60° N. W. No outcrops are found west of the limestone, as the rocks are here concealed by drift. The gneiss and limestone are not seen to be in contact, but the banding of the two is nearly if not quite parallel, and the indications are that we have here a limestone interbanded with gneisses.

About one-sixth of a mile northeast of the marble quarry (Map 2), openings for ore expose the limestone a second time. This exposure seems certainly from its position to be on the northeast extension of

*Van Hise, Bulletin United States Geological Survey, Archean and Algonkian, page 414.

the marble quarry bed. The rock is a white or reddish crystalline limestone, not very coarse. It contains large amounts of basic impurities, sometimes collected into masses of considerable size. These basic portions are seen under the microscope to consist of green monoclinic hornblende, nearly colorless monoclinic pyroxene, biotite and magnetite, and, in less amounts, quartz, tourmaline and apatite. Much of the limestone contains small masses of quartz. Under the microscope the quartz is seen to occur in irregular grains with a wavy extinction, or as aggregates of such grains; and there is nothing to suggest that they are of detrital origin. They are probably secondary, perhaps of metamorphic origin. This quartz-bearing limestone was found abundantly in the limestone debris near one of the openings, but was not seen *in situ*. The banding in the limestone was not distinct. It was taken to be: strike N. 30° E., dip 70° N. W. There is no outcrop of gneiss on either side of the limestone at this locality.

At the bottom of the deepest shaft a basic dike-like band, six inches in thickness, cuts the limestone in the plane of the banding. The rock consists principally of pyroxene and feldspar. Green monoclinic pyroxene occurs frequently in irregular grains. Titanite is almost as abundant. An untwinned feldspar, probably orthoclase, is the principal mineral constituent. Magnetite and apatite occur as accessories. The rock belongs to the gabbro family, though the presence of orthoclase in such a rock is hardly normal. It has the granular structure characteristic of the basic eruptive rocks of the region.

A few hundred feet to the northeast limestone again outcrops. It is here a white crystalline limestone, containing irregular masses of quartz. There is no banding in the limestone, and no contacts are seen. This is clearly an extension of the limestone of the two previous outcrops. There are no gneiss outcrops on either side of the limestone at this point.

Another outcrop of limestone occurs east of the road (Map 3), on a small hill three-quarters of a mile northeast of the marble quarry outcrop. It is a gray crystalline limestone, holding much basic material. It is well exposed in a cutting at the north end of the hill, where it is a white limestone especially rich in garnet. The banding of this limestone strikes N. 60° E. and dips 50° N. W. Gneiss occurs to the northwest, dipping steeply N. W., but no contact is seen.

Half a mile further to the northeast of the road is the last outcrop of limestone before coming to the limestone region at the north end of the mountain. The rock is a gray or white crystalline limestone, with little impurity. There are some grains of pyroxene, mostly decomposed to serpentine and other products. It is banded: strike N. 45° E., dip 40° N. W. To the east there is a finely banded hornblendic gneiss, with dikes and larger masses of coarse pegmatite. The gneiss shows strike N. 42° E., and dips nearly parallel with the banding of the limestone. No contact can be seen between the gneiss and the limestone.

These different outcrops appear to represent a continuous northeast and southwest band, 300 to 400 feet in breadth, running along the southeast side of the mountain, which can be followed by means of these separate outcrops for a mile and a half. Within this distance it fails to appear only where the edge of the mountain retreats, and the alluvium conceals the probable continuation of the belt. In most cases where the topography makes it possible, gneiss occurs on the east of the limestone, dipping as it appears, conformably under it to the northwest. One limestone outcrop is succeeded on the west by a northwest dipping gneiss. West of the other limestone outcrops drift conceals the rocks. The limestone in this part of the mountain has the appearance of being interbedded with the gneiss.

Outcrops of crystalline limestone within the large body of gneisses.—At two points within the gneisses small outcrops of crystalline limestone are found. One of these is a few yards east of the Stinson mine (Map 4). It occurs as a band of gray or red massive crystalline limestone, with the usual amount of dark accessory minerals, and having a maximum visible thickness of about six feet. Just east of the limestone, but without an actual contact, is found a dark, well-banded hornblende-gneiss, striking N. 40° E., and dipping 50° S. E. The limestone band dips apparently conformably beneath this gneiss. Gneiss occurs a short distance west of the limestone. This limestone band was traced a number of yards in a northeast and southwest direction, but could not be followed further.

A mile to the northeast, at the Davis mine (Map 5), a small outcrop of massive white or gray crystalline limestone occurs in an opening, apparently underlying the dark hornblende-gneiss, which here dips 50° S. E. The gneiss and limestone approach within ten feet of each other, but the actual contact does not show. Outcrops are not present immediately adjoining the limestone on the west. The limestone could not be traced along the strike of the rocks in either direction, outside of the opening.

These two limestone bands apparently underlie the dark hornblende-gneisses to the east of them, all dipping southeast. They are both bounded on the west by similar gneiss, also dipping southeast. The indications are that we have here beds of limestone interbanded conformably with the gneiss.

These two outcrops occur at corresponding points within the large western belt of dark hornblende-gneiss, and are in line in the direction of the strike; but it is not possible to trace one into the other along the strike, and so show that they are two outcrops of a single limestone bed.

The crystalline limestone at the northeast end of the mountain.—East of the north end of Jenny Jump mountain is the largest occurrence of crystalline limestone in this region. It is an area of low hills two miles in length, north and south, and from one-half to two-thirds of a mile in breadth. Associated with the limestones here are other rocks, in part true gneisses, in part dark, banded, hornblendic rocks, some of which are eruptive and belong among the diorites. The surface within the area is made up of a broken succession of ridges and valleys with no definite order.

The limestone occurs in a general way in very irregular north and south bands, in the area named. The irregularity of these bands, however, is their main characteristic; for they frequently turn to east and west, and are often cut out wholly by areas of diorite and gneiss. The limestone also occurs as isolated areas or masses enclosed within the gneiss. The outcrops often show a banding which is generally more or less obscure, while at times the rock is quite massive.

Lithologically the rock varies greatly, but mainly in the abundance and character of the accessory minerals. Calcite, usually rather coarsely crystalline, is the principal, and sometime the only, mineral present. Accessory minerals are present in very varying amounts. Sometimes they are almost wholly absent, and the rock is a very pure white or gray crystalline limestone. At other times they are present in very large quantities. Of such accessory rock constituents, magnetite is one of the most abundant. It occurs in irregular grains and aggregates, sometimes in such quantities as to replace completely the calcite, in which case the rock has sometimes been worked as an ore. Quartz and a nearly or quite colorless monoclinic pyroxene occur very abundantly. Besides these three accessory minerals, biotite, hornblende, graphite and pyrite also occur. Serpentine is abundant. Frequently a hand specimen of the limestone is dotted with small rounded masses of serpentine; under the microscope these are seen to be aggregates of serpentine fibres derived from the decomposition of the colorless pyroxene, fragments of the undecomposed mineral being frequently associated with the serpentine. Besides serpentine, calcite, chlorite, muscovite, limonite and epidote occur as decomposition products of the accessory metamorphic minerals of the limestone.

THE AGE OF THE WHITE OR CRYSTALLINE LIMESTONE.

The relations of the crystalline limestones of Warren county to the crystalline limestones in other parts of New Jersey.—Among the crystalline limestones of New Jersey no localities are so well known as those near Franklin, in Sussex county; and writers describing the crystalline limestones of the State have generally had these in mind as typical and representative of other localities. They have generally considered all the separate outcrops in New Jersey to be of the same age with the Sussex county rocks. Cook,* in describing the crystalline limestones of the State, considers together the localities in the southeastern and northwestern Highlands, and places them all in the Azoic (Archean). Nason,† in describing the Sussex county white limestones, extends the belt by isolated outcrops southward to Jenny Jump mountain and to Oxford Furnace, making all these outcrops of the same age and Cambrian.

The evidence in favor of this correlation of isolated outcrops is mainly lithological, for no fossils have been found in any of the crystalline limestones of New Jersey. The reasons for correlating the limestones of Jenny Jump mountain in particular with those of Sussex county are as follows: (1) Their likeness in lithological character. The rocks in both regions are very crystalline, generally white or gray limestones, and carry large amounts of accessory metamorphic minerals. (2) In both areas the limestones are cut by similar eruptive rocks—diabase, granite or pegmatite, and diorite. (3) In both

* Geology of New Jersey, 1868.

† Geological Survey of New Jersey, Annual Report for 1890, pages 25-27.

regions the limestones are more or less closely associated with the granitoid gneisses, which are the most abundant rocks of the northwestern Highlands, and in some cases the limestones appear to be interbedded with them. (4) The limestones at Oxford Furnace and Jenny Jump mountain in Warren county have been taken to be a southwestward extension of the Sussex county belt. An examination of the geological map of New Jersey does not bring out this supposed relation with any marked distinctness. The Warren county rocks do not appear to be strictly a continuation of the northern belt, but to lie somewhat west of where the southern extension of the Sussex county rocks would naturally be expected.

The crystalline limestones of the two areas have thus been classed together, because of their lithological similarity and their association with the gneisses, and not on good structural or paleontological grounds. Lithological resemblances among crystalline rocks are certainly insufficient proof of contemporaneity. This is especially true where the areas in question are at considerable distance from each other. In this case the nearest outcrops of the two areas are separated by a distance of sixteen miles. Where no contrary evidence is found, however, lithological similarity has value as a suggestion; and when, as in the present instance, it is accompanied by association with a similar series of rocks (the granitoid gneisses), and the outcrops occur in a general way in line, it seems quite probable that the correlation between the two series which has been made in the past, is correct.

Views as to the age of the white crystalline limestone in Sussex county.—The question of the age of the crystalline limestones of the Highland region, and especially of the northwestern part of the area, in Sussex county, is one which has been much discussed within recent years. As the Jenny Jump limestones are in the same general northeast and southwest belt with those of Sussex county, are of much the same character, and have, by one writer at least, been definitely considered contemporaneous with the Sussex county rocks, it will not be out of place to take a brief survey of the views of different writers on the age of the white or crystalline limestones of northwestern New Jersey.*

It may be said that two kinds of limestone are found in Sussex

* Van Hise in Bulletin 86, United States Geological Survey, "Archean and Algonkian," pages 399-404, and Nason in American Geologist, Vol. VII., pages 241-252, give a full bibliography of this subject.

county. One is a blue magnesian Cambrian limestone, conformably underlaid by a quartzose sandstone or quartzite, containing Lower Cambrian fossils. This quartzite and limestone are unconformable on the gneisses. There is also a white or gray thoroughly crystalline limestone, the age of which is a matter of dispute.

Vanuxem and Keating,* in 1821, describe the white crystalline limestone at Franklin as agreeing in strike and dip with the syenite of the region, and as distinct from the blue limestone, which is in one case unconformably superposed upon the syenite. They referred the white limestone to what is now called Archean.

H. D. Rogers,† in 1840, considered that the white limestones, which in the locality described by him occur associated with the blue limestones, are blue limestones which have been locally metamorphosed by various igneous rocks into white crystalline limestones, with the production of graphite and various silicates.

Jackson,‡ in 1854, maintained that the crystalline limestones of New Jersey are of igneous origin.

Kitchell, § in 1856, placed the crystalline limestones of New Jersey in the Azoic system.

Cook, in 1868, || 1873 ¶ and 1883,** placed on record his opinion that the white limestones of New Jersey are conformable with the interstratified with the gneiss, and are regular members of the crystalline or Azoic system.

Britton,†† in 1885, and again in 1887, divided the Archean of New Jersey into a massive, a gneissic, and a schistose group, in ascending series, and considered the white limestone to occur conformably in the middle or gneissic group.

Nason,‡‡ between 1890 and 1894, described in detail the white

* Journal Philadelphia Academy Natural Science, Vol. II., pages 277-288.

† Geology of New Jersey, 1840.

‡ Proceedings Boston Society Natural History, Vol. IV., pages 308-309.

§ Geological Survey of New Jersey, Annual Report for 1855.

|| Geology of New Jersey, 1868, pages 309-321; page 37 (sections).

¶ Geological Survey of New Jersey, Annual Report for 1873, pages 18, 19.

** Geological Survey of New Jersey, Annual Report for 1883, pages 27-77.

†† Geological Survey of New Jersey, Annual Report for 1885, pages 36-55. Same for 1886, pages 74-112.

‡‡ Geological Survey of New Jersey, Annual Report for 1889, page 31. Same for 1890, pages 25-50. Other papers by Nason on this subject have since appeared in the American Geologist, and in the Bulletin of the Geological Society of America. The summary given above is taken from one of his latest articles in the American Geologist, Vol. XIV., 1894, page 163.

crystalline limestones of Sussex county, and maintained that they are blue limestones metamorphosed by intrusions of igneous rocks, and hence are of Cambrian age. He urged in favor of this the following considerations:

"1. The white limestones are continuous with the blue limestones (now accepted as of Cambrian age) and every degree of transition may be found between them.

"2. Both have the same dip and strike.

"3. Both are conformable with a quartzite also containing Cambrian fossils.

"4. Both are unconformable with the gneiss upon which they rest.

"5. Both have in sum total the same chemical composition and are magnesian.

"6. The altered crystalline condition of the white limestone is due to the intrusion of igneous masses and to regional metamorphism, while the blue limestone never contains such igneous injections.

"7. The presence of certain minerals, especially chondrodite, is not indicative of geological age."

Dana,* in 1891, in a review of an article by Nason, agreed with Cook in considering the white limestones conformable members of the gneissic Archean series. He denies the power of eruptives to metamorphose the blue limestone to such an extent, and doubted the possibility of proving that the two limestones grade into each other.

Kemp and Hollick,† in 1894, described the northward extension into New York State of this limestone belt, and concluded that the white limestone is the blue limestone metamorphosed by granite intrusions.

H. S. Williams,‡ in 1894, doubted this identification by Kemp and Hollick of the white limestone with the blue, without positive palæontological evidence.

It is thus seen that two different views have been held as to the age of the crystalline limestones of Sussex county, and that these views have been extended by their advocates to include the other crystalline limestones of the State. The view which has generally prevailed in the past, is that these limestones are of Archean age, and are members of the series of crystalline rocks to which the gneissic rocks of the Highlands belong, and with which the limestones are

* American Journal of Science, III., Vol. XLII., 1891, pages 70-72.

† Annals New York Academy of Sciences, Vol. VII., pages 638-654.

‡ American Journal of Science, III., Vol. XLVII., 1894, pages 401, 402.

closely associated. Among the geologists who have accepted this theory are, as has been indicated, Vanuxem and Keating, Kitchell, Cook, Britton, Dana and H. S. Williams. These writers consider the crystalline limestones to be distinct from the Cambrian blue magnesian limestone of Kittatinny valley.

The other view is that these limestones are not true members of the crystalline series, as has generally been supposed, but are of Cambrian age; being blue magnesian limestones, which have been locally metamorphosed by intrusions of igneous rocks. This view was first proposed by H. D. Rogers in 1840, but found no further support until Nason adopted it, giving a large amount of detailed evidence in its favor. Kemp and Hollick accept the same theory for the age of the white crystalline limestones of Warwick, Orange County, N. Y.

It is not the purpose to consider here the evidence concerning the age of the limestones of Sussex county, but merely to give the arguments advanced by the different sets of writers. It requires, however, evidence of a very positive palæontological or stratigraphical character to overthrow the generally held opinion that these two very different limestones are of different age. It does not seem to the writer that such evidence has been given.

Close association of the crystalline limestone and gneisses.—The writer's study of the Jenny Jump crystalline limestones leads him to the belief that these rocks are distinct from and much older than the Lower Cambrian blue magnesian limestone, which also occurs here.

The constant association and apparent interbedding of the crystalline limestone with the Archean gneisses indicates that the limestone is a member of the gneissic series. The band of limestone, which is represented by several outcrops along the southeast side of the middle of the mountain, is bounded on the east by gneiss, with banding apparently comfortable to that of the limestone. Gneiss also occurs west of the limestone, so that this belt has the appearance of being interbedded with the gneiss. The two small isolated limestone outcrops at the Stinson mine and the Davis mine respectively, occur well within the area of the gneisses and interbanded with the western belt of dark hornblendic gneiss, as if a conformable member of that series. It is not easy to see how Cambrian blue limestone could have gotten into this position.

In its larger area at the northeast end of the mountain, the limestone is associated with both acidic and basic gneisses. Some of the dark hornblendic gneisses are probably of eruptive origin, and do not need to be considered at this point. The more acidic, lighter-colored, well-banded gneisses, as will be shown below, occur interbanded with the limestone, in beds ranging from a few inches to many feet in thickness; and it seems certain that limestones and gneisses here form one series. There is no reason for believing that these gneisses interbanded with the limestone are of eruptive origin, and it is difficult to account for their presence here if the white limestone is simply metamorphosed blue limestone, for there are no bands of rock in the unaltered blue limestone from which they can be supposed to be derived.

The present condition of the limestone is the result of general and not local metamorphism.—Within the limestone area at the north end of the mountain occur numerous rocks, some of which are undoubtedly eruptive, as will be shown later. These include coarse granite or pegmatite, which occurs in large, irregular masses; diabase in dikes up to fifty feet in width; and a series of dioritic rocks which are the most abundant of the three. If the crystalline limestone is to be regarded as the equivalent of the Cambrian blue magnesian limestone, it is to these rocks that we must turn to find the agent of the change.

The usual action of an eruptive rock upon ordinary limestone is well understood. The limestone is altered to a greater or less distance from the contact. It becomes more crystalline, and is often changed at the contact to a coarse marble. This change is very generally accompanied by the development on a large scale of contact minerals, chiefly lime-silicates. But it needs to be emphasized that these contact effects are local, and do not usually extend more than a few feet (except in extreme cases, not over twenty or thirty feet) from the actual contact. One of the best known examples of these relations is that at Cortlandt, N. Y., a short distance south of Peekskill. G. H. Williams,* in describing the contact here between the eruptive diorites and the limestone, says:

"The metamorphic action extends but a small distance from the actual contact, but is always unmistakable in its nature. The limestone is in almost all cases bleached and is frequently rendered more coarsely crystalline. There are new contact minerals developed in it, among the most common of which are hornblende and pyroxene."

* American Journal of Science, III, Volume XXXVI., 1888, page 267.

Similar conditions are said by Nason* to occur near Franklin, N. J., at the contact of a granite dike with the limestone.

The limestone on Jenny Jump mountain is thoroughly crystalline, and contains considerable quantities of metamorphic pyroxene, hornblende, and other minerals. If the eruptive rocks were the agents of metamorphism, the limestone should be most crystalline at the contact with the eruptive, and should become less crystalline as the distance from the eruptive rock increases, until at no very great distance an unaltered non-crystalline limestone should be found. This limestone should be the same as the blue magnesian limestone of Kittatinny valley, if the crystalline limestones are simply the Cambrian metamorphosed by intrusives. No such relations occur between the eruptives and the limestones.

In the few cases where the actual contact can be seen, the nature of the intrusive rock is determined, not by the amount of metamorphism produced in the limestone, but by the irregular line of contact, which could only be that of an eruptive rock.

The limestones are not more crystalline at the contact with the eruptives than at a distance from them, but are uniformly crystalline throughout. The accessory minerals, pyroxene, biotite, graphite, &c., are not found more abundantly near the contact than elsewhere. The limestone shows no change in crystalline character, or in the abundance and character of accessory minerals, as the contact with the intrusive is approached.

It may perhaps be urged that the metamorphic action has been so intense that the whole of the limestone in the area cut by the eruptives has been crystallized. If it were granted that such contact results were possible, there must necessarily still be an increase in intensity of metamorphism near the contact with the eruptive rocks, and no such increase is observable.

A similar line of reasoning has been used by C. H. Smyth, Jr.,† to show that the crystallization of certain Adirondack limestones is not due to the action of intrusives:

"So far as examination has been made, the limestone is thoroughly crystalline throughout, the degree of crystallization not depending upon the position in the belt nor the proximity of intrusives, except in the case of a narrow zone in close contact with the latter. If the

* Geological Survey of New Jersey, Annual Report for 1890, page 32.

† Bulletin Geological Society of America, Vol. VI., page 281.

metamorphism were caused by the intrusion we should expect to find a different state of affairs, a more complete crystallization in the neighborhood of the igneous rock. When the actual contact zones are considered, their narrowness and sharpness of definition are striking. Instead of a gradual increase in crystallization and number of different minerals as the igneous rock is approached, there is no perceptible change till within a few feet or inches of the latter, and then there is a distinct zone of contact products. Were the intrusion the cause of general metamorphism it would seem that the contact zone would be much wider and would shade gradually into the ordinary limestone."

The absence of contact metamorphism in the Jenny Jump limestones is believed to show that the highly crystalline character of the limestone and the abundance of the accessory minerals are not due to the agency of eruptive rocks, but to other causes acting over wider areas and producing further reaching and more uniform effects; that the metamorphism of the limestone is not local, but general. Unchanged blue limestone occurs not far from the crystalline at the most northern outcrops of the latter. The metamorphism has affected the crystalline limestone but not the blue. The reason is clear. The blue magnesian limestone had not been deposited at the time of the metamorphism of the present crystalline limestone, else it too would have been involved in the same changes which have affected the crystalline limestones; changes not improbably produced by the same agents that were at work in the crystallization of the associated gneisses. The crystalline limestone is older than the blue Cambrian limestone and is of pre-Cambrian age. It is difficult to conceive that the forces resulting in metamorphism could act over considerable areas and then suddenly stop short. If the two apparently different limestones are of the same age, the blue limestone associated with the crystalline should also have been metamorphosed. A greater agent than local metamorphism by eruptives is required to explain the crystalline character of the Jenny Jump limestanes. Regional metamorphism, which is the only adequate explanation of this character, must have occurred at a time previous to the deposition of the blue or Cambrian limestone.

The nearly complete absence of contact metamorphism is unusual. Possibly if the exact contact could be oftener seen, more extensive changes along the boundary of the two rocks would be revealed. The probable explanation of this absence of contact metamorphism is, that the eruptives were forced through limestone already thoroughly crystalline, when the opportunities for change that would be presented in the case of an eruptive rock cutting a granular unaltered limestone, did not exist.

The field relations of the crystalline limestones and the Cambrian blue magnesian limestone.—The intimate association and apparent intergradation of these two limestones, as they occur in Sussex county, have been strongly emphasized by Nason, as proving their identity. In the Jenny Jump area they do not occur closely associated. Along the southeast side of the mountain the crystalline rocks are bounded by the alluvial deposits of Pequest meadows. It is probable that the blue limestone underlies this valley, but all outcrops have been covered by the sands of the lake which formerly occupied it. The belt of crystalline limestone along this side of the mountain is bounded on the east by gneisses, and is nowhere in contact with the blue limestone.

Along the northwest side of the mountain no outcrops of crystalline limestone occur, except at the extreme northeast end. The rock which forms the lower slopes of the mountain here is a coarse granitoid gneiss. Blue magnesian limestone is found in the valley west of the base of the mountain, but was not seen anywhere in contact with the gneiss. The limestone here is the usual blue limestone of Kittatinny valley.

At the northern end of the mountain the crystalline limestones occupy a large area, but within that area no outcrops of blue limestone have been discovered. All of the outcrops of limestone show a thoroughly crystalline rock, usually carrying a greater or less amount of accessory metamorphic minerals. At the northern end of this belt, however, blue limestone occurs outside of and not far from the white limestone. Outcrops occur on either side of the road which crosses the extreme end of the white limestone in a northwesterly direction towards Southtown. East of the road (Map 6) the blue limestone occurs about two hundred feet north of the white limestone. The blue limestone is the typical fine-grained limestone found widely distributed in Kittatinny valley. The white limestone is thoroughly crystalline, containing large areas and bands of a rock composed either of quartz or of monoclinic pyroxene or of a mixture of the two; a rock which will be described below. There are no undoubted eruptive rocks—pegmatite, diorite or diabase—cutting the white limestone at this point. West of the road (Map 7) the blue limestone is found about one hundred feet north of the crystalline limestone. The blue limestone at this point is a conglomerate, both pebbles and matrix being fine-grained blue limestone. The crystalline limestone is a gray, thoroughly crystalline, rock, and contains large amount of accessory minerals, especially serpentine, in small scattered masses. The two rocks can be traced for several hundred feet to the west, but do not approach nearer to each other than they do at the road. Both east and west of the road, blue limestones and white are typical of their respective varieties, and there is no tendency in either towards gradation into the other.

On Jenny Jump mountain, then, the white and blue limestones do not occur intermingled, but each occupies exclusively its own area. Where the two rocks approach nearest, at the north end of the mountain, each has still its own special lithological character, and there is no tendency to intergradation. This geographic and lithological separation of the two rocks is believed to indicate that there are here two limestones of different ages—a blue Cambrian, and a white crystalline pre-Cambrian limestone.

Summary.—In conclusion, the crystalline limestones of Warren county are believed to be distinct from and older than the blue magnesian limestone of Cambrian age, which occurs along the northwestern side of the New Jersey Highlands. They are believed to be distinct, for the following reasons:

1. They differ lithologically from the blue limestone in being thoroughly crystalline, and in containing large amounts of accessory metamorphic minerals.

2. They are intimately associated with and apparently interbedded with the older gneisses; and gneisses occur also interbedded in the limestones.

3. They show no intimate association in areal distribution with the blue limestone, nor any tendency to grade into it.

4. The metamorphic changes to which the white limestones have been subjected are general in their nature, and not due to the action of the eruptives by which they are cut; so that no sufficient agent is at hand to account for the supposed change from blue into white limestone.

The white limestones are believed to be older than the blue Cambrian limestone, because (1) they occur in intimate association with the gneisses, which are of admitted pre-Cambrian age, and because (2) they have been subjected to general metamorphic forces resulting in great changes, of which the neighboring blue limestone shows no trace.

That the other crystalline limestones of New Jersey are of the same age as those of Warren county, has not been proved. The theory has generally been that they are. If they are, and if the position taken in the present paper is valid, then the crystalline limestones of Sussex county, and of other places in New Jersey, would also be, as they have generally been supposed to be, of pre-Cambrian or Archean age.

ROCKS OCCURRING WITHIN THE LIMESTONE AREA AT THE NORTH END OF THE MOUNTAIN.

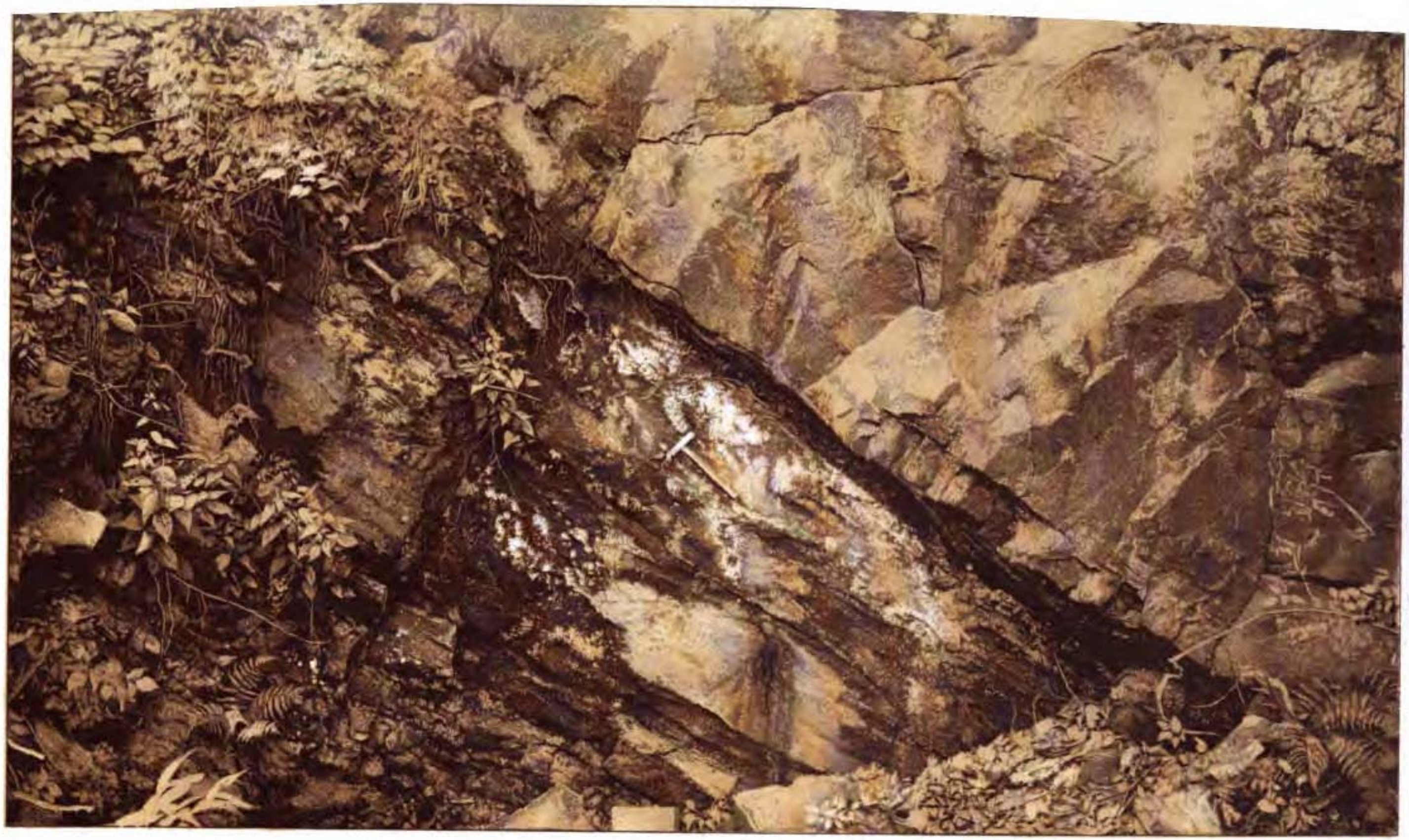
GRAY BANDED MICACEOUS GNEISS.

At numerous places within the limestone area, light-colored gneisses occur, in bands ranging from less than a foot to many yards in breadth. The rock is generally fine-grained, of a grayish or brownish color, and it shows a particularly well-marked, thinly-banded structure. This banding is parallel to the direction of the gneiss band, and to the contact between the gneiss and inclosing limestone. On the cleavage surfaces the rock is quite generally micaceous, often graphitic, while on the fractured surfaces perpendicular to the banding the rock is more massive and shows considerable quantities of quartz.

The distribution of the larger belts of this rock is indicated on the map. These belts are of varying width, and show little or no regularity in areal distribution. Besides these larger belts, the rock also occurs in smaller bands, some of them less than a foot in thickness, which are parallel to the banding of the limestone. Plate IV. is a photograph of the junction of a bed of gray gneiss with the underlying limestone.

Plate IV. The contact is the dark line running diagonally down to the lower right-hand corner and passing just above the hammer.

At some localities several bands of gray gneiss, from one to three or four feet in thickness, occur, separated by thin bands of limestone.



JUNCTION OF A BED OF GRAY GNEISS WITH THE UNDERLYING LIMESTONE, NORTH END OF JENNY JUMP MT.

Microscopically, these rocks are quite uniform in some respects, but variable in others. They all show a typical gneissic structure. In almost every case there is a plane-parallel structure, due either to the alternation of thin bands of somewhat different mineral character, or to the parallel arrangement of plates of mica or graphite and of fibrolite needles. Quartz is uniformly very abundant, and the feldspar is usually untwinned orthoclase; though sometimes it is microperthite, and sometimes twinned plagioclase. The rocks differ somewhat in the species of colored silicates present. The following different varieties may be enumerated:

1. Fibrolite gneiss, mainly quartz and parallel fibres of fibrolite or sillimanite, with some biotite and a little tourmaline.
2. Biotite-graphite-gneiss.
3. Biotite-gneiss.
4. Biotite-pyroxene-gneiss.
5. Biotite-hornblende-gneiss.

Of these varieties the second and third are most common, and when typically developed they are quartzose biotite-gneisses.

These micaceous gneisses often occur in narrow bands in the limestone, looking very much as small dikes of eruptive rock would, but these bands always follow the banding of the limestone when that can be recognized, and do not show the irregularities in width which are found in some similar narrow bands of basic and probably eruptive rock. On the other hand, the typical gneissic structure under the microscope, the unusually well developed banding, and the presence of graphite indicate that these rocks are not eruptive. These gray micaceous gneisses probably result from the complete alteration of bands of siliceous sediment originally interbedded in the limestone.

Nearly identical rocks occur in the Eastern Adirondacks. Professor Kemp * describes these rocks as graphitic mica-schists, sometimes containing abundant sillimanite, and considers them to have originally been sandstones intercalated into a series of calcareous sediments, and to have been since metamorphosed to their present condition.

* Bulletin Geological Society of America, Vol. VI., page 255 and 261.

Quartz tourmaline rock.—Associated with this gray gneiss in the band just west of the Howell mine (Map 9), is a rock composed wholly of quartz and tourmaline. Tourmaline occurs in large irregular pleochroic grains, frequently somewhat elongated parallel to the vertical axis, and lying in an aggregate of very irregular interlocking grains of quartz, which holds abundant hair-like rutile and fluid-and-gas inclusions. This is a medium-grained rock, occurring in irregular patches and masses in the gray micaceous gneiss.

A similar rock has been described by Britton.* It "occurs in the well stratified rocks of Marble mountain and Ragged ridge, Warren county, and in large segregated masses in the crystalline limestone quarry at Lower Harmony."

HORNBLENDIC GNEISS, DIORITE-AMPHIBOLITE OR GRANULAR DIORITES.

Distribution and petrographical character.—Under the above names are included a series of dark hornblendic rocks, often well banded, which may be of diverse origin, but are certainly in part eruptive. These rocks were called gneisses by Cook and by him considered altered sedimentary rocks, interstratified with the crystalline limestones. They agree in most particulars with the dark hornblende-gneisses and amphibolites which have been described as occurring through the main mass of the mountain.

These dark hornblende rocks occur in bands varying in breadth from a thousand feet down to less than a foot. The location of the larger and of many of the smaller bands is indicated on the map. The largest occurrences are in the southern part of the limestone area, but they occur very abundantly throughout the whole of it. They are generally well banded, their banding being parallel to the general trend of the belt, and hence, in a general way, north and south. The dip of this banding is usually, but by no means universally, towards the east. The reason why these dark hornblendic gneissoid rocks are treated separately from those which have already been described is that they occur intimately associated with this limestone, and some of them can be proved to be of eruptive origin.

* Geological Survey of New Jersey, Annual Report for 1885, page 45.

The principal primary mineral constituents of these rocks are green monoclinic hornblende and feldspar. The hornblende occurs in rounded or irregular grains and sometimes in imperfect crystalloids, but rarely with well developed crystalline faces. Orthoclase and plagioclase occur in nearly equal abundance, generally in irregular polygonal-rounded grains. The plagioclase never occurs in lath-shaped crystals—a manner of occurrence which is common in the typical diorites. Besides hornblende and feldspar, light-green monoclinic pyroxene, generally in irregular grains, and a dark-brown biotite occur in lesser amount. Magnetite is the most abundant accessory mineral, and occurs in irregular grains of various size. Quartz is present in but one or two sections. The remaining accessory minerals, apatite, titanite, hematite, and tourmaline, occur with more or less frequency in different sections.

As to microscopic structure, these rocks are uniform in character, varying only within well-defined and narrow limits. While the outcrops may show a banding, there is no evidence of lamination in any of the sections examined. All the principal minerals have a well-marked polygonal-granular development. Where this structure is best developed the rock has the appearance of a mosaic. The structure of these rocks is in marked contrast with both that of typical diorites and of gneisses. The typical diorite is characterized by a very unequal crystal development of the different minerals. The accessory minerals, apatite, titanite, zircon, and the iron ores occur frequently in perfect, though usually small, crystals. Next in order of crystal development are the colored constituents, the hornblendes, pyroxenes, and micas. After them comes plagioclase, and lastly, filling the interstices between the other minerals, come orthoclase and quartz, which wholly lack crystal planes. The order in which the different minerals have separated out from the cooling magma is indicated by the perfection of crystal form. In the hornblendic rocks of Jenny Jump mountain, the accessories, apatite, titanite, and in less degree magnetite, frequently occur in small crystals. But the crystal development of the colored constituents is not more perfect than that of the feldspars. Neither possess crystal planes, and the plagioclase never occurs in typical lath-shaped crystals, but always in more or less rounded grains. This uniformity in the crystal development of the different minerals when the rocks are eruptive, may be the result of metamorphic recrystallization; or it may indicate that the first step in the formation of the rock from the magma was the partial separation of the accessory apatite, and in less degree titanite and magnetite; and that this stage was quickly followed by the nearly simultaneous separation of the colored constituents, the feldspar, quartz, and remaining magnetite, thus resulting in a decided granular structure. The fact that these rocks generally occur in narrow bands supports this explanation; and sections of the rock at the Howell mine, near the contact with the limestone, where the rate of cooling must necessarily have been most rapid, show the mosaic structure in great perfection.

These hornblende rocks show very close relations, in that all are, under the microscope, massive, have a granular structure, and mineralogically consist of hornblende, orthoclase and plagioclase, with biotite and pyroxene in less degree, as their primary minerals. Mineralogically and structurally they are eruptive diorites rather than gneisses.

Eruptive origin of part of the dark hornblende rocks.—It is believed that a part at least of these rocks are of eruptive origin. The reasons for this statement are as follows:

1. A microscopical examination shows that they are massive and lack the typically gneissic structure. In mineralogical composition and variations they resemble the diorites.

2. Like the limestones, they occur in a rough way in north and south bands, which led Cook to say that the two were interstratified. But when the irregularities of some of these bands are considered, this seems hardly probable. They often widen out, narrow, and turn to east or west with very great irregularity, which is in accord with an eruptive origin.

3. Isolated masses of these rocks occur frequently, wholly surrounded by the limestone. This is especially true at the middle and at the south end of the main limestone area. Also, there are several places where small areas of the crystalline limestone occur wholly surrounded by the hornblende rocks.

4. Changes occur within the hornblende rocks themselves as the contact is approached. At the Howell mine, the rock away from the contact is medium-grained, but becomes at the contact very fine-grained, a uniform rock in which separate mineral grains cannot be

detected. At a point (Map 10) on the west side of the middle of the area, this change is even better shown. At a distance from the contact the rock is a dark, medium-grained, banded, hornblendic rock. At the contact it becomes aphanitic, a dark-blue-black porcelain-like rock. The banding has also disappeared and the rock is perfectly massive. There is a gradual change from one into the other. The limestone is thoroughly crystalline and contains considerable amounts of secondary metamorphic minerals, but there is no recognizable contact metamorphism. Figure 3 is a plan of the relations of the two rocks at this locality.

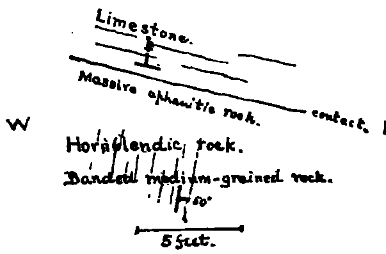


Figure 3.

5. Localities occur at which actual intrusion of the diorite into the limestone can be seen.

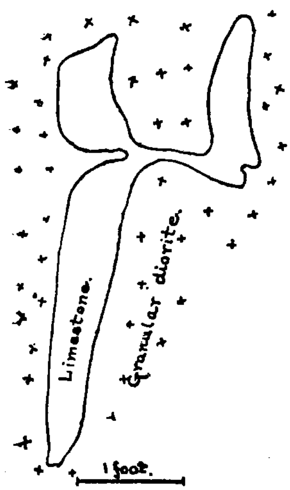


Figure 4.

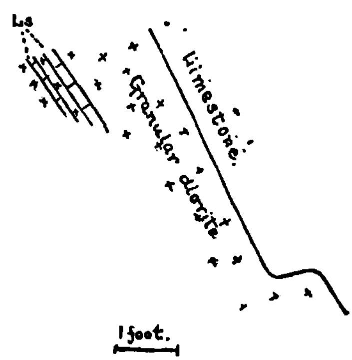


Figure 5.

Contacts of eruptive hornblende rock and limestone.—One locality at which eruptive diorite can be seen cutting the limestone is at the Howell mine (Map 11). Here a horizontal tunnel cuts south into the hill through the contact between the gneiss and the limestone. Figure 4 represents an irregular mass of white crystalline limestone which has been caught in the other rock. Figure 5 represents the irregular contact of the two. Both figures are diagrams of small portions of the walls of the tunnel. The contact is perfectly distinct, and specimens can be broken off showing both limestone and hornblende rock. There is no evidence of faulting or motion along the contact. Not far from the contact the hornblende rock is banded, and in this case at least the banding is a secondary structure, produced by dynamic metamorphism in an eruptive rock. The eruptive rock here is a typical hornblende-diorite. There is a thin contact zone, less than half an inch in thickness, between the diorite and the limestone, consisting of fibrous hornblende, pyroxene, quartz, plagioclase, feldspar, magnetite and apatite. The limestone here contains small, scattered, irregular grains of green monoclinic pyroxene.

Another locality (Map 12) occurs southwest of the Howell mine and east of the road, showing similar relations between the same two rocks. The limestone has been cut out across the strike at several points by the hornblende rock. Figures 6 and 7 represent the ap-

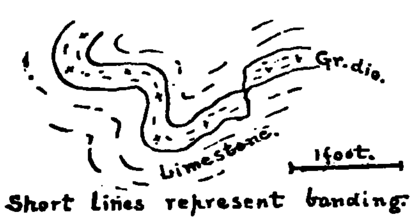


Figure 6.

Figure 7.

pearance of a vertical outcrop of rock on a side hill. Figure 6 is a dike of the hornblende rock in the limestone; it is banded parallel to its course. Figure 7 shows the irregular contact of the limestone with a large mass of hornblende rock, and also some smaller masses of hornblende rock in the limestone.

The frequent small dike-like masses of dark hornblende rock often show by their character that they are intrusive into the limestone. Near the southern end of the limestone area (Map 13) the limestone is cut by numerous vertical bands of eruptive hornblendic rock.

DIKES OF HORNBLENDIC ROCK CUTTING LIMESTONE
NORTH END OF JENNY JUMP MT.

Figure 8 represents diagrammatically two of these bands and the edge of a third as they show in a low vertical cliff of limestone. The middle dike has developed in places a banding parallel to the edge of the dike, due to the arrangement of the hornblende in short parallel lines.

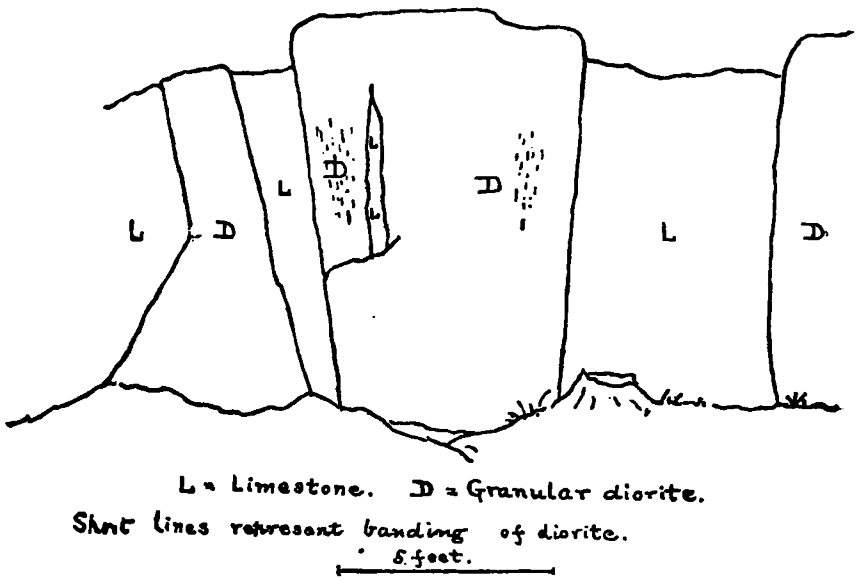


Figure 8.

Plate V. Dikes of hornblendic rock cutting the limestone.

The photograph (Plate V.) shows very well the general appearance of these small dikes of eruptive hornblendic rock (Map 14). In the photograph the dikes appear lighter than the limestone, and cut the latter parallel to its plane of banding. The dike on the right is a foot and a half, the other a foot, in thickness, and they are separated by three feet of limestone. The irregularities in the thickness of the dike on the right are taken (among other circumstances) to indicate an eruptive character.

The preceding facts are enough to show that a considerable part of these hornblende rocks is of eruptive origin. In some cases it has been seen that these eruptives at a short distance from the contact are banded, and these banded phases, if seen alone, would not be distinguishable from the ordinary banded hornblende-gneisses of the region. The banding in these particular instances is, of course, secondary. Just how far an eruptive origin can be assigned to the other banded hornblendic rocks of the limestone area, cannot be determined. The larger areas may have a different origin, and may represent altered bands of rock originally interbedded in the gneiss; and the fact that along the main mass of the mountain the limestone is in some cases apparently interbedded with these gneisses, lends support to this view. A considerable part of these rocks, however, and perhaps most or all of it occurring in the smaller bands, is of eruptive origin.

Varieties of these hornblendic rocks.—While these rocks are in general quite uniform in character, they vary sufficiently in the presence and relative abundance of the different colored silicates to give several distinct rock varieties. These varieties, which must be considered as merely local phases of a single series, are as follows:

1. Diorite, in which green monoclinic hornblende is the principal and sometimes the only colored constituent. No typical mica-diorite is present—that is, no rock in which the biotite occurs in greater abundance than the hornblende, although biotite is frequently present and sometimes in considerable amounts. The diorite is commonly diorite proper, as distinguished from quartz-diorite, which is of rare occurrence.

2. Augite-diorite, which contains, in addition to hornblende, a considerable amount of colorless or light green monoclinic pyroxene.

3. Hornblende-gabbro, differing from the augite-diorite only in that pyroxene occurs more abundantly than the hornblende.

4. Norite, a single section from the contact at the Howell mine, in which orthorhombic pyroxene is the main colored constituent.

5. Scapolite-rock or "gefleckter gabbro," in which feldspar is replaced by scapolite. It was found at but one locality (Map 15) and then was associated with black diorite, of which it is probably a phase. Green monoclinic hornblende, scapolite, and in less abundance monoclinic pyroxene, occur together. The structure of the rock is granular. Similar rocks associated with crystalline limestones have been recorded by Nason * from near Franklin, N. J., and by Kemp † from the Eastern Adirondacks, and by others.

* Geological Survey of New Jersey, Annual Report for 1890, page 33.

† Bulletin Geological Society of America, Vol. VI., page 255.

Of these different varieties the first two are much the most common, so that in speaking of the rocks as a whole they may be called diorite-amphibolites or granular diorites.

QUARTZ PYROXENE ROCK.

A third rock type is found very abundantly associated with the limestones. This rock varies through all stages, from a pure quartz-rock on the one hand to a light-greenish or white rock, composed entirely of an aggregate of grains of green or white monoclinic pyroxene, on the other. Often there is a pronounced radial grouping of the fibres. The rocks are always massive, and usually from medium to coarse-grained. Their mineralogical structure is simple. The quartz occurs in extremely irregular, interlocking grains, usually with a wavy extinction. Monoclinic pyroxene occurs in colorless, rounded, or irregular grains, often elongated in the direction of the prismatic cleavage. Biotite, magnetite and graphite sometimes occur in these rocks, but usually only quartz or pyroxene are present.

This rock is distinct from the limestone. Calcite does not occur in any of the sections as an original constituent. In the field the two rocks are distinct, and are always separated by a sharp line of contact. On one side of the contact the limestone effervesces freely with acid; on the other the pyroxene rock shows a feeble action or none at all. There is no intergradation between the two.

These pyroxene rocks occur very abundantly in the limestone, especially towards the north end of the mountain. In some cases, as at the north end of the mountain, they occur in irregular masses; but in a majority of cases they are bands of greater or less width, sometimes as narrow as six inches. The accompanying figure shows four of these narrow bands of quartz-pyroxene rock, with one large band of gray micaceous gneiss, occurring interbedded in the limestone. (Map 16.)

Rocks of this character are frequently described as associated with the limestones, and are probably original members of the limestone series, since their mineralogical character is unlike that of eruptive rocks.

Besides these rocks which have been described as occurring in the limestones, pegmatite and diabase are also found, but as they are not different from the same rocks as they occur in the gneisses of the main part of the mountain, they do not require further notice here.

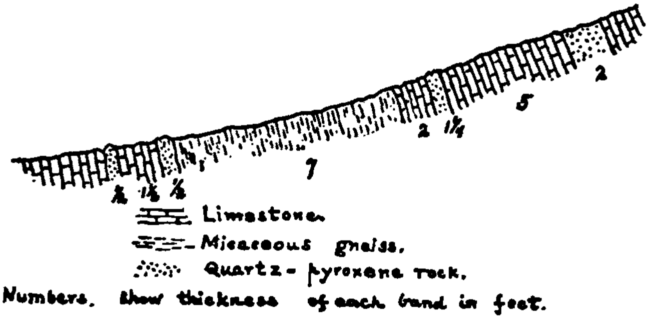


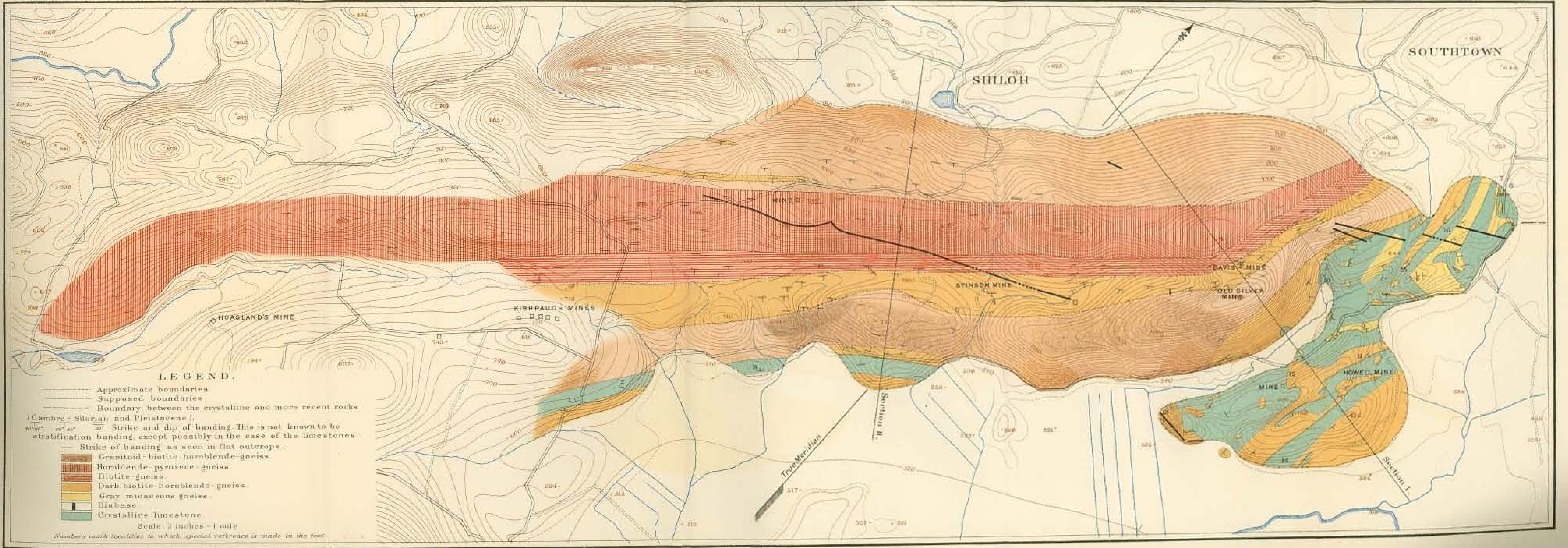
Figure 9.

The contacts between pegmatite and limestone have not been observed. The diabase does not appear to have altered any of the rocks through which it passes.

SUMMARY.

At the northern end of the mountain, hornblendic and micaceous gneiss and quartz-pyroxene rock occur associated with the limestone. These rocks are apparently interbedded with the limestone; and with the possible exception of some of the dark hornblendic gneiss, are believed to represent a series of sediments originally deposited with the limestone and completely metamorphosed. They nowhere show a detrital character, and their origin is inferred from their mineralogical character and geological occurrence. Diabase, pegmatite, and granular diorite cut the limestone at various points. Diabase is the most recent, since it cuts all the other rocks. The age of the other eruptive rocks is not definitely known, but as they are not found cutting the Cambro-Silurian limestone in this region, they are possibly of pre-Cambrian age. These rocks occur very irregularly, and no general structure nor succession has been detected.

Along the main mass of the mountain, the crystalline limestone, when present, is associated with dark banded hornblendic gneisses, and is not found in contact with the lighter granitoid gneisses. This association is perhaps a reason for supposing that these hornblende-gneisses are in part of detrital origin, and suggests that there may be really two series of rocks: (1) A series of limestones and associated interbedded rocks, of sedimentary origin; and (2) a series of more massive granitoid gneisses, probably older and of unknown origin. This is a supposition only, and is not supported by other facts than the association just described.



A GEOLOGICAL MAP OF THE NORTHERN PART OF JENNY JUMP MOUNTAIN.

BY LEWIS G. WESTGATE.

PART III.

REPORT ON

ARTESIAN WELLS

BY

LEWIS WOOLMAN.

ARTESIAN WELLS IN SOUTHERN NEW JERSEY.

BY LEWIS WOOLMAN.

There are presented in the following pages records of wells bored in Southern New Jersey, most of them within the present year (1895).

These are classified geologically and arranged geographically as follows:

1. Those in Cretaceous strata—these are located within a belt some fifteen or twenty miles wide upon the western side of the area under consideration, and are arranged in order from south to north.

2. Those in Miocene strata—these are situated upon the remaining or eastern portion of the area and follow the others in order, but in a reverse direction—that is, from north to south.

3. Those in superficial strata of Pleistocene or later age, and which cover both the Miocene and Cretaceous beds—these wells may therefore be found within both the eastern and western areas previously noted.

The following localities are represented:

Within the Cretaceous area—Gibbsboro, Lucaston, Woodbury (Philadelphia, Pa.), Marlton, Delair, Rancocas, Burlington, Bordentown, Hightstown, Asbury Park, Ocean Grove, Lake Como, Sea Girt, Point Pleasant and Mantoloking.

Within the Miocene area—Brigantine, Atlantic City (three wells), Longport and Wildwood.

In the Pleistocene or more recent strata—Linwood and Clayton.

ARTESIAN WELLS IN THE CRETACEOUS.

ARTESIAN WELL AT GIBBSBORO, N. J.

Elevation, 100 feet; depth, 71 feet. Water rises to within 16 feet of the surface.

In the early summer W. R. Kelly, of Berlin, put down a well at the residence of John Lucas at Gibbsboro, and kindly forwarded to the writer specimens of the borings and a carefully kept record, which is as follows, the notes upon the right being, however, our interpretation of the geology of the strata:

	Commenced in the bottom of a dug well, depth 16 feet; water not satisfactory.		Pleistocene 44 feet.
2 feet.	Yellowish sand and gravel, some pebbles large as walnuts; *water-bearing*	16 feet to 18 feet.	
10 "	Finer sand, still more yellow; *water-bearing*	18 " " 28 "	
3 "	Clayey sand	28 " " 31 "	
13 "	Orange-colored clay, with layers of quicksand	31 " " 44 "	
13 "	Black-clayey sand	44 " " 57 "	Miocene (?) 16 feet.
3 "	Black sand and gravel	57 " " 60 "	
3 "	Marl, gravel and marl stone, with water	60 " " 63 "	Eocene (??) 3 feet.
1 "	Gravel and clayey sand	63 " " 64 "	Limesand, contains Bryozoa throughout, =Cretaceous 8 feet.
2 "	Limestone	64 " " 66 "	
2 "	Shell, with water that supplies the well. Stone four inches thick.	66 " " 68 "	
2 "	Clayey sand and shell	68 " " 70 "	
1 "	Dark sand and clay	70 " " 71 "	

This well is four and a half miles southwest of Marlton and is located upon the 100-foot contour line at the southwestern base of a 198-foot hill whose summit lies two and a half miles southwesterly from the same town. According to Professor Salisbury, in last year's report, this summit is capped with Pensauken gravel. A well was once dug near to and about ten feet lower than the summit that reached a depth of 82 feet without finding water. At that depth a fine quicksand was encountered and further digging was abandoned. The middle marl bed outcrops on the northern slope of this hill at an elevation of about 90 feet, or about 108 feet from the summit.

So far as the author is aware, this well and one reported last year, at Joseph Cheeseman's, near Harrisonville, are the only artesians in the State that draw their supply from the porous layers of the Bryozoan limesand that overlies the middle marl bed.

The line of strike for this well is identical with that of the well upon the farm of Jacob L. Evens * two miles east of Marlton. A parallel line of strike but one-tenth of a mile distant passes through the location of the well at Joseph Evens * in close proximity to that of Jacob L. Evens. In both these wells the Bryozoan limesand was passed at a depth, with reference to sea level, approximating that of the base of this well. The top of the excellent water-bearing sand-bed beneath the middle marl was met with stratigraphically in these Marlton wells about 65 feet deeper. Had the well at Gibbsboro been continued 75 feet further it would probably have reached the same water-yielding horizon.

ARTESIAN WELL AT LUCASTON.

Elevation, 130 feet—Depth 110 feet.

In the year 1893 an artesian boring was made at Lucaston station on the Reading Railroad Company's line to Atlantic City. The work was done by W. R. Kelly who carefully preserved and forwarded to the writer a complete series of specimens of the various earths penetrated. The elevation of the surface at this station is about 130 feet, and the location of the well is one and a half miles south of the well just previously described at Gibbsboro, and in consequence of its geographical position this well is about one mile farther out on the dip of the Cretaceous strata.

The record is as follows:

Specimen.						
No. 1. Soil			Surface	to	1 foot.
2. Fine yellow sand	3 feet	=	1 foot	"	4 feet.
3. Yellow loam and gravel	4 "	=	4 feet	"	8 "
4. Yellow sand and gravel with water in it	2 "	=	8 "	"	10 "
5. Orange-colored and yellow quicksand	20 "	=	10 "	"	30 "
6. Whitish quicksand with water in it	10 "	=	30 "	"	40 "
7. Dark, orange-colored sandy clay	10 "	=	40 "	"	50 "

* See last year's Report (1895), pages 214, 215. And also Plate 10.

8. Alternations of black sand, reddish clay, dark sand and gravel, with shell and charred wood—transitional layers	18 feet	=	50 feet	to	68 feet.
9. Black mud, micaceous; vertebral bone of *Mosasaurus*	25 "	=	68 "	"	93 "
10. Dark, clayey greensand, Glauconitic; carapace of *turtle* and tooth of *Mylobates*	1 "	=	93 "	"	94 "
11. Dark gravel with grains of greensand, lignite and carapace of *turtle*	1 "	=	94 "	"	95 "
12. Greensand	1 "	=	95 "	"	96 "
13. Black sand and gravel with lignite	4 "	=	96 "	"	100 "
14. Bluish clay, with iron pyrite, considerable greensand and some *foraminifera*	5 "	=	100 "	"	105 "
15. Gray quartzose sand with *water*	5 "	=	105 "	"	110 "

This well probably draws its supply from a sand over the Bryozoan limesand that in turn lies over the Middle Marl bed. The water rises within ten feet of the surface.

ARTESIAN WELL AT WOODBURY.

An artesian well was bored at Woodbury, N. J., at the skating park, finding water at the depth of 130 to 136 feet in a gravel bed next below the clay marl.

The well was put down by Thomas B. Harper, who has courteously furnished the following record:

Sand, followed by a thin stratum of blue clay		to 30 feet.
Black clay marl		" 118 "
Sand	118 feet	" 130 "
Gravel	130 "	" 136 "

ARTESIAN WELL IN PHILADELPHIA, ON LITTLE DOCK STREET.

Depth, 96 feet. Draws water from the basal Cretaceous beds of the New Jersey series.

W. C. Barr informs us that a well was put down on Little Dock street, Philadelphia, a few years since. He states that a white clay was found between the depths of eighty-six and ninety-four feet, beneath which was a coarse, heavy, yellow gravel, with flat and egg-shaped stones. This gravel contains water. The well was finished with a depth of 96 feet.

ARTESIAN WELL IN MARLTON, AT THE RESIDENCE OF H. B. DUNPHEY.

Elevation, 105 feet; diameter, 3 inches; depth, 200 feet. Water rises to within 28 feet of the surface.

This wall was bored in the fall of the present year by W. C. Barr, who furnished the following record:

Top soil, yellow loam and gravel	18 feet	= 18 feet.	= Pleistocene.	
Black marl	14 "	= 32 "	Middle marl and Lower marl.	Cretaceous.
Green marl	9 "	= 41 "		
Chocolate marl, with white shell, probably *Gryphea*	29 "	= 70 "		
Gray sand, with irony water	12 "	= 82 "	Clay marl series.	
Black sand	40 "	= 122 "		
Black clay	72 "	= 194 "		
Fine white sand, with *good water*	6 "	= 200 "		

The water from this stratum rose to within twenty-eight feet of the surface, but fell on pumping to about forty feet therefrom.

The water noted above, at seventy to eighty-two feet, represents the same horizon reported last year for nineteen out of twenty-one wells near Marlton and Medford, and which generally furnishes excellent water. There seems, however, to be a small area around the cross-roads in Marlton where the impervious stony shell-crust that, mostly in this region, overlies this water-bearing sand, is absent. This probably permits contamination of the water from this sand with that from the marl beds above.

The remedy, in case of irony water in this region, evidently, is to go deeper, as was done in this case. The lower horizon utilized is probably nearly equivalent with that at the depth of 175 to 183 feet in the Isaac W. Stokes' well near Medford, where the upper of these two water-bearing strata was met with at seventy feet, and likewise proved irony.

ARTESIAN WELL AT DELAIR.

Elevation, 40 feet; depth, 78 feet. Water rises to within 40 feet of the surface.

A well was bored at this locality by W. C. Barr, who furnishes the following record, the situation being along the Camden and Burlington road:

Dug well bottom at		25 feet.
Dry coarse sand	30 feet	= 55 "
Stiff white clay, fine white mud, stiff white clay	18 "	= 73 "
Coarse sand and heavy gravel	5 "	= 78 "

This well is supplied with excellent water from the yellowish white gravels within the plastic clays.

ARTESIAN WELL NEAR RANCOCAS.

Elevation, 78 feet; diameter, 3 inches; depth, 124 feet. Water rises to within 63 feet of the surface.

During the summer a well was bored by W. C. Barr for Albert Hansell on the road from Beverly to Rancocas, about four miles from the former place and one and one-half miles from the latter.

W. C. Barr furnished specimens of the borings and the following record:

Loam	3 feet	= 3 feet.	
Reddish gravel	10 "	= 13 "	
Red clay	2 "	= 15 "	
Black clay	106 "	= 121 "	Clay Marls.
White sand	3 "	= 124 "	Cretaceous.

The bluish-gray sands probably near the base of the clay marls, furnish the water-supply of this well.

ARTESIAN WELL ONE AND ONE-HALF MILES SOUTH OF BURLINGTON.

Elevation, 72 feet; diameter, 6 inches; depth, 128 feet. Water rises to within 40 feet of the surface.

W. C. Barr furnishes the following record of a well put down by him on the road from Burlington to Rancocas, and about one and a half miles from the former city:

Top sand	8 feet	= 8 feet.	Recent.
Sandy crust	2 "	= 10 "	
Gravel and quicksand	3 "	= 13 "	Clay marls.
Green marl	46 "	= 69 "	
Red and white clay	7 "	= 76 "	Plastic clays.
White clayey sand	9 "	= 85 "	
Red clay	21 "	= 106 "	
Gravel and red sand	4 "	= 110 "	
White clay	16 "	= 126 "	
White sand and water	6 "	= 132 "	
Heavy yellow gravel and water	3 "	= 135 "	

With a hot air pump 1,500 gallons an hour were obtained from this well.

The supply of water comes from the yellowish-white gravels within the plastic clays.

ARTESIAN BORING AT BORDENTOWN.

Elevation, 15 feet; depth to water, 195 feet; depth to crystalline rock, 220 feet.

A test boring was made at Bordentown, at the base of the bluff of clay marls and overlying gravels that faces the Delaware river. The work was done by Kisner & Bennett, who courteously furnished the following record:

Made ground, bricks and mortar, &c.	6 feet	= 6 feet.		
Dry white sand	11 "	= 17 "		
Blue clay, nodules of iron pyrites; some sand streaks	14 "	= 31 "		
Coarse sand, blue-gray	22 "	= 53 "		
White clay	3 "	= 56 "	Clay marls.	
White sand, irony water	15 "	= 71 "		
White clay	1 "	= 72 "		Cretaceous.
Blue-gray, coarse sand, *irony water*	17 "	= 89 "		
Blue clay	6 "	= 95 "		
White sand	5 "	= 100 "		
White and red clay	25 "	= 125 "	Plastic clays.	
White sand	5 "	= 130 "		
Red clay	65 "	= 195 "		
Sand, with water that rises about to tide-level or within 15 feet of the surface.				

This well was prospected beyond to the crystalline rock-bed, which was found at the depth of 220 feet. The water is said to contain too much iron. A noted sanitary chemist has, however, stated to the writer that in all other respects it is a good sanitary water. The same authority also believes that if properly treated and ærated the iron will be oxydized and the water rendered good.

ARTESIAN WELLS AT HIGHTSTOWN.

Elevation, 73 feet; four wells, diameter of each, 6 inches; depths, about 200 feet.

Four wells at Hightstown, additional to those noted in last year's report, page 200, have been put down by Kisner & Bennett, who furnish the record below:

Top soil	4 feet	= 0 feet to	4 feet.	} Clay marls.
Black clay	35 "	= 4 " "	39 "	
White sand, with *lignite; water-bearing*	27 "	= 39 " "	66 "	
Dark-blue clay.	9 "	= 66 " "	75 "	
Coarse white sand, *water-bearing*	97 "	= 75 " "	172 "	
White clay	4 "	= 172 " "	176 "	} Plastic clays.
White sand, *water-bearing*	26 "	= 176 " "	202 "	
White clay	4 "	= 202 " "	206 "	

The water-yielding sand supplying these wells occupies the twenty-six feet of interval between the depths of 176 and 202 feet.

The wells are 150 feet apart, and are upon ground having an elevation, according to the borough survey, of 72 feet.

DEEP ARTESIAN WELL AT ASBURY PARK.

Elevation, 10 feet; total depth attained, 1,321 feet; depth of water horizon utilized, 1,083 feet to 1,130 feet. Overflow, 175 gallons a minute.

The water commissioners at Asbury Park having determined to prospect for water from deeper horizons than had heretofore been used, Uriah White has bored a well to the depth of 1,321 feet, which, however, was finally finished with a depth of about 1,130 feet.

From this, and from previously-bored wells, Uriah White has kindly forwarded specimens of the strata. The writer also obtained from the water commissioners a series of borings of the first well put down for them many years since, and which had been preserved in their office. This set is especially valuable, since the material was obtained by the sand bucket and not by the wash-out process now commonly employed. Specimens obtained by this old process preserve the sands, clays and marls more nearly in their natural condition and enable one to judge more correctly of the character of the beds.

After considerable study of the various borings, the following condensed record of strata beneath Asbury Park is presented:

THICKNESS.		INTERVAL.					
16 ft.	Surface soil, &c.	to 16 ft.	—	Recent, 16 feet.			
64 "	Brownish clay, called rotten stone; at about 40 feet, contains *diatoms*, including *Heliopelta*	16 ft. " 80 "	—	Miocene, 64 feet.		Upper Marl bed, 120 feet.	
13 "	Light-colored clay	80 " " 93 "	—	Ash-colored clay; resembles the ash marl, at 100 to 140 feet.	Eocene, 60 feet.		
7 "	Greensand	93 " " 100 "	—	Blue marl of Prof. G. H. Cook; or upper layer, Upper Marl.			
40 "	Whitish clay; contains abundance of *foraminifera*	100 " " 140 "	=	Ash marl of Prof. Cook.			
60 "	Clay containing considerable greensand	140 " " 160 "	—	Green marl of Prof. Cook; or lower layer, Upper Marl.	Cretaceous, 60 feet.		Cretaceous, 1,181 feet.
	Greensand	160 " " 180 "					
	Clay, containing considerable greensand	180 " " 200 "					
40 "	Whitish clay and a thin stratum of *Bryozoan* limesand	200 " " 240 "	—	Limesand of Prof Cook.		Middle Marl bed, 187 feet.	
40 "	Greensand, *Terrebratula* and *Gryphea*	240 " " 280 "		Middle Marl.			
7 "	Black sand, with a *little water* that overflows	280 " " 287 "	=	Redbank formation, Dr. Clark; or red sand bed of Prof. Cook.			
93 "	Greensand, with some clay on top and at the bottom *Gryphea*, *Exogyra* and *Belemnitella*,	287 " " 380 "	=	Lower Marl bed, 148 feet.			
50 "	Gray sand, *with water*	380 " " 430 "					
200 "	Alternations of sands and clays, *water-bearing* below 500 feet; Lignite at 514 feet, conglomerate at 615 feet	430 " " 630 "	=	Laminated sand of Prof Cook, 200 feet.			
324 "	Clays containing greensand	630 " " 954 "	=	Clay marls.			
72 "	Fine whitish-gray sands, *water-bearing*; Lignite at 1,000 feet, rock at 1,026 feet	954 " " 1026 "					
57 "	Sandy clay	1026 " " 1060 "	=	Probably transition layers between the clay marls and the plastic clays.			
	White clay	1060 " " 1067 "					
	Bluish clay	1067 " " 1083 "					
52 "	Coarse whitish-gray sands, *water-bearing*; Lignite and conglomerate at 1,100 feet	1083 " " 1135 "					
186 "	Dark-bluish sandy clay; Lignite at 1,160, *molluscs* at 1,195, among them *Exogyra*	1135 " " 1321 "					

This well was finally finished with a depth, as previously stated, of about 1,130 feet, and draws water from a coarse white sand and gravel below the depth of 1,083 feet. The water is said to have a natural flow of 175 gallons a minute and will rise in the pipe twelve feet above the street level.

The total depth attained, 1,321 feet, probably carried this boring to within fifty or one hundred feet of the plastic clays of the Raritan formation, at the base of which, in the region about Camden and Gloucester and to the eastward, occur coarse cobble-stone gravels which furnish a considerable supply of good water.

ARTESIAN WELL AT OCEAN GROVE, N. J.

Elevation, 20 feet; depth, 1,134 feet.

During the summer of 1894 a well was bored at Ocean Grove to a much greater depth than that of any previous well there. The work was done by Uriah White, who has forwarded specimens of the borings to the writer.

After an examination of the specimens and a comparison with notes furnished by the contractor, the following record has been compiled:

20 ft.	Surface sands to	20 ft.	Recent.		
55 "	Brownish clays, called rotten stone; no microscopic organisms seen	20 ft. to 75 "	Miocene, 55 feet.		
19 "	Light-colored clay, containing *coccoliths* and *foraminifera*	75 " " 94 "	Ash-colored clay, containing *foraminifera;* resembles ash marl, 113 to 160 feet.	Eocene, 85 feet	Upper Marl bed, 152 feet.
11 "	Light-colored clay, containing *coccoliths*	94 " " 105 "			
8 "	Pure greensand	105 " " 113 "	Upper layer — Upper Marl or Blue Marl of Prof. G. H. Cook.		
47 "	Whitish clay, containing *coccoliths* and *foraminifera*	113 " " 160 "	Ash Marl of G. H. Cook.		
48 "	Darker clay, much mixed with greensand; greensand layer at 172 to 198 feet	160 " " 208 "	Green Marl—G. H. Cook; or lower layer, Upper Marl.	Cretaceous, 67 feet.	
19 "	Hard clay, with greensand grains through it	208 " " 227 "			
37 "	Clay, with much greensand; *bryozoa, echinus spines, Nodosaria* and other *foraminifera* at 261 to 264 feet	227 " " 264 "	Limesand of G. H. Cook	Middle Marl bed, 78 feet.	
20 "	Grayish greensand, with *foraminifera, Nodosaria,* &c.	264 " " 284 "	Middle Marl.		
16 "	Greensand, with comminuted *shell* at the bottom	284 " " 300 "	Red-bank sand of W. B. Clark.		
81 "	Greensand; *shell* at 362 feet	300 " " 381 "	Lower Marl bed, 81 feet.		
76 "	Gray sand; comminuted *shell*	381 " " 457 "	Laminated sands, or upper division of the Clay Marls, 172 feet.		
39 "	Gray sand, with marl	457 " " 496 "			
57 "	Gray sand	496 " " 553 "			

Below this depth the specimens did not come to hand. Four feet of rock, however, were passed through between the depths of 684 and 688 feet, after which identically the same succession of laminated sands and clay marls were encountered as were met with in boring the deep well at Asbury Park, of which the record immediately precedes this. The total depth reached was 1,134 feet, the water being obtained from a heavy bed of coarse white gravel and sand at the bottom. The horizon utilized by this well is the same as the one used in the well just noticed at Asbury Park, which did not find water at the greatest depth reached by the boring, but in a coarse, whitish sand higher up, between the depths of 1,083 feet and 1,130.

ARTESIAN WELLS AT LAKE COMO.

Depth, 535 feet.

Uriah White reports that there are two or more wells at Lake Como, about four miles south of Asbury Park. One of these wells has a depth of 535 feet and draws water from the 400-foot horizon of Asbury Park. The record, in brief, is approximately as follows:

Superficial sands		80 feet.
Miocene clay, commonly called rotten stone	40 feet	= 120 "
Succession of marly clays and greensand marls, &c	415 "	= 535 "

ARTESIAN WELL AT SEA GIRT.

Elevation, 11 feet; depth, 755 feet. Water flows 50 gallons a minute and rises 13 feet above the surface, or 24 feet above tide; temperature, 65°.

Before the commencement of the summer season at seaside resorts, Uriah White completed a well at the Beach House at Sea Girt, N. J., and courteously preserved and forwarded a full series of the borings.

The following is the record:

Thickness	Strata	From	To	Correlation		
10 ft.	Beach or dune sand, surface to.		10 ft.	Recent .... 25 feet.		
2 "	Yellowish clay	10 ft. to	12 "			
13 "	Yellow sand and gravel	12 " "	25 "			
25 "	Solid blue sandy clay	25 " "	50 "	Post Pliocene, or Pliocene, 101 feet.		
10 "	Solid blue clay, with streaks of sand and wood	50 " "	60 "			
6 "	Fine white sand	60 " "	66 "			
4 "	Hard rock	66 " "	70 "			
9 "	Sand and shell	70 " "	79 "			
47 "	Clean white sand, 11 ft.; Coarse white sand, 15 ft.; Finer white sand, 21 ft.	79 " "	126 "			
109 "	Brownish clay, with streaks of sand; lignite at 126 to 146 feet	126 " "	235 "	Miocene .... 109 feet.		
25 "	Light-colored greenish clay, contains *coccoliths* and *foraminifera*	235 " "	260 "	Ash-colored clay, much like ash marl, at 275 to 345 feet.	Eocene, 110 feet.	Upper Marl bed, 165 feet.
15 "	Black sand marl, glauconitic	260 " "	275 "	Upper layer, Upper Marl, or the Blue Marl of Prof. G. H. Cook.		
70 "	Light-green marl, contains *foraminifera*, 285 to 306 feet; hard blue stones in the marl	275 " "	345 "	Ash marl of Prof. G. H. Cook.		
15 "	Black sand marl, glauconitic	345 " "	360 "	Green marl of G. H. Cook, or the Lower layer, Upper Marl.	Lower layer, Upper Marl, 55 feet.	Cretaceous, 110 feet.
40 "	Light-greenish-gray clays	360 " "	400 "	Ash color, similar to 275 to 345 feet.		
50 "	Gray marl	400 " "	450 "	Equivalent to lime sand.	Middle Marl bed, 89 feet.	
39 "	Black marl	450 " "	489 "	Middle Marl bed and red sand.		
81 "	Sandy marl	489 " "	570 "	Lower Marl bed — 81 feet.		
50 "	Sand, *water-bearing*	570 " "	620 "	Laminated sands, equal the upper division of the Clay Marl series of the Cretaceous.	— 185 feet.	
74 "	Dark, sandy clay	620 " "	694 "			
26 "	Sand, *water-bearing*	694 " "	720 "			
15 "	Dark clays and crusts	720 " "	735 "			
20 "	Sand, *water-bearing*	735 " "	755 "			

The bottom of this well corresponds with a depth of about 550 feet at Asbury Park.

ARTESIAN WELL AT POINT PLEASANT.

Kisner & Bennett report that in 1893 they drilled a well at Point Pleasant to the depth of 806 feet, obtaining water that rose in the pipe 35 feet above the ground, and flowed at the surface 45 gallons a minute. From notes furnished, the following record is made out:

Sand and blue clay to		100 feet.	
Brownish, miocene clay, called rotten stone	80 feet	= 180 "	Miocene.
Variations of marly clays, greensand marls and laminated sands	566 "	= 746 "	Cretaceous.
White sand, containing lignite, water-bearing	60 "	= 806 "	Cretaceous.

The water horizon reached is probably that of the 550 to 600-foot wells at Asbury Park.

ARTESIAN WELLS AT MANTOLOKING.

No. 1. Depth 175 feet,* in the Miocene.
" 2. " 790 " = 400-foot horizon at Asbury Park, in the Cretaceous.
" 3. " 922 " = 550 to 600-foot horizon at Asbury Park. Cretaceous.

At various times, since about the year 1887, there have been made three borings at Mantoloking by Kisner & Bennett.

The first well was noticed in the Annual Report for 1889, wherein it is stated to have a depth of 175 feet.* A second well was afterwards bored to 790 feet—to the 400-foot water-bearing sand of Asbury Park, which was here found occupying the interval between the depths of 690 and 740 feet.

Still later another well was sunk to the depth of 922 feet, drawing water from a sand between 872 and 922 feet. This horizon is probably the equivalent of 550 to 600 feet at Asbury Park.

ARTESIAN WELLS IN THE MIOCENE.

ARTESIAN WELL, BRIGANTINE, N. J.

Diameter, 6 inches; depth, 798 feet; overflow, 100 gallons a minute.

During the early summer of the present year Uriah White, contractor, successfully finished an artesian well at Brigantine. From specimens carefully saved and from notes kindly furnished to the writer, the following record has been made:

* Kisner & Bennett have recently informed the writer that the water furnished to well No. 1 came from a coarse sand at the depth of 130 to 140 feet.

Gray sand from the surface to (Contained shell at 40 to 60 feet.)		60 feet.	= Recent, 60 ft.
White sand, with a white clay streak at 70 feet	60 feet to	90 "	Pleistocene, 288 ft. (?)
Yellow sand; yellow clay streak at 110 feet	90 " "	110 "	
Sand, shade like that of a good quality of brown sugar; clay streak at 155 feet	110 " "	180 "	
(a) Yellow sand; clay at 205 feet	180 " "	207 "	
(b) Yellow sand, slightly lighter in color	207 " "	240 "	
(c) Yellow sand, shade of (a)	240 " "	260 "	
(d) Yellow sand, slightly reddish cast	260 " "	280 "	
(e) Yellow sand, not so red, contains black sand grains scarcely noticed above; clay streak at 288 feet	280 " "	301 "	
(f) Yellow sand, very slightly reddish cast	301 " "	320 "	
(g) Yellow sand, slightly red = shade of (d)	320 " "	348 "	
Brownish sand and clay, sponge spicules	348 " "	358 "	Miocene, 497 ft.
Alternations of sand and clay	358 " "	389 "	
Sandy clay, a few diatoms	389 " "	413 "	
Brownish clay, *diatomaceous*	413 " "	434 "	
Brownish clay, *comminuted shell*	434 " "	454 "	
Brownish clay	454 " "	471 "	
Bluish clay, fine texture, *diatomaceous*	471 " "	484 "	
Bluish clay, *diatomaceous*	484 " "	517 "	
Sand, with some *water*	517 " "	525 "	
Bluish clay, *diatomaceous*	525 " "	538 "	
Sand	538 " "	540 "	
Bluish clay, *diatomaceous*	540 " "	625 "	
Clay and fine and coarse sand, *comminuted shell throughout*	625 " "	641 "	
Clay	641 " "	670 "	
Sand, some *water* at		670 "	
Sandy clay	670 " "	728 "	
Brownish sand, coarse	728 " "	748 "	
Brownish sand, somewhat finer	748 " "	763 "	
Brownish sand, fine	763 " "	798 "	

Water-bearing strata, 728 to 798 feet, but not entirely penetrated.

This well was finished with a 50-foot strainer-point drawing from below the depth of 738 feet.

On comparing the stratigraphy of this well with that of the wells at Atlantic City, Longport and Ocean City, while there is found to be an identity in the succession of main beds, there is also to be observed the following differences:

The sands and gravels, with their few thin interbedded clay seams, which at Atlantic City terminate at the depth of about 265 feet, here reach a depth of 348 feet. They are also more prevailingly of a yellowish color, at least from 180 feet downward. These sands and gravels are, either wholly or in large part, of Pleistocene age.

The top of the brownish water-bearing sand horizon beneath the great Miocene diatomaceous and associated clay beds was found at the depth of 728 feet in close harmony with the depth thereto of 720 feet at Longport, while the depth to the same bed at Ocean City is 755 feet; at Atlantic City, on the meadows, it is likewise 755 feet, though near the beach it is 770 feet.

The Miocene clays at Brigantine are *diatomaceous* from the depths of 389 feet to that of 670 feet, thus showing a thickness of 291 feet. A few *foraminifera* and also *polycistina* were observed in these clays.

The shells of molluscs noted at 40 to 60 feet were probably recent forms. Those noted at 434 to 454 feet and again at 625 to 641 feet were undoubtedly Miocene as known from borings elsewhere—they were, however, so finely comminuted, probably by the drill, as not to be identifiable.

The correspondence of the three water horizons with the same horizons at Atlantic City is noted below:

At Brigantine. Depths.		At Atlantic City. Depths.
517 to 525 feet	=	525 to 550 feet.
670 "	=	725 "
728 " 798 "	=	755 " 813 "

The first two of these water horizons are the minor horizons noted on page 155 of last year's report as occurring respectively in sands near the middle of the great diatom and near the base of the same bed, while the lowest is the equivalent of what is noted in the same paper as a principal horizon, occurring about 100 feet below the said diatom bed.

While the supply of water in this well was scant from the two upper horizons it was abundant from the lowest one, and flowed over the surface at the rate of a little more that 100 gallons a minute.

ARTESIAN WELL AT THE BRIGHTON, ATLANTIC CITY, N. J.

Elevation, 10 feet; diameter, 6 inches; depth, 843 feet. Overflow about 100 gallons a minute.

The twelfth successful artesian well at Atlantic City, N. J., was completed at the Brighton House in November of the present year. This well is located about one-half mile nearly southeast of the group of wells put down upon the meadows for the Consumer's Water Company. A full detailed report of the deepest of these wells (1,398 feet), with an illustrated columnar section, appeared in the Annual Report for 1889,* while records of each of the others occur in each subsequent Annual Report.

A line drawn from the location upon the meadows to that of the Brighton House approximates the direction of the dip of the Miocene beds and their associated water horizons. Through the courtesy of the contractor, Uriah White, and of his superintendent, specimens of the borings were received. An examination of these shows that the same succession of beds was met with as in the former wells, but that after reaching the Miocene the depth to corresponding horizons was about twenty feet deeper in this well than in those upon the meadows. After making an allowance of a few feet for the greater elevation of the ground at the Brighton, this difference in depth corresponds closely with the amount of dip heretofore indicated in these reports of twenty-five or twenty-six per mile, southeast, for the Miocene water horizons. This rate of dip holds good for a considerable belt of country, both north and south of a line connecting Winslow and Hammonton with Atlantic City. In Cape May county the record published last year of a deep well at Wildwood, indicates that the dip in that county is not so great. In fact, data in the author's hands points to a gradual decrease in the amount of dip of the Miocene as we proceed southward through Delaware, Maryland and Virginia.

As may be inferred above, this well is located on ground a few feet higher than that of any other of the Atlantic City artesians. It will overflow at the surface at all times. On the addition of a few feet of casing to the top the flow ceases. The level of the water has then been found to rise and fall about fifteen inches, apparently with the tide. This fact has been verified by the engineer of the Brighton,

*The geology and paleontology of this well (1,398 feet), with a similar illustrated section, was published in the Proceedings of the Academy of Natural Sciences, of Philadelphia, for 1890, pages 132 to 147, also page 444.

A paper on the geology of the first well (1,100 feet) had previously appeared in the Academy's Proceedings for the year 1887, pages 339 to 342. This well is located at the gas works, about one-fourth of a mile southeast from the group on the meadows above alluded to.

who, at the writer's request, carefully observed this phenomenon for two weeks and compared the same with a daily tide-table card he had at hand.

The following shows the geological succession as revealed by an examination of the borings from this well:

65 feet.	Beach sands, with 5 or 10 feet of mud at the base.............	65 feet.	=Recent, 65 ft.
235 "	Gravels and sands, mostly sands, with gravel and pebbles at the top; prevailing color of this division, yellowish........	65 feet to 300 "	=Pleistocene(?), 235 ft.
100 "	Drab-colored sands................	300 " " 400 "	
300 "	Diatomaceous clays (fossil *molluscs* 642 to 670 feet)...........	400 " " 700 "	
30 "	Sandy, gravelly clays, fossil *shells*, but no micro-organisms................	700 " " 730 "	
13 "	Gravel, sand and *shell*, *water-bearing*............................	730 " " 743 "	=Miocene, 543 ft.
27 "	Non-diatomaceous sandy clays..	743 " " 770 "	
70 "	Brownish sands, shade varying to gray near the base; *water* in abundance......................	770 " " 840 "	
3 "	Gray micaceous quicksand......	840 " " 843 "	

The water horizon utilized by this well (770 to 840 feet) is the equivalent of that supplying wells noticed in this report as put down at this place for the Cooling Company and for the Electric Light Works, and also at Brigantine and Longport.

ARTESIAN WELL IN ATLANTIC CITY, AT THE ATLANTIC CITY COOLING COMPANY'S PLANT, BALTIC AVENUE, NEAR TENNESSEE AVENUE.

Diameter, 6 inches; depth, 813 feet; overflowed 105 gallons a minute; pumped 400 gallons a minute. Temerature, 66°.

Early the present year a well was put down by Uriah White for the Atlantic City Cooling Company. The following record of this well was furnished by Frank Brower, superintendent:

The depths to the bottom of the Pleistocene sands at 268 feet—to the top of the great 300-foot diatom bed at 375 feet, and to the top of the great 60-foot water horizon beneath the diatomaceous clay bed at 755 feet—correspond very closely with the records of previous wells at this locality.

Meadow mud	4 feet	= 4 feet.	Recent, 70 feet.
Gray sand	36 "	= 40 "	
White sand	30 "	= 70 "	
Brown clay	5 "	= 75 "	Pleistocene (?), 198 feet.
Various-colored gravels	15 "	= 90 "	
White clay	3 "	= 93 "	
Gravel	17 "	= 110 "	
Yellow sand	40 "	= 150 "	
White sand, in layers	62 "	= 212 "	
White sand	56 "	= 268 "	
Brown clay, with streaks of sand from which *water flowed*	24 "	= 292 "	Miocene, 545 feet.
Dark-brown or red sand	83 "	= 375 "	
Clay	180 "	= 555 "	
Sand, *water flowed seven gallons a minute*	15 "	= 570 "	
Clay	120 "	= 690 "	
Sand, *water flowed five gallons a minute*	20 "	= 710 "	
Clay	11 "	= 721 "	
Sand, with water	24 "	= 745 "	
Clay	10 "	= 755 "	
Reddish-brown sand, with *water*	30 "	= 785 "	
Light-bluish clay, *six inches;* whitish sand, with *water*	28 "	= 813 "	

This well was finished at the bottom with a fifty-foot strainer. At its completion the water flowed over the surface at the rate of 105 gallons a minute, and rose in the casing to a height above the surface of nine and one-half feet. The temperature of the water is 66°.

Miocene clays, with an occasional thin sand parting, occupied the 380 feet between the depths of 375 and 755 feet. The upper 300 feet of this interval was probably diatomaceous. Specimens, however, were not received.

ARTESIAN WELL, ATLANTIC CITY, AT THE ELECTRIC LIGHT WORKS, RAILROAD AVENUE, NEAR KENTUCKY AVENUE.

Diameter, 6 inches; depth, 809 feet.

A well was bored during the summer by Uriah White at the above locality. The record is in all respects substantially the same as that furnished for the well at the Atlantic City Cooling Company's plant, except that a log or tree, which was probably in a half upright position, was met with between the depths of 240 and 250 feet, or just above the top of the Miocene which occurs at this locality at the depth of about 265 feet.

A series of specimens of the borings from the surface to the depth of 390 feet was, by request, kindly furnished by the contractor and his superintendent. These cover the recent and underlying Pleistocene sands and gravels, and the upper portion of the Miocene to the top of the great 300-foot diatom bed. They comprise for the strata above the Miocene a much more complete series than has heretofore been obtained of these superficial deposits from this locality.

The full set will be deposited in the collections of the Survey at Trenton. A comparison of these and other borings in the Pleistocene already deposited at Trenton ought to reveal much of the structural relations of these strata up and down the beaches and inland.

The water horizon from which this well draws occupies the interval between 755 and 809 feet.

ARTESAN WELL AT LONGPORT.

Depth, 803 feet; diameter, 6 inches. Overflow, 180 gallons a minute.
Temperature, 66°.

Early in the year a well was put down by Uriah White, at Longport. Through the courtesy of M. S. McCullough, who was financially interested in the enterprise, and of the superintendent, a full series of specimens of the borings were furnished. After a careful examination of these, the record introduced below has been made. On the completion of the boring, the water flowed 180 gallons a minute, at the surface, and would rise in the pipe fourteen feet above the ground, which, however is but a couple of feet or so above high water. The temperature of the water is 66°.* The well has a fifty-foot strainer-pipe of four and one half inches inside diameter at the bottom. It draws its supply from the sixty-foot sand bed that is now certainly known to occur about 100 feet below the great Miocene diatom bed of the Atlantic coastal plain. This well has the greatest natural flow of any well that has yet been put down to this horizon.

Ordinary beach sand, some fragments of shells in the lower 10 feet		to 55 feet.	Recent, 75 feet.
Mud or clay, contains *diatoms*	55 feet	" 75 "	
Whitish sand	75 "	" 125 "	Pleistocene, 93 feet.
Clayey sand, no micro-organisms	125 "	" 130 "	
Yellowish-white sand	130 "	" 168 "	
Clayey sand	168 "	" 174 "	Age (?), 92 feet.
Drab-colored sand	174 "	" 260 "	
Sandy clay	260 "	" 272 "	Miocene, 543 feet. Diatomaceous 292 to 664 feet = 372 feet of thickness.
Sand	272 "	" 292 "	
Sandy clay, *with diatoms*	292 "	" 310 "	
Sand, with clay	310 "	" 320 "	
Clay, contains *diatoms* and fragments of *molluscs*	320 "	" 330 "	
Clayey sand	330 "	" 374 "	
Clay, with *diatoms*	374 "	" 480 "	
Sandy clay, *diatoms*	480 "	" 500 "	
Clay, sand and *shells*	500 "	" 505 "	
Sandy clay, *diatoms*	505 "	" 613 "	
Clay, *diatoms*	613 "	" 664 "	
Sandy clay, with *shell*	664 "	" 720 "	
Brown sand, water-bearing, the lower 23 feet a finer sand of lighter brown than above	720 "	" 803 "	

The mud or clay at fifty-five to seventy-five feet, which contains diatoms, is probably the equivalent of similar diatomaceous deposits occurring at the following places:

At Wildwood, at the depth of 29 feet to 46 feet.
" Absecon, " " " " 18 " " 24 "
" Atlantic City, " " " 70 " " 90 "
" Beach Haven, " " " 55 "
" Long Branch, outcrop.
" Bridgeton, "
" Buckshutem, near Millville, outcrop.
" Mays Landing, outcrop.

*A small flow of water occurred at the depth of 535 feet. This had a temperature of 57°.

The shells observed at 320 to 330 feet were so fragmentary as to be unidentifiable, but they probably represent the St. Mary's portion of the Chesapeake, which has been recognized at Wildwood by *Melanopsis Marylandica* and other shells found at the depth of 409 to 428 feet.

The top of the diatomaceous portion of the Chesapeake Miocene was found nearly 100 feet higher than in the Atlantic City wells, seven miles to the northward. It occurs here at the depth of 292 feet, while at the last named place it is met with at the depth of 380 feet. The lowest diatomaceous specimen observed came from the depth of 664 feet. The bed thus presents here a thickness of 372 feet. Along the coast the thickness of the bed is less to the northward and greater to the southward. The bed also probably thins out inland, since its thickness as shown in outcrops in Maryland and Virginia averages about twenty-five feet. It, however, thickens outward upon the dip, which is southeastward in New Jersey and nearly eastward in the more Southern States.

The intervals of depths between which it occurs at various localities from each of which the writer has a full series of borings are as tabulated below:

At Asbury Park, N. J,	between	the depths of	16 ft.	and 94 ft.	= 75 ft. thick.
" Barnegat,	" at	" "	" 120	" not passed through.	
" Harvey Cedars,	" between	" "	" 164	" and 315 ft.	= 151 ft. thick.
" Beach Haven,	" "	" "	" 290	" " 543 ft.	= 253 " "
" Brigantine,	" "	" "	" 389	" " 670 "	= 281 " "
" Atlantic City, (Beneath the meadows.)	" "	" "	" 380	" " 670 "	= 290 " "
" Atlantic City, N. J., between (Beneath the beach.)	"	" "	" 400	" " 700 "	= 300 " "
" Ocean City, N. J., between	"	" "	" 300*	" " 680 "	= 380 " "
" Wildwood,	" "	" "	" 370	" " 793 "	= 423 " "
" Clayton, Del.,	"	" "	" 100	" " 150 "	not passed through.
" Cambridge, Md.,	"	" "	" 192	" " 335 "	" " "
" Crisfield,	" "	" "	" 365	" " 771 "	= 406 feet thick.

*In last year's Report, the interval for Ocean City was stated to be between the depths of 370 and 380 feet. A re-examination of the specimens reveals diatoms at an earlier depth, viz., at that of 300 feet.

ARTESIAN WELLS AT WILDWOOD.

No. 1.—Depth, 215 feet; water did not overflow.
" 2.—Total depth, 1,244 feet; draws water at 887 to 931 feet; overflows.
" 3.—Depth, 655 feet; draws water at 580 to 655 feet; overflows.

During the present year an artesian well has been put down at Wildwood by the American Pipe Company, the work being superintended by John A. Durst, who has carefully collected and furnished a full series of specimens of the borings.

This is the third well that has been sunk at this seaside resort. The first was noticed in the Annual Report for 1893.

In the report for 1894 the second well was very fully described and illustrated, its geology and paleontology being demonstrated and lists given of fossil molluscs and of other fossil organisms, the latter mostly microscopic forms called diatoms.

The boring for this well attained a total depth of 1,244 feet. A strong flow of salt water was had at the depth of 1,185 feet, while flows of fresh water were observed at the depths of about 625, 750 and 843 feet, and a larger fresh water flow between the depths of 887 and 931 feet. This well was finally finished so as to utilize the supply at the last-named horizon.

The well (No. 3) now reported was sunk to develop one of the higher of these deep fresh-water horizons. The borings therefrom have only been received as the writing of this paper was being concluded, and time at command does not permit an extended study of the same. The depth attained was 655 feet, and water was obtained from sands and gravels interbedded in the lower seventy-five feet.

RECORD.

[Compiled from notes by John Arthur Durst respecting color and character of strata.]

	Thickness.	Intervals.	
Soil and black muck full of roots of cedar and holly	8 ft.	0 ft. to 8 ft.	Recent.
Beach sands, lower 10 feet slightly darker in shade	27 "	8 " " 30 "	Recent.
Dark-blue clay *Melosira*, and other marine *diatoms*.	2 "	30 " " 32 "	Age (?)
Sand; and fine, medium and coarse gravel, with *Nassa* and other shells	8 "	32 " " 40 "	Age (?)
Sand; and fine, medium and coarse gravel without shell	21 "	40 " " 61 "	Age (?)

	Thickness.	Intervals.			
Bluish clay, *sponge spicules* and *diatoms*, the latter both *fresh water* and *marine*	12 ft.	— 61 ft. to 73 ft.	Clay.	Marine and fresh-water Diatoms.	This division, upper part at least, mixed marine and fresh water deposit, say 61 to 185 feet. Age (?)
Brownish clay, with *lignite* (more sandy than that next above)	4 "	— 73 " " 77 "			
Blue clay, about as sandy as the brown layer just above	14 "	— 77 " " 91 "			
Sand and fine and coarse gravels, with some fossiliferous Silurean and Devonean pebbles of the size of shellbarks	7 "	— 91 " " 98 "	Gravel.		
Bluish clay, with *marine* and *fresh-water diatoms*	34 "	— 98 " " 132 "	Clay.		
Sand and coarse gravel, with pebbles as large as hickory nuts	7 "	— 132 " " 139 "	Gravel.		
Sand, not much gravel, but some large stones,	13 "	— 139 " " 152 "			
(*a*) Sand, with clay and *lignite*	33 "	— 152 " " 185 "	Sand.		
(*b*) Sand, *lignite* plentiful	5 "	— 185 " " 190 "			
(*c*) Sand, similar to (*a*)	10 "	— 190 " " 200 "			
Sand very fine and lively, slush very dirty, lower 10 feet contained about 2 feet of *lignite*	20 "	— 200 " " 220 "			
Sand, slush greenish in color	48 "	— 220 " " 268 "			
Alternations of sand and drab-colored clay, slush loses its greenish tinge	22 "	— 268 " " 290 "			
Drab-colored clay	12 "	— 290 " " 302 "	Mainly clays; diatomaceous below 369 ft.		Miocene, Chesapeake—Upper part the St. Mary's Division.
Drab-colored coarse gravel	2 "	— 302 " " 305 "			
Drab-colored sandy clay	2 "	— 305 " " 307 "			
Drab-colored gravel	2 "	— 307 " " 309 "			
Sand, with scattering gravel	19 "	— 309 " " 328 "			
Sandy clays, lighter in color than from 290 to 309	15 "	— 328 " " 343 "			
Fine sand and gravel, alternated with clay in thin strata	23 "	— 343 " " 369 "			
Blue clay	15 "	— 369 " " 384 "			
Sandy clay, with shell; includes 1½ feet black sand at 388 to 389½ feet	32 "	— 384 " " 416 "			
Solid clay, some shell	15 "	— 416 " " 431 "			
Solid clay, no shell	9 "	— 431 " " 440 "			
Solid clay, again a little shell	24 "	— 440 " " 464 "			
First rock 464′ 3″ to 464′ 7″ = 4 inches (quite solid) say		464 " " 465 "			
Sandy clay, with broken shell	25 "	— 465 " " 490 "			
Solid dark-blue clay, much more tenacious, very little shell	45 "	— 490 " " 535 "			
Second rock, 535′ 5″ to 536′ — 7″ 11 inches, say,	1 "	— 535 " " 536 "			
(*d*) Dark-greenish clay, sand and gravel in it,	18 "	— 536 " " 554 "			
Third rock, 554′ 1″ to 555′ 5″ = 16 inches, say,	1+"	— 554 " " 555+			
(*e*) Solid greenish clay, same as (*d*)	1 "	— 555 " " 556 "			
Dark-brownish clay	21 "	— 556 " " 577 "			
Sand, with thin and very sandy clay seams	29 "	— 577 " " 606 "	Mainly sands and gravels. The thin clay seams, diatomaceous, water-bearing, 577 to 648 feet.		
Fourth rock (soft), 606′ 2″ to 606′ 10″ = 8 inches, say	1 "	— 606 " " 607 "			
Sand, with shell very plentiful and some coral, 606′ 10″ to 608′ 11″ = 2 feet, say	2 "	— 607 " " 609 "			
Fifth rock, 608′ 11″ to 610′ 4″ = 17 inches, say,	1 "	— 609 " " 610 "			
Sand, gravel and shell, with very little clay,	8 "	— 610 " " 618 "			
Sand and fine gravel, not much shell	13 "	— 618 " " 631 "			
Coarse sand and splendid gravel	17 "	— 631 " " 648 "			
Solid brown clay, richly *diatomaceous*	3 "	— 648 " " 651 "			
Fine, clayey sand, *diatomaceous*	14 "	— 651 " " 665 "			

This well and the deep one reported last year demonstrate the existence at Wildwood of at least two deep fresh-water horizons, as follows:

One occupying the interval of 590 to 655 feet, and another occupying the interval of 887 to 931 feet. The temperature of the water, as it flows over the surface from both wells, was taken at the same time. We are informed it was, for the water from the upper horizon, 63°, and for that from the lower horizon, 67°.

The boring of the well this year has verified the general correctness of the geological section published last year; the differences in reported depths of any given horizon varying but a very few feet.

There has been pumped from the well of this year 300 gallons per minute. The natural flow therefrom is said to be about three times greater than from the deeper horizon opened by the well of last year.

ARTESIAN WELLS IN SUPERFICIAL STRATA.

SHALLOW WELL AT LINWOOD.

Elevation, 20 feet; depth, 45 feet.

A shallow well was put down by Uriah White, at the residence of I. G. Adams, at Linwood. The record furnished is:

	Depths.
Surface gravel, then sand	to 22 feet.
Blue clay, with shells at the bottom	22 feet " 30 "
Clay and sand mixed	30 " " 40 "
Fine white sand	40 " " 45 "

This well is of geological interest, because of the eight feet of blue clay described at twenty-two to thirty feet in depth. No specimen was received of this clay, but it was probably diatomaceous, and corresponds with a bed of clay known to be diatomaceous that was penetrated between the depths of nine and eighteen feet by the wells at the old Atlantic City water works, and which are situated near the shore road about five and a half miles north of this well and one mile south of Absecon. (See Report 1892, page 383.) This bed probably is also the same with a bed met with in boring the well at Longport at the depth of fifty-five to seventy-five feet. (See page 84.) This bluish clay represents a deposit that lies on top of the Pleistocene gravels and sands and has in turn been covered over by gravels and sands that have been obtained from these Pleistocene deposits by a working over and redepositing of the same.

A similar blue clay exists beneath the beaches elsewhere at no very great depth and occupying a similar stratigraphic position. It is, of course, of very recent age, and is doubtless equivalent to the diatomaceous bed at Wildwood, between the depths of twenty-nine and forty-six feet, and which was described in last year's report, page 160, and which is also again noted in this report, page 86, as observed at thirty to thirty-two feet.

ARTESIAN WELLS AT CLAYTON, N. J.

Four wells; elevation, 135 feet; depth, 86 to 93 feet.

The American Pipe Company put down four wells at Clayton for the water company there. A series of the borings were saved by J. A. Durst, superintendent for the pipe company. These the writer was permitted to examine and from them he has compiled the following record:

	Depths.	
Sand and loamy clay, surface to	7 feet.	Pleistocene, Pensauken (?)
Gravel and sand	7 feet to 8 "	
Yellowish-white sand	8 " " 10 "	
Orange-colored sandy clay	10 " " 12 "	
Light-gray clay	12 " " 15 "	
Sand, color of light-brown sugar	15 " " 21 "	
Orange-colored sand	21 " " 28 "	
Whitish sand	28 " " 34 "	
Yellow sand	34 " " 40 "	
Sand, color of light-brown sugar	40 " " 53 "	
Sandy clay, color of light-brown sugar	53 " " 57 "	
Yellowish-white sand	57 " " 71 "	
Sand, still more yellow	71 " " 84 "	
Coarse white sand, water-bearing	84 " " 86 "	
Sand, light-yellow, water-bearing	86 " " 92 "	
Coarse white sand	92 " " 94 "	
Gravel, color of brown sugar	94 " " 96 "	
Coarse-grained yellow sand	96 " " 98 "	
Bluish clay	98 " " 105 "	= Miocene.

These wells are located on ground adjoining the property occupied by Moore Bros.' Glass Works, where two wells are noted in the

Annual Report for 1893 (page 115), with depths of 85 to 105 feet, the ground being slightly higher than that where the wells now being considered are located.

ARTESIAN WELLS AND BORED WELLS IN PERTH AMBOY, WOODBRIDGE, TOTTENVILLE, S. I., BAYONNE AND ADJACENT COUNTRY.

Reported by W. R. Osborne, of Perth Amboy, N. J.

Otto Jaeger's residence, Tottenville, S. I., on east shore of Staten Island Sound:

Hardpan, gravel and clay	25 feet.
Red sand	12 "
	37 "

Water, 10 gallons per minute.
Elevation of surface, 15 feet above tide level.

Abram Cole, half way between Tottenville and Kreischerville, S. I.:

Hardpan, gravel and clay, mixed	30 feet.
Sand	6 "
	36 "

Water, 5 gallons per minute.
Surface elevation, 15 feet.

Albert Killmyer, Kreischerville, Staten Island:

Gravel	4 feet.	=	4 feet.
Sand	36 "	=	40 "
White clay	21 "	=	61 "
White sand	30 "	=	91 "
Blue clay	10 "	=	101 "
Fine white sand	90 "	=	191 "
Sandstone (black)	3 "	=	194 "
Quicksand	2 "	=	196 "

No water.

Smelting Works near Maurer, Middlesex county. Well No. 1:

Blue and white clay .... 50 feet.
White sand. Water rising to within three feet of the surface and yielding 25,000 gallons daily.
Elevation of surface .... 5 feet.

Smelting Works near Maurer. No. 2 well:

Blue and white clay .... 87 feet.
Rock. No water.

This well was near the office of the company and 300 yards west of well No. 1, and the ground is higher—twenty-five feet above tide level.

Raritan Hollow and Porous Brick Company; on the Raritan river, two miles west of Perth Amboy. Well No. 1:

Salt meadow	15 feet	= 15 feet.
Blue clay	25 "	= 40 "
Fire-clay	12 "	= 52 "
Water.		

Well No. 2:

Salt meadow	15 feet	= 15 feet.
Blue clay	20 "	= 35 "
Fire-clay	10 "	= 45 "
Flow, 30,000 gallons per day.		

Well No. 3:

Blue clay	30 feet	= 30 feet.
Fire-clay	15 "	= 45 "
Mottled or spotted red clay	5 "	= 50 "
Flow, 20,000 gallons per day.		

Wells 1 and 2 are within thirty feet of one another. No. 3 is about 500 feet east of 1 and 2 and seventy-five feet from the river.

Surface of ground five feet above tide level. Flow of No. 3 is stronger when the tide is high than when it is low.

Marcus Schautz's residence on Perth Amboy road, one and one-half miles from Metuchen:

Sandy gravel	35 feet	= 35 feet.
Sand (water)	4 "	= 39 "
Hardpan	10 "	= 49 "
White sand, water	4 "	= 53 "

Hans Ericson's residence, near Ford's Corners and on the road from Woodbridge to Valentine's Station:

Sandy gravel	70 feet	= 70 feet.
Blue clay	5 "	= 75 "
White clay	10 "	= 85 "
Red clay	5 "	= 90 "
Yellow sand (water)	5 "	= 95 "
Reddish-colored clay	8 "	= 103 "
Yellowish-clayey sand; sandy clay; white sand, water	23 "	= 126 "

This well was drilled in the autumn of 1894, and proved to be unsatisfactory. In the summer of 1895 work was resumed here, and the red shale was found at a depth of 135 feet. The four-inch pipe was driven down to 142 feet. At 227 feet the well was finished. Water began to come in at 180 feet. At the bottom the shale was very hard. At the top it was red in shade, resembling the red clays used in this vicinity for the manufacture of terra-cotta.

The well supplies about two gallons of water a minute.

The surface elevation is about 160 feet. The thickness of the morainic drift is shown to be seventy feet. The Raritan clay series is therefore sixty-five feet thick at this point—probably the Woodbridge fire-clay bed and the fire-sand bed, and at the bottom the Raritan clay bed or its equivalent sands.

During the past summer four additional wells were bored at the smelting works in Perth Amboy (near Maurer), all within 150 feet of one another and near well No. 1. The five wells yield 150,000 gallons a day. They are all about fifty feet deep. The water is not a good drinking water.

C. Pardee's works, Perth Amboy. Well No. 4:

Gravel	18 feet	= 18 feet.
Blue clay	23 "	= 41 "
Dark-colored clay	20 "	= 61 "
Red clay	85 "	= 146 "

Elevation, 3 feet above tide level. No water.

Well No. 1:

Gravel	18 feet	= 18 feet.
Blue clay	42 "	= 60 "
Fine red sand	20 "	= 80 "
Sandy clay	20 "	= 100 "
Red sandstone	7 "	= 107 "
Red clay	9 "	= 116 "

No water. Elevation, 3 feet.

Well No. 3:

Blue clay	32 feet	= 32 feet.
White clay	15 "	= 47 "
Red clay	6 "	= 53 "

Water. Elevation, about 10 feet.

Well No. 2:

Gravel	15 feet	= 15 feet.
White sand	7 "	= 22 "
Yellow sand	9 "	= 31 "

Rock. Elevation, about 3 feet.

These wells were all driven within a square of less than 700 feet, No. 3 being in a hollow below the old water works station, and about 500 feet from the latter and towards the river. A well at the pump station is reported to have found granite at 110 feet, having been drilled 400 feet into this rock without change.

These wells show a great variation in the thickness of the clay beds within short distance.

It seems highly probable that some of the so-called red clay may represent the top of the red shale, particularly that in wells Nos. 1 and 4, and at about 100 feet, which would correspond with the depth of the formation as found in the artesian well of the Lehigh Valley Railroad Company at their docks in Perth Amboy.

Henry Maurer's brick works, Maurer:

Blue clay	47 feet	= 47 feet.
Red clay	6 "	= 53 "
White clay	2 "	= 55 "
Black clay	2 "	= 57 "
Sandy clay (with some water)	2 "	= 59 "
Sandstone	1 "	= 60 "
Mixed clay	14 "	= 74 "
"Stone"	½ "	=
Clay	2½ "	= 77 "
Trap-rock at		78 "

Very little and muddy water at 59 feet.

This well was bored the past summer. The trap-rock here may be a part of the Staten Island trap range, continuous across the sound and in line with the Rocky Hill range.

M. D. Valentine & Brothers Company's works, Woodbridge:

Sandy drift	20 feet	= 20 feet.
Bluish clay	10 "	= 30 "
Gravelly drift	24 "	= 54 "
Gray and green material resembling marl	2 "	= 56 "

Rock, supposed to be trap.

At last account of this well the boring was in rock at 100 feet, apparently more shaly, and a mixture of black sand and red shale.

The occurrence of rock here and at the Boynton Beach well and at that of Henry Maurer is suggestive of the existence of continuous formation, and at uniform depth of 60 to 78 feet, or with a dip to the southeast.

S. S. Tucker, Edgar Station, Woodbridge:

Red shale drift	16 feet	= 16 feet.
Whitish clay	4 "	= 20 "
Red shale drift	5 "	= 25 "
Pink-colored clay	5 "	= 30 "
Red shale	47 "	= 87 "

Water.

Ellis Edgar, Edgar Station:

Sandy drift	35 feet	= 35 feet.
Red shale	41 "	= 76 "

Water.

These wells are interesting records of the depth of the red shale at this place and the thickness of the overlying drift upon the thin edge of the clay formation.

Metuchen.—Four wells on adjoining lots on Graham avenue on lands of W. R. Osborne, Charles Edgar, Mr. Woodward and Mr. Wilson:

Drift	18 feet to	25 feet.
Red shale to bottom	48 "	= 70 "

Plenty of excellent water.

New Brunswick.—Well at Natatorium, Liberty street;

Drift	5 feet.
Red shale	135 "

Water at from 40 feet to bottom of well. Seventy-five gallons per minute can be pumped. Finished by exploding dynamite at bottom.

Runyon Station.—Pennsylvania Railroad Company's Camden & Amboy branch, about one mile northeast of Old Bridge. Well put down for the city of Perth Amboy in 1895:

Yellow sand	25	feet =	25	feet.
White sand	15	" =	40	"
Sandy-white clay	39	" =	79	"
Sandy-bluish clay	21	" =	100	"
Stone	½			
Bluish clay, very fine sand	59	" =	159½	"
Stone	½			

This well is at an elevation of twenty-three feet. A two-inch pipe was driven down ninety feet. The "stone" reported at 160 feet was apparently a thin layer of cemented sand or a "sulphur ball." As the jetty system was here used it is impossible to be entirely certain as to the nature of beds on account of mixing of materials.

The hope of reaching the water-bearing sand whence the wells at South River get their supply (at about eighty feet below tide level), was not realized, and probably because the well was not deep enough to reach it.

Identification of these beds with the clay series is not as yet made out.

Bayonne.—Well driven for G. W. Yates, 101 Newman avenue:

Gravelly formation and drift to rock	31 feet.

Water in wells in this part of Bayonne is found generally in sandy layers in the drift and twenty to twenty-five feet deep.

PART IV.

REPORT ON
FORESTRY.

REPORTS OF PROGRESS.

REPORT ON FORESTRY IN NORTHERN NEW JERSEY.

BY C C. VERMEULE.

Last year we began a detailed survey and inquiry into the physical condition of the forests of Northern New Jersey, and reported thereon in the last Annual Report. This work has since been extended to cover all of the Highlands, the Central Passaic valley, and that portion of the country east of the Watchung mountains which is included in Bergen, Hudson and Essex counties. As a result of this work we now know the location and extent of all forested areas, and the size, varieties and character of the growth. The forest is considered in these studies to include the following classes:

1. Brush or stump land, to include no areas intended to be cleared and cultivated.
2. Old clearings formerly cultivated, but now growing up to timber.
3. Young growth, in which class was included all timber less than six inches diameter, the approximate age, size and height being noted.
4. Large timber, including all over six inches in diameter, the diameter and height being noted as before.

Without attempting any strict botanical classification, the varieties of timber have been designated as follows:

1. Deciduous, with the prevailing varieties indicated.
2. Coniferous, classified as pine, cedar, hemlock, &c.
3. Mixed deciduous and coniferous.

Notes were kept of the general character of scattered growth over lands under cultivation, also of the general condition of the forested areas, and of any remarkably large trees, any original forest, planted timber, brush land which seems incapable of producing timber, the succession of growth, &c. Information was also collected as to the value per acre of stump land of twenty-years or thirty-years growth, and all heavy timber of various kinds; also of the testimony of reliable persons as to how the amount of timber now standing compares with that of previous periods, and of how the growth on slopes of hills compares with that in the valleys or on the top of plateaus.

It will be noted that the inquiries were of the most practical kind, and it is believed that the information obtained will be of value in reaching an understanding of the actual economic condition of our forested areas. Thus far they have developed the fact that there have been no important changes either in the limits of cultivated land, or in the proportion of forested and cultivated areas, since the topographical surveys were begun in 1877. There have been minor changes, and a few old clearings of small area have been allowed to grow up, the areas thus added to the forests being just about offset by that which has been brought under cultivation, likewise in small, scattered parcels.

The topographical maps showed forested lands as distinguished from those under cultivation. They made no attempt to indicate the varieties, size or condition of the timber. There is very little land in the State which, if left uncultivated, does not spontaneously produce, in a few years, a fairly good growth of timber; consequently, the land represented as forest on the maps, for which the surveys were completed in 1887, ranges from brush to good timber of from forty to fifty years growth, and for the most part every gradation of growth is represented in due proportion. The examinations made during the past year have attempted to differentiate this growth into varieties of trees, age and size, as we have explained.

Like almost every other physical feature of the State, the forests may be classed broadly into five divisions corresponding with the geological formations, and each of the three northern divisions must be subdivided into glaciated and unglaciated districts. There is a marked difference in the proportion of forest area, and also a less marked difference in the varieties of timber north and south of the terminal moraine line. Consequently we can most conveniently consider the forests by the several topographical divisions adopted and followed in the "Physical Description" of the State, published in 1888.

For convenient reference, and in order to give something like completeness to this present progress report, we have incorporated herein the results of the two years' work.

THE HIGHLANDS.

The region known as the Highlands has been often described in the reports of the Survey. Its boundaries are indicated on the accompanying map, and it is the region of Archean or gneissic rocks. The most significant geological subdivision in connection with forestry is into two districts; first, the northeastern or glaciated, and second, the southwestern or unglaciated Highlands. The former being denuded of soil on the ridges, and the valleys filled with gravel, boulders, &c., by the action of the great ice sheet, is less adapted to agriculture, consequently more generally forested than the southwestern portion, which has smoother ridges, well covered with soil, and clean, unlittered valleys.

We may indicate the difference by comparing the percentages of forest areas in two classes of townships, each typical of one of these subdivisions of the Highlands.

GLACIATED NORTHEASTERN HIGHLANDS.

Township.	County.	Percentage of area in forest.
Byram	Sussex	77
Jefferson	Morris	74
Rockaway	"	72
West Milford	Passaic	74
Pompton	"	76

UNGLACIATED SOUTHWESTERN HIGHLANDS.

Mendham	Morris	30
Chester	"	46
Washington	"	32
Lebanon	Hunterdon	27
High Bridge	"	25
Bethlehem	"	35

It will be seen that the northeastern section has, generally, 75 per cent. of the area forested, as against about 30 per cent. of the southwestern, and this difference is undoubtedly almost entirely due to the different surface conditions brought about by glacial action.

The forests of this Highlands region have a direct relation to the future water-supply of the State, for here lie the splendid gathering-grounds which are already coming rapidly into use for the supply of our cities. We estimate that the Highlands region has in all about

340,000 acres of forest, of which 240,000 acres are in the northeastern, and 100,000 acres in the southwestern section. In our detailed descriptions of each of these subdivisions we shall follow the topographical subdivisions of the Highlands which we adopted in the "Physical Description" published in 1888, beginning on the northwest and passing to the southeast side of the plateau.

FORESTS OF THE NORTHEASTERN HIGHLANDS.

First, on the extreme northwest of this district we have Pochuck mountain, a Highlands region lying detached from the main plateau, like an island, at the eastern side of the great Kittatinny valley. The forests of this region cover about two-thirds of the area, and consist mainly of oak and chestnut, with a considerable amount of hemlock, and some red cedar where old clearings have grown up. A considerable portion of this timber is from 40 to 50 years old, and there are a number of large trees which we shall note later in connection with the forests of the main plateau.

Vernon valley, which separates Pochuck mountain from the main group of the Highlands, is a fertile agricultural district, with a very small amount of forest, but it has a goodly supply of scattering trees which are thrifty and often of large size.

Passing on to the southwest we come to the Alamuche-Pohatcong range, the glaciated portion of which includes the district lying between the Lehigh and Hudson River railroad on the west, and the valleys of the Wallkill and Lubber's run on the east, and extending from Franklin Furnace southwest to the Vienna and Hackettstown road. We find the conditions as follows: From Franklin Furnace southwest to the line of the New York, Susquehanna and Western railroad, this ridge is known as Pimple Hill. The growth of wood is thin, ranging from 2 to 8 inches in diameter, and consisting mainly of chestnut, oak and red cedar, with a few other coniferous trees scattered throughout the whole district. On the high hill near the railroad and north of Sparta, and also along the ravine southwest of Franklin Furnace, the conifers are quite abundant. The growth, however, is principally chestnut and oak, the best of which is from 6 to 24 inches in diameter, and 30 to 55 feet high, a good proportion of these trees being about 12 inches in diameter. Not much cordwood is cut in this section, but the best timber is selected and taken out here and there as needed. Between the New York, Susquehanna and Western railroad and the highway from Sparta to Pinkneyville there are very few coniferous trees, chestnut and oak being predominant, and somewhat larger than on the Pimple hills, measuring from 9 to 16 inches in diameter and 30 to 55 feet high. Just northwest of Sparta there is a ridge which has been entirely stripped of timber, but there is no clearing in any of this district for farming purposes, and there does not appear to be much cleared land lapsing back into forest. The flat swamp land on the Wallkill southwest of Sparta has some timber, mostly bordering the stream. There are maples and elms 12 to 24 inches in diameter and 40 to 50 feet high interspersed with a good deal of brush, and near the head of the swamp there are a few good white pines, also a number of hemlocks about the headwaters of the stream. The ridge just west of this swamp is well wooded at the north end, the trees being mostly 10 to 14 inches in diameter, but ranging up to 24 inches. The larger trees have been cut out at the southern end of the ridge. There are red cedars bordering the clearings. Tar Hill ridge in Andover township, just east of the Lehigh and Hudson River railroad, is quite well wooded. A small portion has been cut off within the last five years, more within ten years, but generally the timber runs from 6 to 24 inches in diameter and from 30 to 50 feet high, the larger sizes being not very numerous. There are a good many hemlocks and red cedars and a few white pines. On the ridge line between the upper Wallkill and the easterly branch of Lubber's run, and stretching from Sparta to Roseville, the timber is small southward as far as the Gaffney mine, most of the large growth having been cut out. In a few spots trees were noted 18 to 24 inches in diameter, but for the most part they are less than 8 inches. On the west slope there are a great many red cedars and a few hemlocks. In the swamp near Gaffney mine, and also the one just southwest along Lubber's run, there are a good many tamaracks. The hills just east of Stag pond are well wooded on the tops, the trees ranging from 6 to 18 inches in diameter, but the steep slope just east of the pond and its outlet is broken and rocky, and is mostly red cedar and hemlock, with a few white pines. There are also hemlocks and a few white pines on the ridge north of Roseville. A tract of 500 acres at Roseville has had all trees 9 inches in diameter and over cut out. An examination of the stumps showed that oak 60 to 70 years old ranged from 18 to 24 inches in diameter; from 40 to 50 years old ranged from 13 to 21 inches, being mostly 13 and 14 inches. An oak stump 89 years old measured 24 inches, and showed that for the first 20 years the growth had been very slow. Chestnut 63 years old measured 31 inches, and hickory 90 years old 19 inches. Generally over this tract from Sparta southwest to the Roseville and Andover highway the timber was in good condition. In a few places it had been cut within 3 years; other tracts within 15 years, but a great many of the trees would average from 12 to 20 inches in diameter. Other portions would average from 8 to 15 inches in diameter and from 40 to 55 feet high, although some of the largest timber seemed to be over 60 feet. While oak and chestnut predominate, there is scattering white pine and hemlock throughout.

Between the Andover and Roseville highway, the Sussex railroad and Lubber's run there are a few trees 24 inches in diameter, but for the most part they run from 6 to 14 inches, with a height of from 30 to 50 feet. Near Andover, on the road to Roseville, the timber was 10 to 20 inches in diameter, and 50 to 60 feet high.

The portion of this district extending from Sussex railroad southwest to the highway from Hackettstown to Alamuche is known as Alamuche mountain, and is almost a solid forest. In the Kitattinny valley, between the foot of the mountain and the Lehigh and Hudson River railroad, the country is highly cultivated, the scattering patches of timber being composed of small oaks and chestnuts from 4 to 6 inches in diameter and 15 to 35 feet high. In each grove there are a few large trees from 10 to 30 inches in diameter and 40 to 60 feet high, but most of these larger trees have been cut out for timber or other purposes. There are also a good many red cedars. Along the streams and in the swamp near Alamuche elms and maples prevail, the larger ones being 24 inches in diameter and about 50 feet high. There has been a considerable amount of clearing recently in this swamp, which is being ditched and brought under cultivation as a result of the improvement in the drainage of the Pequest valley. Passing along the road from Andover to Alamuche the first growth seemed to range from 8 to 20 inches in diameter and about 55 feet high; further along, from 6 to 24 inches in diameter and from 30 to 55 feet high, mixed with a smaller and denser growth. About Tranquility timber was noted from 10 to 20 inches in diameter and 40 to 50 feet high, and near Alamuche it ranged from 4 to 18 inches and from 20 to 45 feet high. It is somewhat similar toward the top of the mountain eastward from Alamuche, and there seems to be a predominance of trees all through the mountains, ranging from 7 to 11 inches in diameter. Trees as large as 20 inches are scarce and scattering, while there is a good deal of young and small growth. There are a few hemlocks on the rocky slope north of Cranberry reservoir, on the end of the mountain north of Alamuche, and near Waterloo, while the swamp north of Waterloo has some tamaracks. South of the road from Alamuche to Waterloo there is a game preserve or deer park, and the wood is chestnut and oak, with some hickory, whitewood, birch, maple and elm. South of the road from Warrenville across the ridge to Saxton Falls, the timber is very short, mostly chestnut and oak on the tops of the hills. On the east slope, where it has not been cut, there is a thrifty growth of chestnut and oak ranging from 6 to 14 inches in diameter. A considerable portion has been cut within 3 years.

Mr. James French, of Waterloo, owns 3,000 acres of timber in this vicinity. Mr. Henry French, his son, reports that they do not cut any cordwood there now, as they do not find it profitable, not being able to compete with the pine cordwood of South Jersey. They sell a good deal of timber on special orders for various purposes, getting out almost anything, for ship-building or other purposes, which may be required. Their tract does not produce timber quite as fast as they need at present. He claims that they work up everything and waste nothing, and thinks that forests are generally in a better condition now than they were 40 years ago, as the larger mills are not cutting much and cordwood is not profitable, that the demand is for the largest timber, and consequently the younger growth is allowed to mature. These gentlemen also peel quite a good deal of butternut, hickory, oak and birch bark for their trade.

It is interesting to note that about 20 years ago Mr. French bought a tract of woodland in these mountains which had been cut off a few years before. This tract has not appeared to grow since, and is said to be not much more than brush at present.

Continuing southwest to the road from Hackettstown to Vienna we find that the timber is inferior in quality. On the slope just northwest of Hackettstown the timber has been cut within three years, but on the hill-top it is 6 to 14 inches in diameter and from

30 to 40 feet high, of chestnut and oak. The timber through this section is in detached tracts, the larger part of the area being under cultivation. Between Hackettstown and Alamuche the timber does not appear to grow well or is too closely cut. West of Alamuche pond the ridge has a larger growth of chestnut and oak, mixed with a good deal of red cedar. There are also a few white pines on the western slope of this ridge. Along the highway from Warrenville to Meadville, at the edge of the Pequest meadows, there is some of the finest timber which was observed in this region, of chestnut, oak and hickory, from 10 to 30 inches in diameter and 50 to 60 feet high. One piece of about 50 acres near the head of the small swamp has been cut within two years. A good deal of the timber on the end of Cat mountain, west of Petersburgh, has been recently cut; what remains is from 8 to 16 inches in diameter and from 30 to 50 feet high, but it is scattering and mixed with small growth. At the head of the stream just northeast of Petersburgh there are a number of tamarack trees. Agriculturally this section about holds its own. There is not any important lapsing back of cultivated land into forest, and while the smaller houses are allowed to go into decay, the land continues to be farmed as before. It was noted that the end of the ridge extending westerly and southwesterly from Alamuche pond to Meadville is badly washed just north of the latter place near the small mill-pond. The bed rock seems to lie close to the surface and the soil washes off. Such land should be left in forest, as it must become less and less valuable for agricultural purposes.

The region above described constitutes the glaciated portion of that section of the Highlands which we described as the Alamuche-Pohatcong range in the physical description of the State, Vol. I., 1888.

Continuing westerly, we cross the Pequest meadows, which are not strictly a part of the Highlands but lie within the district. They contain much heavy timber, all deciduous, and of many varieties, but some of the best has been cut during the building of the Lehigh and Hudson River railroad, and since that time. On Mount Mohepinoke, west of Townsbury, less than half the area is forested. The timber varies from 2 to 14 inches in diameter and from 15 to 50 feet in height, being generally good timber and containing some large trees, from 14 to 24 inches in diameter, and 35 to 60 feet high. The undergrowth is quite thick, and there are red cedars near Townsbury on some abandoned pasture and stump land. Near Pequest mines some large sumac was noted, 2 to 4 inches in diameter and 10 to 20 feet in height. On Jenny Jump mountain there has also been some recent cutting of timber about the old silver mine. The best growth is on the main ridge of the mountain, and it includes some hemlock. The timber on the foot of the hills, especially on the limestone, is inferior. A chestnut tree, 70 years old, measured 5 feet in diameter at the stump, but was rotten at the heart. About the foot of the mountain, in the valley, oak, chestnut, cedar, ash and poplar were observed. At Southtown some large sumac was noted, measuring from 2 to 6 inches in diameter and 10 to 25 feet in height. Just north of Shiloh, at the foot of the mountain, there is a locust grove covering about one and one-half acres, the origin of which was not ascertained. Southward from Shiloh chestnut and oak prevail, ranging from 2 to 16 inches in diameter and 10 to 45 feet in height, with some good timber near the Hope and Danville road. Southward from this highway, to where the road crosses to Green's pond, there has been much cutting within 15 years and the timber is now poor in quality. Just south of Kishpaugh mine a chestnut stump showed 100 rings, and measured 36 inches in diameter. One ring was observed measuring one-half inch in thickness. On the south end of Jenny Jump mountain the timber is quite good, ranging from 6 to 18 inches in diameter, and 25 to 50 feet in height. There has also been some cutting here within 15 years. At the outlet of Green's pond there is a tamarack swamp quite heavily timbered. Generally over this region of Jenny Jump mountain and Mount Mohepinoke the steeper slopes are wooded, but some of the gentler slopes have been cleared and are cultivated without suffering from wash. It is generally the fact that there is little or no evidence of wash where the Highlands ridges are deforested on the slope, although it is true that almost invariably the steeper slopes are well wooded. There is much more wash on the slate ridges, showing that it is largely due to the nature of the soil.

Mr. L. V. Williams, of Danville, speaking of this region, thinks that on an average timber is worth $20 per acre, and most of the mountains have a growth ranging from 12 to 18 inches in diameter, with chestnut predominating, but there is also a good deal of oak, especially rock oak, on the ridges. He thinks the tendency is for chestnut to increase and oak to grow scarcer, because the chestnut sprouts grow more rapidly and crowd out the oak. He considers the growth now much better than it was 30 years ago, as it is allowed to stand longer before cutting. Good poplar is growing scarce. Each succeeding growth of chestnut appears to be thrifty. The growth is better on the south and east sides of the hills, although this is not so noticeable when the soil is good. On the Jenny Jump mountain district there seems to be a deterioration in the cleared lands, but elsewhere they are well kept up.

The timber in the Pequest valley, from Danville to Bridgeville, contains maple, elm, oak, hickory, and a little hemlock and spruce. Mr. Williams, before quoted, says that 15 years ago he cut off a piece of timber near Townsbury, consisting principally of oak, and since then nothing had grown there but red cedar.

The plateau bounded by Bearfort mountain, the New York line, Vernon valley, and the New York, Susquehanna and Western railroad, has about 80 per cent. of its area in timber, consisting mainly of oak and chestnut, a considerable portion of which is from 35 to 40 years old, and only a few acres older, the remainder being younger, ranging down to 5 or 10 years. The growth from 30 to 40 years old ranges from 6 to 10 inches in diameter, and from 35 to 45 feet in height. The more accessible portion of the timber is said to be cut at 20 years. Timber is believed to grow as rapidly as in earlier years. The only wastefulness apparent in cutting comes from the tendency to cut at too early an age, and this practice seems to be just about at the point of reform, owing to a change in demand for hoop-poles and cordwood, so that there is likelihood of future improvement. The swamp areas indicated on the topographical maps on this plateau are generally wooded with maple, beech, elm, and occasionally with scattered pines, larches and white cedar. A dense growth of rhododendron makes some of the swamps very dark and almost impenetrable. Forest fires sometime give trouble, and a large area east of Canistear, near Bearfort mountain, was burned over during this year. On this same plateau, southwest of the railroad at Stockholm, the condition of the timber is quite similar to what we have already described for the first two or three miles, but farther southwest the timber is older and larger. Chestnut is said to generally succeed all other growth, accompanied by a considerable percentage of oak. Pine is said to have been succeeded by oak and chestnut. The eastern slopes of the hills are thought to produce the best timber, especially near the foot, while the extreme tops also often produce good timber. This is attributed to greater depth of soil.

Pochuck mountain, lying just west of this plateau, does not differ from it materially, excepting that there is more hemlock and a somewhat thriftier growth. It is also not quite so densely wooded. Over the cleared portions the scattered growth is usually oak and chestnut, with some red cedar, maple, black walnut, &c. All these trees are of good size, the cedars from 8 to 12 inches in diameter and 40 feet high, and the other varieties from 12 to 24 inches in diameter and averaging about 45 feet high.

In noting large trees, here as elsewhere, no attempt was made to include them all, the purpose being rather to indicate about what could be seen in passing over the country, and the capacity of the soil to produce good timber. Four chestnuts were noted, ranging from 42 to 60 inches in diameter, and from 40 to 60 feet high, mostly near Stockholm and along the road to Vernon. The following oaks were also seen on Pochuck mountain: One, one-quarter mile west of Sand Hills, 48 inches in diameter and 60 feet high; another, one mile north, 36 inches by 60 feet, the spread of branches being 40 feet. In Vernon, there is one 42 inches in diameter by 50 feet high, and 3 miles north of Stockholm another oak was seen 30 inches in diameter by 45 feet high. An elm, one mile north of Stockholm, measured 30 inches by 50 feet, and another, northwest of Vernon, 30 inches by 60 feet. A maple was seen on Pochuck mountain 36 inches by 70 feet; two, east of McAfee, in the valley, about 30 inches by 50 feet; two, south of Vernon, about half way to Stockholm, about 48 inches in diameter by 50 and 60 feet high. Black walnuts were noted as follows: One, one-half mile east of Vernon, along the valley road, 36 inches by 50 feet, said to be one of the original forest trees. At McAfee, there is one 66 inches by 85 feet. On the side of the mountain, southeast of McAfee, there is an apple tree measuring 36 inches in diameter by 45 feet high, which is said to be the largest in Sussex county. Two miles southwest of Vernon, on the road to Stockholm, an oak and a walnut have grown together. At the base their combined diameters are 48 inches; above the junction each is about 24 inches in diameter.

The following was obtained as average values of timber near Stockholm: Stump land, $2; 20-years' growth, $7; 30-years' growth, $10; heavy chestnut or mixed oak and chestnut, $80. Heavy oak is said to be extremely scarce, but is quoted at from $60 to $100 per acre. At Vernon, stump land, $2; 20-years' growth, $7; 30-

years' growth, $12; heavy chestnut or mixed oak and chestnut, $80. There is said to be very little valuable pine. At McAfee, stump land, $3; 20 years' growth, $7; 30 years' growth, $10; heavy chestnut and oak, $75 to $80. At Canistear, stump land, $3; 20-years' growth, $10; 30-years' growth, $15; heavy chestnut, $60.

We shall next take up the balance of the glaciated portion of the central highland plateau which lies between Longwood and German valleys on the east, and the valleys of the Wallkill, Lubber's run and the Musconetcong on the west. Northeast of the Sparta turnpike, connecting Sparta and Dover, it is very generally forested, probably less than 10 per cent. of the whole being under cultivation. Along the western slope, between Hardistonville and Sparta, the growth is mixed, deciduous and coniferous, the latter being much the larger, from 10 to 20 inches in diameter and 40 feet high. On the top of the mountain, just east of Franklin Furnace, about Two Bridges, the growth is young, but little being even large enough for cordwood, and very little as much as 30 years old. Thence along the top of the mountain to Ogden mines, the timber is mainly deciduous, and from general report, practically all of the timber has been cut once since the period of charcoal forges. About Ogden mines there is some older growth, but all the larger trees are cut out, the stumps averaging 40 years old, and a single one running as high as 53 years. Between Morris pond and the road to Ogden Mines the growth is from 2 to 6 inches in diameter and 15 to 20 feet high, and about 12 years old. Between Ogden Mines and Hopewell, down to the Sparta and Milton highway, we noted stumps which indicated the growth there to be from 34 to 40 years old. Generally it appeared to be from 4 to 8 inches in diameter and 20 to 30 feet high, but a few trees 16 inches in diameter and 50 feet high were noted. The growth is all deciduous. The north slope of Bowling Green mountain, and westward beyond the Ogden mines railroad, has a growth from 34 to 44 years old; one oak stump was noted 47 years old and 10 inches in diameter. On the top of the ridges hereabout the growth is from 2 to 8 inches in diameter and from 20 to 30 feet high, but where there is more soil the trees are from 4 to 14 inches in diameter and about 40 feet high. Between Morris pond and Hurdtown, west of the railroad, the timber is deciduous, with a few scattering pines, and it is generally small with some stump land, some 5 years' growth. The different tracts ranged from 2 to 5 inches in diameter and 20 feet high, from 6 to 12 inches in diameter and 35 to 45 feet high, from 6 to 24 inches in diameter and 55 feet high, but trees 24 inches in diameter are very scarce. The best wood in this section is along the road from Woodport to Schofield mine, and is from 6 to 15 inches in diameter and 60 feet high, most of the trees being of the larger size, but the portion of this near the railroad is now being cut. The timber on the top of Bowling Green mountain is also good, from 6 to 14 inches in diameter and 40 to 55 feet high, the larger sizes predominating. This has also been cut in places. The west slope of Longwood valley was cut about 12 years ago; there are a few coniferous trees, spruces, pines and red cedar.

West of Woodport, between the head of Lake Hopatcong and the head of Lubber's run, the country is well wooded with oak and chestnut and scattering conifers. About Henderson cove, on the lake, there are scattering white pines and hemlocks. Excepting toward Bear ponds, where it is about 10 years old, the growth ranges from 6 to 24 inches in diameter and 30 to 60 feet high, most of the trees being from 8 to 14 inches, but occasionally one is found 36 inches in diameter. There is exceedingly little cleared land in this tract.

Between Lake Hopatcong and the valley of Lubber's run, from Byram cove to Stanhope, the country is almost entirely wooded. About Bear ponds there is much young growth from 6 to 15 years old, with better timber along the lake about Byram cove and Davis cove, ranging from 2 to 8 inches in diameter and from 20 to 35 feet high. From the River Styx to Brooklyn, it ranges from 6 to 14 inches in diameter, from 30 to 50 feet high and is entirely deciduous. Along the highway from Roseville to Stanhope reservoir, across the mountain, the timber is still better, while along the Musconetcong river, from Stanhope to Old Andover, it is large, ranging from 10 to 24 inches in diameter and 40 to 60 feet high, with quite a number of hemlocks. There seems to be a general absence of coniferous trees near Lake Hopatcong, but they are much more prevalent toward the valley of Lubber's run. It was noted that generally, throughout this western portion of the Highlands, there was very little evidence of bad effects from deforestation, even where the slopes are cleared and cultivated they do not seem to be inclined to wash as a rule. This is probably largely due to the nature of the soil. It was also noted that while many of the small buildings are allowed to go down, the land cleared is as well cultivated as 15 years ago, when the topographical survey was made. There is practically no change in the location or extent of the forested areas. There was some exception to this state of things noted in the valley of Lubber's run, throughout which the farm lands seemed to be not so well cultivated, and showed signs of lapsing back into forest. Throughout the hill region chestnut and oak predominate, but in places there is a great deal of hickory. The better timber seems to sell at from $40 to $60 per acre.

Taking next the plateau east of Lake Hopatcong over to Longwood valley, we find, between Hurdtown and Lower Longwood, timber generally from 6 to 12 inches in diameter and 25 to 40 feet high, with some portions smaller. Near the Dover and Sparta turnpike the timber becomes somewhat better, ranging from 6 to 18 inches in diameter and 35 to 50 feet in height. On the end of the ridge east of Woodport, and near the lake, there are several white pines. Following down the turnpike toward Longwood valley, the growth becomes smaller again. Along the western slope of Longwood valley, from Lower Longwood toward Berkshire valley, a fire has extended about 1½ miles through young growth from 2 to 4 inches in diameter, all of which is dead. Further southwest, the timber ranges from 4 to 12 inches in diameter and 25 to 40 feet high. There is some coniferous growth, mainly spruce and hemlock. Continuing southwest from Berkshire valley, on the road to Davenport mine, it was noticed that some large oaks had been cut, ranging from 91 to 99 years old, and from 21 to 31 inches in diameter. From Davenport mine to Hopatcong, the timber ranges generally from 6 to 24 inches in diameter and 25 to 60 feet high. At one place all trees large enough for railroad ties had been taken out. Southwest of Lake Hopatcong branch of the Central railroad, over to the Delaware, Lackawanna and Western railroad, the timber is generally from 6 to 12 inches in diameter and 20 to 60 feet high, but there is some smaller growth only about 2 inches in diameter.

The age and diameter of a number of stumps in this region east of Lake Hopatcong were recorded, and become an index of the rate of growth of the timber. I give following, first the age, and then the diameter for different kinds of timber: Chestnut, 93 years, 32 inches; 89 years, 13 inches; 60 years, 14 inches; 43 years, 12 inches; 33 years, 9 inches. Oak, 99 years, 24 inches; 98 years, 31 inches and 21 inches; 95 years, 24 inches; 94 years, 27 inches and 24 inches; 79 years, 14 inches; 78 years, 13 inches; 37 years, 9 inches; 33 years, 9, 11 and 14 inches; 32 years, 13½ inches; 30 years, 13 inches. Maple, 33 years, 14 inches. It was noted that several trees from 74 to 89 years old had apparently grown rapidly and uniformly until 30 years old, then very slowly for 10 years, but after that more rapidly again.

There is a general improvement in the cleared land and buildings in the neighborhood of the line of the Ogden Mine railroad. This is, no doubt, partly due to better railroad facilities since this railroad was connected with the Central railroad of New Jersey, and partly to the recent extensive operations at Ogden mine. Notwithstanding this improvement, however, little land has been cleared for cultivation, but the old clearings are better cultivated and cared for. Along the east shore of Lake Hopatcong there has been a considerable development as a summer resort, but this has not been attended by much clearing off of forests, the trees being preserved so far as possible.

From interviews with Mr. Titman, of Sparta, and others, it was learned that the greatest damage to forests in this vicinity comes from fires and cattle, the latter browsing off the young growth, or breaking it down. It is said that a fire which causes no great apparent damage at the time will cause the timber later on to decay at the heart. There seems to be very little wood in this district over 40 years old taken as a forest, although there are scattering trees very much older. As a rule the timber grows slower on the west and north slopes of the hills. The growth also varies with the character of the soil, and where the latter is very thin in certain instances a 40-years' growth has not attained sufficient size to be of any use, even for cordwood. Mr. Decker, who formerly ran a forge at Sparta, says that he shut his works down in 1865. He also says that when forges were running throughout this section, wood was often cut when 15 years old for coaling. Sprouts now come up quickly, and appear to be thrifty, but he thinks that if fires continue they will cause a deterioration in the forests. He also says that hemlock is usually left standing when the other timber is cut off, as it does not pay to get it out if at all inaccessible. This fact accounts for the larger size of most of the coniferous growth standing throughout this part of the State.

On Bearfort mountain timber has suffered much from fires. In

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1882, during the prosecution of the topographic survey of that section, a fire ran over a large area south of the road from Greenwood lake to Wawayanda, and this fire did injury from which the forests have not yet recovered. A fire in 1891 ran over most of the mountain tops from the State line to Cedar lake. The timber is generally, both on account of these fires and the thinness or entire absence of soil over much of the mountain, scattering and of little value on the high ridges, but owing to its inaccessibility there has always remained a considerable amount of original forest, and in 1882 there was some quite heavy timber in the ravines, notably in the one heading at the westernmost of the two small ponds near the State line. This ravine was then heavily timbered, and travel through it was difficult, owing to fallen tree trunks. It was a good example of virgin forest. But, generally speaking, over the mountain tops the growth is scattering and inferior, which condition has been much aggravated by the recent fires referred to. There is a good deal of the common pine and some hemlock scattered over the mountain. The best timber is along the eastern slope, although this is all second growth; but the present growth is from 30 to 40 years, 8 to 10 inches in diameter, and 40 to 45 feet high. It is mainly oak and chestnut and scattering pine and hemlock.

Green Pond and Copperas mountains are mainly covered with a 40-years' growth of oak and chestnut, rather sparse and poor on the top and eastern face, where the soil is thin, but fairly good on the western slopes, being there generally from 8 to 12 inches in diameter and 35 to 45 feet high. As on Bearfort mountain there is a sprinkling of common pine. Some lots, aggregating perhaps 150 acres, have been cut off within from 10 to 15 years, but the remainder, if recently cut at all, has been only thinned out.

The west slope of Green Pond mountain has deciduous and coniferous trees in nearly equal amounts, consisting mainly of oak and chestnut from 4 to 10 inches in diameter and 30 feet high, or spruce and hemlock 6 to 12 inches in diameter and 50 feet high. The east side of the mountain has timber of the same general character, but more thrifty, while the flat top has a scattering growth of common pines, interspersed with scrub oak. It is noticeable that the coniferous growth disappears on this mountain, south of the highway from Middle Forge to Berkshire valley, and the deciduous growth begins, at from 4 to 14 inches in diameter and 20 to 45 feet high, deteriorating southwest, and ending in brush and scrub oak in the district north of Kenvil. Scrub oak prevails over the entire Bearfort and Green Pond mountain district, especially on the top of these ridges and on the sands which accompany this formation west of Clinton and on Succasunny plains.

The valley at Milton and Oak Ridge contains most of the cultivated land of this region, but about one-third of its area is in timber, mainly oak and chestnut of all ages from 15 to 60 years, with a little pine along the road south of Clinton, and some maple and other soft woods in the low grounds. It is noticeable that all the principal slopes about this valley, and generally on the upper Pequannock water-shed, are well timbered. The valley has a considerable number of scattered trees over its cultivated portion, mostly from 8 to 12 inches in diameter and 40 to 50 feet high. The large trees noted were a black walnut, three-quarters of a mile west of Milton, 30 inches by 50 feet; a red oak, one-quarter of a mile north of the same place, 36 inches by 40 feet, and another, near Upper Longwood, 60 inches by 60 feet. From Petersburg to Upper Longwood, along the road, there are from 20 to 30 oaks and maples, ranging from 12 to 24 inches in diameter and averaging 45 feet high. A maple east of Oak Ridge measures 36 inches in diameter by 50 feet high.

The portion of the Highlands lying between the valley running from Greenwood lake to Newfoundland, and Wanaque and Passaic valleys, was designated the Passaic range in the "Physical Description." A portion of this, north of Pequannock river, has 75 per cent. of its area in forest, the central belt of the range being almost unbroken by clearings. In the northern part there is a considerable amount of oak and chestnut, from 30 to 40 years old, including, perhaps, one-quarter of the whole region, while another large tract appears to exceed 45 years in age, all the more accessible portions near Wanaque valley and the Pequannock being young growth of all ages from 3 to 5 years and upward, with very little stump land and no new clearing. It is evident that the practice of cutting at 20 years or younger has prevailed for several years along the lower Pequannock, and it would appear that the forest has suffered injury in consequence. This young timber seems to have been mainly cut for charcoal, firewood, hoop-poles, &c. While the timber is mostly oak and chestnut, there is some pine and hemlock between Macopin and West Milford, also red cedar in old pastures, and some white cedar south of Greenwood lake. The only portion of consequence which seems to have suffered from fire is an area of perhaps 150 acres along the Greenwood Lake railroad, just east of the lake. Most of the eastern part of this section is owned by Cooper & Hewitt, being a part of the Ringwood tract, and the forests of this part seem to be steadily improving. There is some new cutting about Hewitt, two or three hundred acres of stump and brush land being noted, and also some considerable areas of young growth of all ages.

Continuing along the Passaic range, southwesterly from the Pequannock river, to the moraine line at Denville and Dover, chestnut and oak still prevail, with some hickory, and many other kinds of timber distributed throughout. For the most part, it is from 30 to 40 years old, and some scattering parcels much younger between Charlottesburg and Marcella, and also between Bloomingdale and Brook valley. This younger portion is considerably mixed with cedar, white birch, &c. There is very little brush or stump land to be seen, and very little timber less than 10 years old. A tract of several thousand acres is now held as a private preserve about Stickle pond, and its forests are likely to be cared for.

The clearings in this district are almost entirely confined to the valleys of Green Pond brook, Beach Glen, Stony brook and the Rockaway river. The high lands are almost entirely covered with forest, the area of which amounts to some 75 per cent. of the whole district. The cleared portions are almost entirely grass lands. The population is decreasing, but there does not appear to be any considerable amount of cleared land which shows signs of lapsing back into forest. Between Rockaway and Mount Hope the timber is oak and chestnut ranging from 4 to 24 inches in diameter. Between Mount Hope, Hibernia and Denmark the timber ranges from 35 to 50 years old, and cutting appears to be more by culling out the best trees than by clearing off the entire tract, the smaller growth being preserved. West of Rockaway there is thrifty timber from 8 to 12 inches in diameter and 40 to 60 feet high, said to be about 60 years old. The timber continues to be excellent to and about Mount Pleasant mine. About Baker and Richards mines it is apparently as old, but the best has been culled out. Still, it continues to be fair on over to the valley of Green Pond brook. On the mountains, between Rockaway and Hibernia, the timber ranges from about 40 years old, near Beach Glen valley, to 60 years old further west. Some portions have been recently cut, and some are from 10 to 20 years old. But generally the range is from 6 to 20 inches in diameter and from 30 to 60 feet in height. It is mainly oak and chestnut, with a few white pines and other conifers on the top and the more rocky slopes. Between Beach Glen and Meriden, it ranges from 12 to 34 inches in diameter and 50 to 60 feet in height, with a few coniferous trees as before. South and west of Split Rock, the oak and chestnut range from 7 to 35 inches in diameter and 30 to 45 feet in height. It is said that the last cutting about Split Rock for the use of the furnace was some 30 years ago. Further toward Marcella, oak and hickory were noted 10 inches in diameter and 55 feet high, while along the Marcella and Hibernia road the oldest timber is 45 years old, but there has been some recent cutting, and there are some tracts of younger timber.

From Beach Glen, eastward to the Morris canal, the country is best known by Mr. W. K. Clarke, of Rockaway. He says the last cutting for iron furnaces and forges in this district was done 40 years ago, although a trifling amount has been done since. He believes that after the forests here are cut two or three times more the growth will become stunted and worthless, and there will be a necessity for reseeding. He mentions a 10-acre tract on his property where, in 1838, his father raised a crop of buckwheat. It was then abandoned and oak and chestnut came up. The timber was cut off in 1866, the 10 acres yielding 200 cords of wood. In 1883 it was cut again, yielding from 12 to 15 cords per acre, and now, in 1895, the growth averages 4 inches in diameter and 25 feet high. He thinks the best growth is on the east and south slopes of the hills.

The district which we are describing has generally a growth of from 4 to 16 inches in diameter and 35 to 45 feet high. There are a few coniferous trees, principally white pine, the largest of which was 2 feet in diameter and 60 feet high, and about this tree there were a great many small pines, some 20 feet high, apparently sprung from the seed of the large tree.

North and northeast of Boonton, the mountains appear to have been cut off from 30 to 50 years ago, and are now beginning to yield good timber again. Some of the cleared land in this vicinity begins to grow up with red cedar. About Taylorville, it is said that the timber was cut about 30 years ago for the use of the forges. Mr. Ezekiel Earle, of Lyonsville, furnished the following interesting facts as to this region: Last winter he cut a tract on the hill north of Dixon's pond, the timber of which was 60 years old and which yielded 50 cords per acre. He has some chestnut and oak timber which he has trimmed out and taken care of, and he believes it will yield one-third more wood per acre than other wood of the same kind and similarly located, which has been allowed to grow up in the usual way. His experience is that wood will usually yield one cord per acre for each year that it has been growing. He complains that the timber rots more at the heart now than formerly, and says this applies only to that which has sprouted up from the stump. The seedling trees are much thriftier and straighter than the sprouts. Just east of his home he has a tract of chestnut which has fine timber. The trees are about 45 years old, from 8 to 18 inches in diameter and 40 to 50 feet high. He says the seedling trees in this growth can be picked out with no difficulty. He says the continued cutting and lack of care is injuring the growth from the stump, and believes that the timber will deteriorate from this cause. He mentions a tract which was cut by his father, and which he believes was original forest. Since then it has been cut once more, about 20 years ago, and has never been more than brush since that cutting. He also stated that Andrew Cobb, who owned the forges at Split Rock, used to say that wood was most profitable for coaling when cut every 20 years. The opinion is general hereabout, as elsewhere in the northern part of the State, that the timber is better cut at from 30 to 35 years old than at 50 years, being sounder.

Mr. C. B. Dickerson, of Denville, who has much experience, furnishes the following facts: He is now cutting a tract of 100 acres, for which he paid $50 per acre, including timber and land, the timber being about 60 years old. So far as the young growth is concerned, he thinks it makes no difference whether timber is cut in February or August. He believes the forests in this section are now in better condition than they were 25 or 30 years ago, as they were then cut much younger, owing to the demand of forges, railroads, limekilns, &c., and later the hoop-pole industry. He says the second growth of timber is stronger, thriftier and thicker than the original, and each succeeding growth appears to improve. Timber ought to be cut at from 30 to 40 years old, as after that it begins to rot at the heart, and the older stumps do not send out as many or as thrifty sprouts as the younger. He says, also, that cordwood costs 60 cents to cut, $1.00 for cartage, $1.50 for freight, and, allowing 15 cents for waste, this makes the total $3.25, whereas the market price ranges from $3.00 to $4.00 per cord.

Near Taylorville, some wood 12 years old was recently cut, and the larger trees were decayed at the heart. It is also stated that timber growing rather thin on the ground is better in quality than where it stands too close together, and that it should be trimmed out when about 3 years old, leaving the healthier sprouts to grow. The general trend of opinion seems to be that the rotting at the heart indicates the necessity of reseeding.

On this northeastern portion of the Highlands all of the steeper slopes are well forested, excepting a few which are rocky and will not support any growth. The cleared land is almost entirely confined to the bottom of the valleys, which are usually rather flat. The cleared portions are not highly cultivated, consisting largely of grass land. The water-sheds of the Ramapo, Wanaque, Pequannock and Rockaway lie almost entirely upon this glaciated Highland district, and to this fact is due their peculiar excellence as sources of water-supply for our cities. The foregoing description gives as good an idea of the forest conditions of these water-sheds as could be given by a separate description for each stream.

In Wanaque valley, although the timber is more interspersed with clearings, it does not differ from that already described, excepting that there is more red cedar, which is probably due to the fact that the land has been some time cleared.

Ramapo mountain is practically an unbroken forest, mainly oak and chestnut. The main ridge from Negro pond, south to the highway crossing from Midvale, is covered with a good growth of perhaps 30 to 40 years old, and most of the flatter portions of the mountain are likewise well timbered. Perhaps one-third to one-half of the slopes are not so well timbered, owing to thinness of soil. The southern end of the mountain is mostly covered with quite young timber and brush, and the timber on most of the more accessible parts has been cut within 20 years.

Generally, the Passaic range of the Highlands and Ramapo mountain are more lightly wooded, and the timber has been more severely cut during the last 20 years than on the Central Highland plateau westward. The proportion of forested area to the whole is about the same. In this part of the Highlands it is thought, generally, that the timber grows as vigorously as in former years, and it is asserted that a 30-years' growth will yield as much wood per acre as the original forest. Some of the best timber here is on the slopes, but on the other hand more slopes have thin soil and there are more bare rock ledges than on the central plateau, and these have only a stunted growth or none, although they do not exceed probably one-third of the entire slope area. Flat hill-tops and ravines are well timbered as a rule, although some ridges are quite bare of soil on the top, and the forest is correspondingly poor.

The larger trees noted were two hemlocks, one mile southwest of West Milford, which measured 30 and 36 inches in diameter and about 60 feet high; a red oak at the same place measured 42 inches by 40 feet; an oak one mile north measured 54 inches by 70 feet, and another, one and one-quarter miles north, 42 inches by 45 feet, being a very beautiful tree. Near the same place we observed two chestnuts 42 inches in diameter and 40 and 60 feet high; a maple 42 inches by 80 feet; another, in a swamp, 48 inches by 70 feet; an elm 30 inches by 75 feet, with a beautiful spread of weeping branches. A chestnut near by measured 36 inches by 50 feet, and one at Midvale 54 inches by 50 feet; a pine at Wanaque measured 30 inches by 50 feet. No very large trees were observed on the high part of the Passaic range.

Not much reliable data could be had as to values. In the vicinity of Greenwood lake estimates ranged about as follows: Stump land, $5; 20-years' growth, $20; 30-years' growth, $30. At Midvale, stump land, $5; 20-years' growth, $10 to $20; 30-years' growth, $15 to $25; large oak and chestnut, $60 to $80 per acre.

We have noticed that a large amount of Highland forest ranges from 30 to 40 years old, and only a very small amount exceeds 45 years. All recent cutting also seems to have been of timber about 30 years old or younger. It would appear that much of the forest now standing, or which has been cut in recent years, dates from about 1850. Up to about that date there was a very large consumption of timber for charcoal to supply forges and furnaces, as well as for other kinds of fuel. Recently the cutting of timber less than 20 years old appears to have been somewhat checked. Most of this young timber was cut for charcoal, fuel and hoop-poles. The reason for this check is mainly to be found in the lessened demand or lower prices for these products. The evidence which we have collected seems to indicate that the best results are obtained by cutting at an age of 30 or 35 years. Chestnut, particularly, does not grow so thriftily after this age. A potent factor in checking this cutting of young timber is the tendency now prevailing to acquire large holdings of these northern Highlands. This movement is rapidly under way, and will undoubtedly result in a marked improvement in the condition of the forests during the next 20 years. At Wawayanda lake one owner holds 3,000 acres, and on Bearfort mountain an iron company holds 2,000 acres. At Cedar lake a club holds a large tract as a game preserve. At Ringwood the property of Cooper & Hewitt embraces a large extent of territory. At Stickle pond a private owner has acquired an extensive preserve. Thus private enterprise seems to promise the solution of the forest question in this portion of the State. As most of this land is entirely unfit for cultivation, and should always remain in forest in order to maintain the steady flow of the streams, as well as for other economic reasons, not to speak of the æsthetic, it is a matter for congratulation that such a movement has set in.

FORESTS OF THE SOUTHWESTERN HIGHLANDS.

The line of the terminal moraine, which subdivides the Highlands, crosses from Denville through Dover, Drakesville, the north end of Budd's lake, a point about one mile north of Hackettstown, through Townsbury to the Delaware at Belvidere. The unglaciated portion southwest of the moraine is, as we remarked, much better adapted to agriculture, so that generally speaking the Archæan plateaus and ridges have fully half their surfaces cleared and under cultivation, while the rather broad intervening valleys, which are on the slate and limestone, are almost entirely deforested and under a high state of cultivation.

Beginning at the northwest side as before, we have first the upper Pohatcong mountain lying between the Musconetcong and Pequest valleys. We have previously considered the glaciated portion northwest of the Hackettstown and Vienna highway. Southwestward the mountain is about half forested, the slopes especially being well covered, while the head of Pohatcong valley is deforested. The slope of the mountain, toward Musconetcong valley, is followed by the Morris canal, to which fact may be due the recent cutting which probably includes 60 per cent. of the timber, within 15 years, and much of this has been cut within 5 years. The better growth standing ranges from 8 to 20 inches in diameter and 30 to 50 feet high. This larger growth prevails over the top of the mountain, where there has been much less cutting. On Furnace mountain, which includes the portion west of the head of Pohatcong valley, the timber ranges from 6 to 24 inches in diameter and 25 to 55 feet in height. Here, also, there has been some recent cutting. The timber is principally chestnut, with a good deal of oak, but we also find maple, birch, beech, poplar, ash, butternut, &c. There is no washing noticeable on the mountain slope, but there is some in Pohatcong valley, especially in the peach orchards and other areas which are not kept in grass or grain.

Just southwest is Scott's mountain, which includes some 40 square miles of plateau, surrounded by deforested valleys of slate and limestone. About one-half of the surface of the mountain is forested, including all the steeper slopes. North of the highway, from Oxford Furnace to Belvidere, the growth is deciduous; oak, chestnut and hickory, with the usual scattering birch, beech, maple, elm, poplar and ash. The best timber is from 8 to 24 inches in diameter and 30 to 55 feet in height, which includes about three-quarters of the whole, the remaining one-quarter having been cut within 10 years. There is a little hemlock near Oxford church. The southeast slope of Scott's mountain, which is also followed by the Morris canal, contains timber from 6 to 18 inches in diameter and 25 to 45 feet high, some of which has been cut within 15 years. On the western slope, toward the Delaware, there has also been some cutting, and in general the best timber is on the top of the plateau, ranging from 8 to 20 inches in diameter and 25 to 50 feet high, mainly of chestnut, oak and hickory, with the other varieties previously mentioned. There is a little cutting, but less than on the slopes. Such slopes as are cleared show no evidence of washing. The most accessible clearings are generally well cultivated. Those less easily reached show a few signs of deterioration.

The valley of the Delaware, westward, is almost entirely deforested, but the few scattered clumps of timber are good. The bluff along the river contains considerable hemlock.

The Pohatcong valley, eastward, including the broad stretch of level country at the south end of Scott's mountain, reaching over to the Delaware river, is entirely deforested, there being a lack even of scattering trees, which makes this territory seem more bare than any other in Northern New Jersey. What little timber there is is confined to the bluff along the Delaware, and consists of a few larger trees from 10 to 13 inches in diameter and 30 to 45 feet in height, interspersed with a good deal of brush. We find here hickory, butternut, beech, oak, elm, birch and a little chestnut and hemlock.

Pohatcong mountain is a narrow ridge extending from Washington southwest to the Delaware river. It has some timber along its slopes, mainly oak, hickory and chestnut, with the other varieties which we have previously named interspersed, and also some clumps of common pine north of Asbury. The north end of the ridge has a medium growth from 4 to 6 inches in diameter, and some of the pasture is growing up to red cedar. A 50-acre lot was noticed on the northwest slope which has been cut within 7 years, and which shows almost no new growth since. The timber seems to have been principally oak. The timber is better as we proceed towards Bloomsbury, ranging from 10 to 30 inches in diameter and 30 to 55 feet in height, but the tracts are small. The best has been, or is now being cut. Just southwest of the Lehigh Valley railroad there is a piece of chestnut, oak and hickory which is better, ranging from 6 to 14 inches in diameter and 25 to 45 feet high. Thence to the Delaware it ranges from 8 to 24 inches in diameter and 30 to 50 feet high, but nearly all has been cut within 10 years, and the best of the remaining is now being cut out. On the ridge near Bloomsbury, oak stumps were noted as follows: 150 years old, 28 inches in diameter; 125 years old, from 21 to 29 inches, and 118 years, 25 inches.

The Musconetcong valley, southwestward from the crossing of the moraine, is generally deforested, but not quite so bare of timber as the Pohatcong valley previously described. The underlying rock of the valley is either slate or limestone, and its surface is highly cultivated. The slopes in the valley show considerable erosion from water, and it would seem that the steeper ones might well be re-forested, but, as a whole, the country is too fertile to be kept in forest.

Schooley's mountain is crossed by the moraine from Drakesville by the north end of Budd's lake to a point about one mile north of Hackettstown, and this northern drift-covered portion presents a marked contrast to that south of the moraine. It is not only more generally forested but its clearings are neglected, buildings and fences are falling down, and it is deteriorating into a wilderness, whereas, just southwest the clearings are in a high state of cultivation. The timber over this drift-covered area is generally from 6 to 12 inches in diameter, with some better, ranging from 8 to 24 inches in diameter and 30 to 55 feet high, but there is also a considerable proportion of small and inferior growth. There appears to have been a good deal of cutting done 10 or 15 years ago, but not so much recently. The timber is mainly chestnut and oak, but includes a wide range of other varieties. In the swamp west of Budd's lake there are a few tamaracks.

Southwest of the moraine line about 50 per cent. of the surface of the mountain, including the more level portions, is cleared and well cultivated. North of Drakestown the timber ranges from 6 to 16 inches in diameter and 30 to 50 feet high, and from Drakestown to Schooley's Mountain springs, from 6 to 24 inches in diameter and 20 to 55 feet high, but about half of this has been cut within 10 years, although there remains some very good timber. Around Mount Olive the growth varies from 8 to 20 inches in diameter and 30 to 55 feet in height, but there is some smaller growth interspersed. Along the east face of the mountain it runs from about 6 to 14 inches in diameter and 25 to 45 feet high, and there is a little cutting at present, while considerable has been cut from 5 to 10 years ago. There is not a great deal left here which is large enough for profitable cutting. Along the western slope, from Beattystown to Pennville, the timber is good, ranging from 6 to 16 inches in diameter and 30 to 55 feet high, some of which has been, and is now being cut. It is principally chestnut and oak, mixed with other deciduous trees. From Pennville to Changewater the growth is quite good, and about the same size as above, but from Changewater to Junction it is light, and ranges mostly from 6 to 18 inches in diameter and 30 to 45 feet in height, with a few larger trees. This slope of the mountain has washed considerable in places, and especially where there are peach orchards, the wash being much less when kept in grass. Taking this southern part of the mountain, from Schooley's Mountain post-office to the New Jersey Central railroad, the cutting within 5 years has been very severe, and all the heavier timber is being rapidly taken out. This is more the case than on any other part of the Highlands. Along the south branch of the Raritan all the old timber is cut, and when the lots now being cut are taken off there will be nothing left but timber too young to be of any use. The farms in this section appear to be well kept up. Near Pleasant Grove an oak stump was noted showing 104 rings, which was 30 inches in diameter. The timber being cut on these southwestern Highlands at present is mostly worked up by steam mills into merchantable lumber of all kinds, including almost everything for which a ready sale can be found. Practically none of the area being now cut off is intended to be cultivated, but it will be allowed to grow up again in forest.

Musconetcong mountain is next, southwest. Along its western face, from Junction to West End, the average timber ranges from 4 to 8 inches in diameter and 25 to 45 feet high, of which a good deal has been cut within 10 years, and some quite recently. Some of this recent cutting seems to be followed by a poor and stunted growth, possibly due to the browsing of cattle. Around Pattenburg the chestnut and oak range from 6 to 10 inches in diameter and 30 to 50 feet high, and on the eastern slope, thence to the Central railroad, the timber is small. The best of this region is on the hills, near Glen Gardner. It is generally oak and chestnut, and other deciduous trees intermingled. The result of interviews in this region indicated that, in the first place, the timber was largely cut and coaled for the use of forges and furnaces, and then, after the Central railroad was built, there was a good demand for timber, and the forests were cut off, since which time there has been a lessened demand. The lots now being cut are those which escaped in the period following the completion of the Central railroad. It is said that chestnut grows faster than oak, although there was no complaint of deterioration of chestnut hereabout after reaching 30 years of age. There is no erosion of the slopes here, and the clearings appear to be well cultivated. Between the Lehigh Valley railroad and the road from Little York to Bloomsbury, the timber is mainly chestnut, oak and hickory, ranging, in different parts, from 4 to 8 inches in diameter and 20 to 30 feet in height, up to 18 inches in diameter and 30 to 50 feet in height. Quite a good deal has been recently cut, and a considerable area is brush. Along the Musconetcong valley slopes, above Warren paper mills, there are a few hemlocks; and on the same slope, near the West End mines, the timber ranges from 10 to 24 inches in diameter and 40 to 55 feet high. Further southwest the timber on this mountain varies a good deal, the different wood lots having been cut at widely different periods. Near Gravel hill an oak stump was noted 100 years old and averaging 32 inches in diameter. Mr. D. Harrison, of Bloomsbury, mentions a lot of 20 acres on this mountain which was cut about 12 years ago and which has grown very little since, being now only 10 or 12 feet high, although all around it the growth is good. In general, the timber grows well and quickly. Chestnut usually comes up after cutting off, and he thinks the wood grows as well as ever it did, and that the wood is now better than it was formerly, that is, it is more durable. He mentions a young chestnut pole which was cut 80 years ago and has been in use ever since, being still well preserved.

On Succasunna plains we find a good deal of scrub oak, especially just northeast of Flanders, about the sand-pits and eastward of the Morris canal to the northeast of Kenville. This seems to be on a sand belonging to the Green Pond mountain rocks, and it is said that this scrub oak has been the same for a long time. It was noticed that where these scrub oak lands had been cleared they appeared to raise good crops. Generally, there is more timber over the plains than on the other valleys of this portion of the Highlands. Quite a good many white pines were noticed near Flanders, with some young pine, and a few hemlocks. Along the south side of the road from Flanders to Succasunna the timber ranges from 10 to 15 inches in diameter and 30 to 50 feet high. In some abandoned clearings common pine is coming up. There is some tamarack in the swamp south of Drakesville, and it is also found in the swamp on Black river from Horton Station to Succasunna.

German valley is generally deforested, especially from Naughright down to Califon.

On the long, narrow ridge at the southeast side of German valley, and running from Succasunna plains to Califon, there is a considerable amount of timber on the northwest slope, mainly chestnut and oak, ranging from 4 to 18 inches in diameter and 20 to 50 feet high, and it appears to be generally attached to farms and utilized in connection therewith.

Taking now the extension of the Passaic range southwest from Dover and Denville, we find generally about one-half of the country in timber, the greatest amount of cleared land being about Mendham and on the Upper Whippany, including Morris Plains. Along the west face of the plateau from Port Oram to Ironia, timber is from

6 to 12 inches in diameter and 30 to 45 feet high, while south of Port Oram, on the hill, it is good, but rather thin. Just south of Dover there has been some clearing near the town, but otherwise the hills are covered with a good growth, principally chestnut and oak, 6 to 16 inches in diameter and 30 to 40 feet high. Elsewhere in Randolph township it usually varies from 4 to 10 inches in diameter to from 6 to 16 inches, and there has been some recent cutting, but it is not extensive. The hills between Franklin and Rockaway are timbered with a growth 40 years old or younger. Some has lately been cut off, and probably one-half is less than 20 years old. West of Franklin, on the same ridge, it is from 6 to 10 inches in diameter, and 30 to 45 feet high, mostly oak and chestnut. The timber east of Den brook, over to Morris Plains, also appears to range up to about 45 years old, something near half being of this age, and the rest generally less than 20 years old. Oak and chestnut prevail. Near Camp Tabor several large trees have recently been cut, which had stood in the open with plenty of room. They were all 35 years old, measured from 24 to 34 inches across the stump and were from 40 to 50 feet high, sound at the heart. A case was mentioned here of a wood lot, the timber of which was from 40 to 50 years old, for which an offer had been made of $100 per acre. The trees between Shongum and Morris Plains, and, generally, in this vicinity, are about 44 years, all of which range from 6 to 24 inches in diameter and from 40 to 50 feet high. There are a very few coniferous trees; mostly in the valleys and along the streams. On Trowbridge mountain, northeast of Shongum, a few acres of timber were noted, measuring from 10 to 30 inches in diameter and 60 feet high. A few red cedars were noted near Morris Plains, and also some near Shongum. The timber near Morristown seems to be older and better than it is further west. Generally, from Morristown, Mendham and Chester, on the south, to Ironia and Mount Freedom, on the north, chestnut and oak predominate, either one or the other prevailing, but there is also a good deal of hickory, with some birch, white birch, maple, elm, &c. There does not appear to be much cutting at present, but there has been a good deal 10 or 15 years ago, so that there is much timber only from 2 to 5 inches in diameter, but it runs from these sizes up to 20 inches. A fair average of the timber would be from 6 to 10 inches and 30 to 45 feet high. The steeper slopes are generally forested, and there is no evidence of washing from deforestation. On

the easterly edge of the plateau, southwest from Morristown, the timber is of the same general character as that we have already described. As this is becoming a residence district there is a tendency to preserve the timber, and most of this is of fair size and age, and there is very little cutting. Further southwest, on Mine mountain, the growth is good and thrifty, ranging from 8 to 20 inches in diameter and 30 to 55 feet high. There is but little cutting, and, what there is, is mostly for fencing. It is mainly held either in connection with farms or the country places of people from the near-by cities, and there is a general tendency to cut the wood carefully and make the most of it. Over along the north branch of the Raritan there is some good timber, but most of it runs from 4 to 6 inches in diameter and 20 to 30 feet high. It is noticed that as we approach the red shale country there is generally more hickory and less chestnut. The region between Peapack and Chester has timber running from 6 to 14 inches in diameter and 30 to 50 feet high, but not much has been recently cut. A considerable amount was taken off between 10 and 15 years ago. There is good timber on Mount Paul, ranging from 6 to 12 inches in diameter and 25 to 45 feet high, and including about half a dozen white pines. Along the Black river, from Chester to Pottersville, the best timber has been or is now being cut, and the average growth is from 2 to 10 inches in diameter and 10 to 40 feet high. There are a few hemlocks near this stream.

Passing southwest, to the Fox hill district, we still note that chestnut disappears at the edge of the red shale, while the oak and hickory is good, but only small parcels are left standing, most of the country from the foot of the Highlands being cleared. There is also a good deal of cleared land on the plateau, about Fairmount and southwesterly, but the small lots of timber left standing are generally good, ranging from 7 to 16 inches in diameter and 30 to 45 feet high. Still further southwest, about Cokesburg and toward High Bridge, there are only scattering parcels of timber left, and here, as on the south end of Schooley's mountain, what remains is being rapidly cut off. The timber continues to be mainly chestnut and oak, with the usual sprinkling of other varieties, but here also, as elsewhere, the disappearance of chestnut, when we reach the red shale country, is very marked.

It will be noticed from the foregoing detailed review and description of the Highland forests, that the severest cutting at present is to the southwest, where the proportion of forested area is the smallest. Further northeast, cutting is by no means severe, and the timber is steadily improving. It is also apparent that there is very little tendency to wastefulness, that the cutting of timber is determined entirely by the demand, and this is true not only as to the amount cut, but as to the age at which the timber is cut. In the past it was found profitable to cut timber for charcoal when 20 years old, and more recently for hoop-poles at a still earlier age, but, owing entirely to a change in the markets, this has all been altered, and the tendency at present is not to cut until the age of 30 years, or thereabout, has been reached. These facts, as to the history of the past, suggest at once that the same influences must determine how these forests shall be managed in the future. If there should come a demand which would make it profitable to cut at an earlier age than 30 years, it is difficult to see how such cutting can be prevented. It appears, however, that owners of the forest are ready for any suggestions which will enable them to derive a greater profit from their holdings, that they will not be slow to receive and take practical suggestions, or to improve on their present methods, and that a great deal can be done to aid the cause of forestry in this section of the State by instruction.

PASSAIC VALLEY.

This valley, lying between the trap ridges variously known as Watchung, or the First and Second mountains, and the eastern slope of the Highlands, is a portion of the red sandstone plain, and is all glaciated, excepting the portion lying southwest of the line of the Delaware, Lackawanna and Western railroad, between Summit and Morristown. This unglaciated portion, however, partakes to some extent of the character of the rest, rather than of the unglaciated portion of the red sandstone plain south of the trap ridges, both in the variety and the extent of its forest growth. This fact may possibly be due to the prevalence of gravel deposits traceable to Lake Passaic, which once occupied the whole valley, and partly due to a number of trap hills and ridges contained within the area, but whatever may be the cause, it is a fact that the whole valley may be classed together in relation to its forests. Generally, the percentage of forested area ranges from 20 to 40, averaging for the whole valley about 30 per cent. Pompton Plains is the most sparsely wooded section of the

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valley. Over the northern part, generally, oak from 10 to 20 inches in diameter and 60 to 80 feet high is common enough to indicate that the soil is able to produce heavy timber, but the prevailing growth is quite irregular both in size and variety, and is generally smaller than that above noted. Softer woods, such as gum, maple, willow, &c., prevail on the flatter portions of the valley. There are also over the cultivated portions many scattering trees, planted forest trees, fruit trees, &c., many of which are of a large size, so that a general view of the valley from any commanding point gives the impression of a well wooded country. Riker Hill, Hook mountain, and the other trap ridges within the valley have timber resembling closely that of the Watchung mountain ridges, which we shall describe later. They are generally covered with cedar trees. The original growth was oak and hickory, and this was succeeded, when cut, by the red cedar to a great extent. On Hook mountain the timber of the east end was cut about 35 years ago, some parts a little later. Some is now being cut for fencing, &c., the trees running from 20 to 30 feet long, and cutting posts worth one and one-half cents per foot. A portion of the mountain near Tom's point was cut off from 8 to 20 years ago, and the growth is slow, consisting of oak, hickory, chestnut and whitewood, but little cedar, and it is generally true that there is little cedar all the way down on the east slope of the mountain, but on the west slope, wherever the oak and hickory is cut off, red cedar comes up abundantly. In one place the original forest had been cut off not over three years ago, and scarcely a sprout could be seen excepting red cedar. The oak and hickory is large, some of it apparently over 100 years old.

On Long Hill the timber is short and thin, with a good many red cedars, and a very little timber that would pay to cut. There is very little chestnut on this ridge.

Around Troy Hills and northward to Boonton, the larger timber is cut off for various uses, but the tracts being held in connection with farms are not cut off as a whole. Near Littleton some timber was sold 30 years ago for $60 per acre. Parsippany woods, east of Tabor, is about 40 years old, although a freshly-cut stump was noted 51 years old. The wood is light, 30 acres being recently sold for $20 per acre. Red cedars have come up here quite thickly, especially on former pasture lands. The wood is mainly oak and chestnut, and is all deciduous, excepting the red cedar. Along the road from Tabor to Parsippany there are some oak and chestnut trees which appear to be from 100 to 150 years old. North of Lee meadows there is some timber said to be worth $75 per acre. The balance of the tract has had the large trees cut out, leaving mostly trees of about 30 years' growth.

On Horse hill, east of Morris Plains, the timber is from 4 to 7 inches in diameter and 20 to 35 feet high, on the south end, while on the top and east slope, it is from 10 to 20 inches in diameter, and toward the north end from 2 to 5 inches in diameter and 10 to 25 feet high, but here also there is some better timber, ranging from 6 to 24 inches in diameter and 25 to 45 feet high. The timber on this hill is mostly oak, with some chestnut, hickory and maple, and a good deal of red cedar about the clearings. About Malapardis, Whippany, Troy Hills and Parsippany much of the timber ranges from 6 to 18 inches in diameter and 25 to 50 feet high, but there is some 24 inches in diameter and 60 feet high. There appears to be no chestnut here, but mainly oak, hickory and maple, all looking thrifty, and there is very little cutting. There is also considerable red cedar hereabouts, and on the lower lands a good deal of pin-oak.

On the uplands, between Pine Brook and Swinefield Bridge, timber averages from 6 to 12 inches in diameter and 30 to 50 feet high, with very little chestnut, being principally oak and hickory. It looks thriftier on the uplands than on the meadows, the best of the timber being pin-oak. On the ridge between Whippany and Passaic rivers, from Hanover Neck to Madison, the timber seems thrifty, and ranges from 7 to 12 inches in diameter and 30 to 50 feet high, and seems to be carefully preserved by the owners. Between Whippany and Morristown, also, it is good, ranging from 6 to 12 inches in diameter and 30 to 55 feet high, but, for the most part, there is a little too much brush and young growth. There does not appear to be any chestnut, excepting along the banks of Whippany river, until we approach Morristown, and there is less red cedar than elsewhere. The timber is also quite good on the ridge near Convent, ranging from 6 to 24 inches in diameter, but there is considerable small growth mixed through it. There is a little chestnut between Hanover and Chatham, and the timber here is also thrifty, ranging from 4 to 24 inches in diameter, with most of the trees between 7 and 11 inches. South of Madison, on the ridge, timber ranges from 6 to 24 inches in diameter and from 30 to 60 feet high, this being much larger than most of the timber in this neighborhood. The different kinds of oak predominate, but there is also some chestnut and hickory, with a few elms, maples, &c. On the upland, bordering the Great swamp, most of the oak appears to have been cut out within three years. There are quite a good many chestnuts and hickories. The larger trees left standing are from 6 to 11 inches in diameter and 25 to 40 feet high. There is, also, quite a good deal of brush and underbrush, with a good many young cedars. North of Green Village the timber is good, that is, what remains of it, but some has been cut within a few years. What remains runs from 6 to 10 inches in diameter and 30 to 45 feet high, with a few trees as much as 24 inches in diameter. It is principally oak and hickory, with some chestnut, maple, birch, &c. Northward of Green Village, and toward Morristown, timber is generally from 4 to 24 inches in diameter and from 20 to 50 feet in height, most trees ranging from 6 to 10 inches in diameter. The owner of a portable saw mill has just cut off a tract between Silver lake and Madison. On the southwest slope of the ridge, between Madison and Morristown, timber ranges from 6 to 11 inches in diameter and from 30 to 55 feet high, with some trees as much as 24 inches in diameter. It consists of oak, chestnut, hickory, maple, elm, birch, &c., with a good deal of cedar in places. Some of this timber has been trimmed out. In the neighborhood of New Vernon, the average timber ranges from 6 to 12 inches in diameter and 25 to 50 feet high. There are some pieces of young growth, and again there are tracts with trees 24 inches in diameter and 50 to 60 feet high. As a general thing there is little chestnut, excepting near the foot of the Highlands. Oak of all kinds predominates, especially white oak, and, on the flat places, pin-oak. We also find some maple, beach, elm, birch and white birch, with red cedar everywhere where old clearings have grown up. There has been very little cutting on this tract, between Morristown and the Great swamp, within the last 4 or 5 years.

On the northeast end of the Great swamp, near the edge of the uplands, there is a good deal of small growth, including red cedar. Further in the swamp the wood appears to be better, the larger trees ranging from 6 to 24 inches in diameter and 30 to 50 feet high. Larger sizes are not numerous, and a great many pin-oaks were noted. Along the edge of the swamp, next to Long Hill, a good many red cedars were found about the neglected clearings, and it also appears to have succeeded the timber where it has been cut off. The timber in the swamp consists of oak, largely pin-oak, maple, birch and elm, with a few chestnuts, the latter growing only on the high ground. Taken as a whole, the timber in this swamp is very poor. One hundred acres in the southern part was cut off last year. The best timber is said to be near White Bridge, but good timber was also noted near the northeast end of the swamp, elsewhere the larger and better trees have been cut out. This cutting has been especially severe during the last 10 years. In the valley, along the river above Chatham, the most of the timber is either close to the stream or in widely-separated clumps, much of the valley being under cultivation. A good deal was noted ranging from 6 to 24 inches in diameter and from 30 to 50 feet in height, but some is smaller. Generally, this valley timber is thrifty and better than that on the adjoining ridges. The best of it is just west of New Providence. There is almost no chestnut here.

In the northern part of the valley it is estimated that swamp land timber of the older and heavier growth is worth, on an average, about $50 per acre, and upland timber of about the same age, $100 per acre, supposing, in each case, that the timber is mostly oak and hickory. It was claimed that stump land was worth from $20 to $40 per acre, but this estimate evidently does not consider swamp lands, which are generally worth less than this after the timber is cut off. Here, as in other portions of the State, the ordinary rule is followed to estimate for 30 years' growth a yield of 30 cords per acre, and thereafter about one cord per acre for each year that the timber has been growing. Observation seemed to indicate that most of the timber grows less rapidly after reaching about 30 years of age, and the largest yield is thought to be obtained by cutting it between 30 and 40 years old, especially if the growth is largely chestnut, as this timber often deteriorates as it grows older. There is some difference of opinion as to whether this deterioration is, or is not, increased by continual reproduction from the old stumps without reseeding, but the general trend of opinion is that this is at least increasing the tendency of chestnut to decay at the heart. If this is the cause it will be advisable to begin reseeding when timber is cut off.

WATCHUNG MOUNTAINS.

These two trap ridges have from 40 to 60 per cent. of their entire area covered with forest, the average being not far from 60 per cent. There is much more timber than on the Passaic valley to the westward, but the contrast is still sharper with the deforested country south and east.

North of Campgaw, there is an unbroken tract of about 2,000 acres of timber covering the trap hill. It is principally chestnut and oak, about 50 feet high and from 6 to 12 inches in diameter in the northern portion, and from 20 to 40 feet high and 3 to 8 inches in diameter in the southern part. From Campgaw, by Sicomac to the Goffle, the timbered areas are more scattering and also more varied in character, but oak and chestnut are still predominant. Over all these trap ridges red cedar prevails, springing up spontaneously and persistently in abandoned clearings. It is generally less than 20 feet in height. The Goffle has some good oak and chestnut timber 50 to 70 years old, from 50 to 70 feet high and 10 to 14 inches in diameter. On Preakness mountain, and the ridge just west, the growth is largely mixed with red cedar, and is of an inferior size and quality on the trap, being much better on the red sandstone portion of the eastern slope near the foot. Near Pompton lake there is considerable good hemlock, this last being a rather unusual growth for this part of the State. Second mountain, about Caldwell and northward, has some fair oak, chestnut and hickory. First mountain is not so well timbered, and has more red cedar. Abandoned clearings are quite frequent, and the whole of the growth is irregular and patchy. Most of the timber is also younger than that in the Hackensack valley. There is a noticeably greater prevalence of hickory on the trap than on the red sandstone.

Southwest from Caldwell and Verona the timber ranges, generally, from 4 to 12 inches in diameter and 20 to 45 feet high. There is very little chestnut, excepting near Montclair, on First mountain. On the same ridge, at Eagle Rock, the timber is small. Around St. Cloud the growth ranges all the way from 2 to 12 inches in diameter and from 10 to 45 feet high. On the east slope of First mountain, from West Orange to Wyoming, there is also much variation in the size. The west slope seems rather better wooded, ranging from 6 to

24 inches in diameter, with the larger part from 8 to 12 inches, and there is less young growth. On Second mountain, about Livingston, the timber is mostly oak and hickory, with very little chestnut. There is a good deal of small growth, but there are some trees ranging up to 24 inches in diameter. There is also much red cedar. Around Livingston there has been more clearing away of forests for cultivation than anywhere else noted. The timber on these ridges, here as elsewhere, continues to be inferior to that in the adjacent valleys. Near Northfield, a piece of timber was noted, about the best of any in the vicinity, ranging from 6 to 24 inches in diameter and 30 to 50 feet high. This lot contained 19 acres, and had just been sold, including land and wood, for $600. It was estimated that it would yield 28 cords per acre. Over this part of the mountain the timber ranges all the way from 2 inches up to 18 in diameter and from 10 to 45 feet high, with a large proportion of the smaller sizes, but some scattering trees are as much as 24 to 28 inches in diameter, the poorer timber being, generally, toward the top of the mountain and on the eastern slopes, but for two or three miles north of Millburn there is an exception to this rule, as the timber is good, and ranges from 6 to 24 inches in diameter. Around Short Hills and Summit there is a good deal of chestnut again, and not much cedar. Southerly from South Orange turnpike, First mountain and the valley west contains some pine. There is also a little hemlock along the Passaic near Stanley, and again near Millington. There is also a little pine on Long hill near Stanley, and on Second mountain, south of Murray Hill. Continuing southwest from Summit, the best timber continues to be on the west slope of the mountain. The various kinds of oak prevail, with chestnut, hickory and the other usual varieties. For the most part the wood is poor and appears to be stunted, although it is claimed that it can be profitably cut in 20 years, but our examination seemed to indicate that 40 years would be generally necessary, and even then the growth would be much inferior to that of the adjoining valleys. There is much of this timber ranging from 2 to 4 and 6 inches in diameter and 10 to 30 feet in height, with a little ranging up as high as 18 inches in diameter and 50 feet high. Continuing southwest of the road from Basking Ridge to Bound Brook, the timber becomes still poorer ; the trees appear to be old, but are short and stunted. Continuing on around to Basking Ridge, the same conditions, generally, prevail, the wood being mostly

small, but with a few large trees. Throughout the whole extent of the ridges, red cedar appears to be abundant about the edges of the clearings, and where the clearings have grown up. Not much cutting was noted, as the growth was too small to make it profitable. The woods consist of oak, hickory, maple, birch and beech, with a little chestnut. We are inclined to think that the general inferiority of the timber of the trap ridges arises, partly, from the nature of the trap-rock soils, and partly from the fact that these ridges are very accessible to a thickly-settled country, where timber is comparatively scarce, and, in consequence, cutting has probably been more severe than elsewhere. As a result of these two causes the timber is deteriorating. On the whole, the tendency on these ridges seems to be to allow clearings to grow up, but as they have, within a few years, become occupied, to a great extent, by an immigrant population, this tendency may, possibly, be reversed, owing to different methods of farming. It may be mentioned, in this connection, that the curious fact has been noted, in our forest studies, that there is less disposition to destroy and waste the forests shown by our native rural population than by the immigrant population from countries where the control and management of forests is, on the whole, far superior to our own methods.

HACKENSACK VALLEY.

The Red Sandstone country lying between Palisades mountain on the east and Ramapo and Orange mountains on the west, was designated by us, the Hackensack valley, in the "Physical Description." Topographically, it is all one valley, although not all drained by the Hackensack river. It includes all of Bergen and Hudson counties, Passaic county, southeast of Paterson, and the northeastern corner of Essex county. It contains a large urban and suburban population, and it seems somewhat anomalous that it should also include some of the best timber of the State. The valley, as a whole, has 30 per cent. of its upland area in timber, or, in other words, 61,000 acres in a total of 180,000 acres of upland. Bergen county has 39 per cent. in timber, Hudson county only 5 per cent., the Passaic county portion 9 per cent., and the Essex county portion 20 per cent. In topographical position this timber is largely confined to the slopes, level valley bottoms and plateaus being mainly under cultivation. These cultivated portions, however, have a very liberal allowance of scattering forest trees, orchards and other planted trees, so that in looking over the valley from an elevation it appears to be very generally wooded. The really forested portion ranges through all conditions, from a very limited amount of brush and stump land to heavy timber. Very little of it is now cut off entirely, most of the cutting being selected trees, so that the considerable amount of timber taken out each year is scarcely missed. There is no wastefulness apparent, as a rule, in the handling of the forests. It is generally a mixed deciduous growth, with oak predominating in the lower land along the Hackensack, while chestnut prevails on the higher ridges westward, and softer woods, such as gum, white birch, beech and maple in the swamps. Here and there are a few scattering hemlocks. From Closter to Englewood there is much red cedar. The timber is usually in rather small, isolated areas, not often reaching 100 acres in extent. There is a tract of some 500 acres along the Hackensack near the State line. Proceeding southward from the State line, across the whole width of the valley, there is a gradual decrease in the amount of timber. The growth in the vicinity of Ramseys to Wyckoff is rather mixed, consisting of oak, chestnut, maple, beech, elm, white birch, red cedar, &c., in all stages of growth, from brush to trees 80 feet in height, but there is a notable absence of stump land or new clearing. Near Paterson the country is quite deforested, the 9 per cent. of forest in the Passaic portion of the valley consisting mainly of small patches of oak and chestnut, preserved in connection with farms, and only cut occasionally and sparingly as needed. Most of the groves contain much fine timber, and are generally well cared for. Proceeding southwest into Essex county the wooded area is increased to 20 per cent. and is somewhat similar to that described, although the timber is, as a rule, not so good. There are some quite large timber areas north of Belleville. In this Hackensack valley, as a whole, the timber is probably as well cared for as in any other equally large section of the State. It is thrifty and healthy, and suffers comparatively little from fires.

The value of the land here is, of course, generally much too high for profitable forestry. In most well-located places it is worth from $400 to $1,000 per acre, where it is still sold by the acre instead of by the foot. In a few out-of-the-way places it ranges lower, but is in any case largely independent of the character of the timber. From inquiry, it was estimated, however, that the timber alone was worth from $30 to $50 per acre for a 30-years' growth, and in proportion for younger timber, but old timber of mixed varieties is worth from $100 to $150 per acre. Swamp land timber is said to be rarely worth more than $20 per acre. In the vicinity of Wyckoff we obtained the following general prices: Swamp land, $5; 20-years' growth, $15 to $25; 30-years' growth, $25 to $35; large oak and chestnut, $75 to $100 per acre. About Oakland, stump land, $3; 20-years' growth, $20; 30-years' growth, $30; large mixed growth, $60. In such inquiries as this it becomes quite evident that many of the estimates given are based on the prevailing rule that timber will produce one cord of wood per acre for each year that it is growing, and that this wood is worth about $1 per cord on the stump, as was determined by a large number of written inquiries sent out by the Survey, the results of which were published in the Annual Report for 1885. This rule seems to prevail all over the State, but it is quite evident that it cannot be equally fair for all sections, although probably a good working average.

A few tracts claimed to be original forest were noted in the Hackensack valley. One is half a mile east of Hillsdale, containing about 30 acres of oak, 15 to 28 inches in diameter and about 70 feet high; a small piece of oak, one-half mile south of Riverdale, another, one mile west of Englewood, containing oak from 15 to 30 inches in diameter and from 60 to 80 feet high, and another piece of oak, one mile northwest of Oradell, on the ridge. It is noticeable that all of these tracts are of oak.

Several large trees were noted throughout the valley. At Hohokus, a fine elm 50 inches in diameter and 80 feet high, with a spread of branches of about 100 feet; one mile southwest of Etna, an oak 46 inches in diameter and 60 feet high; in an old clearing, one mile northeast of Saddle River, two chestnuts each 60 inches in diameter; on the estate of the late Hon. W. W. Phelps, at Teaneck, two oaks 40 inches in diameter; at Ridgewood, a chestnut 60 inches in diameter; at Haworth, a chestnut 84 inches and another 78 inches in diameter; north of Arcola, a chestnut 72 inches in diameter; at Overton, a chestnut 76 inches in diameter. Most of these chestnuts are only remarkable for girth, but near Oradell there is a fine chestnut tree 63 inches in diameter and 55 feet high; at the forks of the road, a little over one-half of a mile north of Ramseys, a chestnut 60 inches in diameter and 50 feet high; another, three-quarters of a mile northwest, 60 inches in diameter and 45 feet high. Near Campgaw we noted a chestnut 62 inches in diameter and 60 feet high, and two others 66 inches in diameter and 50 and 60 feet high; north of Wyckoff, a large whitewood 36 inches in diameter and 80 feet high; near Wortendyke, a chestnut 48 inches in diameter and 65 feet high. Near Paterson chestnuts were noted 36 to 60 inches in diameter and 60 feet in height; also, two large black walnuts, near the river, northeast of Paterson, 42 inches in diameter and 60 feet high. The total consumption of saw-mills in this district was ascertained by inquiry to amount to practically 2,400,000 feet, board measure, of lumber, and besides this kindling-wood factories consumed the timber from about 25 acres annually. The whole consumption by these mills would, therefore, probably not exceed the growth from 85 acres annually. Besides this use, however, there is the consumption for railroad ties, telegraph and telephone poles and fuel, the amount of which has not yet been ascertained.

As regards the succession of growth, the general opinion seems to be that it is of the same kind as that cut off, although some claim that white oak and hickory are followed by a more mixed growth. It is evident that since the cutting off entire of areas of timber seems to have been long ago abandoned in this vicinity, and that most of the cutting is, as we have remarked, by culling out, there cannot be much reliable data obtained on this point. At Moonachie, maple is said to have succeeded oak, and at other places the succession has been chestnut. There is no room for doubt, however, that as a rule abandoned clearings grow up in red cedar, although this is occasionally accompanied by, or replaced with, white birch.

Groves of planted white pine may be seen on the estate of the late William Walter Phelps, and also one mile east of Saddle River, south of the road from Ridgewood to New Milford.

PALISADES MOUNTAIN.

It will be a surprise to many to learn that this ridge, so near to the large cities and in the most populous section of the State, is so well wooded. From the State line, south to Edgewater, a distance of 13 miles, and for a width of 1½ miles back from the bank of the Hudson, practically 90 per cent. of the whole area is well timbered. The forest covers an unbroken tract of 11,000 acres. Beginning at the

State line and extending to 1 mile below Huyler's landing, we have, on the talus slope along the river, a mixed deciduous growth, mainly chestnut and oak, from 30 to 60 feet high, varied with pine and hemlock near Huyler's landing. We give here, as elsewhere, only the prevailing timber, but in reality this whole Palisades forest includes a large number of varieties. Further down, to Linwood, the growth on the talus is more irregular, containing a fair proportion of oak and chestnut of good size, with scattering hemlock. From Linwood to Fort Lee the talus is well wooded, some good white pine being found, but oak and chestnut prevail. From Fort Lee to Edgewater the river slope of the ridge is well timbered, but a strip of land along the river, at the foot, has been cleared and occupied by residences. On the flat top and upper portion of the western slope of the mountain, from the State line to Edgewater, if we except some red cedar near the State line, the growth is practically of mixed deciduous varieties, mostly oak and chestnut. This timber ranges from undergrowth to trees 40, 60 and 80 feet in height. Diameters of from 20 to 30 inches, and heights of from 60 to 80 feet, are not at all uncommon, especially from Huyler's landing to Edgewater. Taken as a whole, there are not many finer belts of timber in the State. The land is largely held in such a way that there is comparatively little danger of wholesale deforesting, but this beautiful forest has almost as good a claim to future preservation as the escarpment of the Palisades. South of Edgewater the ridge is practically a city to Bergen Point, and entirely deforested.

FOREST COVER ON THE SLOPES.

On the southeastern part of the Highlands we find steeper slopes, very generally wooded, and a detailed examination of such slopes as would be likely to wash, because of lack of forest cover, shows that not more than 5 per cent. of their area has been cleared of timber. There is, to be sure, also a small proportion of rocky slope which does not bear timber, because the soil is lacking, and which never has been able to support the growth of forest. As we have remarked, in dealing with this section, the clearings are almost entirely confined to the valley bottoms and a few level places on the plateaus. Over the southwestern Highlands we find more slopes deforested, as should be expected, as a larger percentage of the whole area is under cultivation.

We find here that 30 per cent., or about one-third, of the steeper slopes have been cleared. There is no evidence of serious wash due to this clearing on the Highlands proper, excepting a little along the Musconetcong valley, where the slopes are in peach orchards. These orchards, being kept cultivated, with no cover of grass or grain, are peculiarly liable to wash. Some of the slopes in the deforested and highly cultivated valleys, where the underlying rock is slate or limestone, also show considerable erosion due to wash, and here, if anywhere in this section, some attention might profitably be given to reforesting the steeper slopes, although, as a rule, the land is too fertile and productive to be allowed to remain in forest. On the red sandstone plain, northeast of the moraine, we find 53 per cent. of the steeper slopes stripped of forest, but it must be remembered that here the country is much more level, as a whole, than in the Highlands, and while there the slopes cover a large proportion of the whole area, they are here comparatively insignificant in area. What forest there is on the red sandstone is rather more likely to be on level areas than on slopes, as it is left standing where the soil is wet and cold, or where it is largely covered with boulders and drift, so as to be untillable.

FOREST CONSIDERED BY WATER-SHEDS.

The most important Highlands water-sheds are the headwaters of the Passaic, and those who would know in detail the condition of the forests on these streams should refer to the description of the southeastern Highlands, already given in this report. The Rockaway, at Boonton, has 82 per cent. of its catchment in forest, while the Pequannock has 78 per cent., and the Wanaque and Ramapo each about 75 per cent., including the portion in the State of New York. These four streams are all in the northeastern Highlands. On the southwestern Highlands we have only the Whippany, above Morristown, which has 55 per cent. of forest. The upper Passaic, at Chatham, lies largely in the central Passaic valley and the red sandstone plain. It has 23 per cent. of its catchment in forest. The Passaic, as a whole, has a catchment of 949 square miles, of which 508 square miles lies on the Highlands, and 441 square miles on the red sandstone. Forty-four per cent. of the whole catchment is forested, but about 59 per cent. of the portion above Paterson. The Raritan headwaters also lie on the southwestern Highlands, and have about 30 per cent. of their catchment in forest, while the Musconetcong, in this same region, has 39 per cent. in forest.

Here in the Highlands, as elsewhere to a great extent in the State, the principal importance to be attached to the proportion of forest on the water-shed is that it is indicative of absence of cultivation, and to a certain extent, of population, consequently there is less roiliness of the water, and less liability to pollution where the per cent. of forest is large. While, as a whole, the Highlands streams are of good quality in their natural condition, and good potable waters, it is nevertheless plainly evident that those streams which have their catchment in the northeastern glaciated Highlands carry much less sediment, and are purer and clearer than those in the more highly cultivated southwestern Highlands. This fact we believe to be due partly to the larger percentage of forest and less extent of cultivated lands which we have noted. The Pequest catchment also lies to a considerable extent on the southwestern Highlands, but has so much of its area in the Kittatinny valley that the forested portion is only 18 per cent. of the whole.

On the red sandstone the Hackensack catchment has about 60 per cent. of forest area, and we believe that it is at least partly due to this fact that the Hackensack carries much less sediment than streams like the Raritan, on the deforested portion of the red sandstone.

RELATION OF FOREST TO THE FLOW OF STREAMS.

In connection with our studies of the water-supply of the State, we have, since 1890, made extended observations of the flow of our streams. We also studied a large number of measurements of the run-off of streams over the United States. Incidentally some attention was given to the question of the relation borne by forests to stream flow, but this being merely incidental, it is our purpose at present to give a fuller account of these studies and supplement them by some further examination.

The question of the effect of cutting of forests had been brought to our attention by the widespread opinion held by the people of the State that the streams had been unfavorably affected by the cutting off of forests, and believing that widespread popular opinion usually is founded on some fact, we were led some years ago to give some attention to the matter. The grounds most frequently stated for the belief that the streams had fallen to a lower stage than formerly appeared to be that certain streams, like the Rancocas and other branches of the lower Delaware, the Raritan, &c., had formerly been navigated to a considerable extent, and it is popularly believed that this would be impossible at present. It was also claimed that the streams run much lower than formerly and are more subject to serious floods. I have found that these opinions are shared alike by the ordinary and the more scientific observers familiar with the streams of the State. It was also found that the extremely dry years of 1880 and 1881 led to a widespread expression of these opinions, and the cause assigned to the falling off of streams was almost invariably the cutting off of forests. The assignment of this cause appeared to be, to a considerable extent, due to the suggestion of writers on forestry and advocates of forest protection. The aim of our studies has been to ascertain what definite data and actual measurements show as to the truth of these assertions.

Before proceeding very far we were confronted with lack of evidence that the amount of land in forest has sensibly decreased within the State during the last half century. In general, the land not actually cultivated in the State is forested, excepting about 10 per cent., which represents fallow land, highways, town sites, &c., consequently we will take the statement of the number of acres in farms, and of the portion of that land improved, from the United States Census, since 1850, in order to ascertain whether there has been any considerable change in the amount of forested land:

	1850.	1860.	1870.	1880.	1890.
Total land in farms............	2,752,946	2,983,525	2,989,511	2,929,773	2,662,009
Improved land in farms.......	1,767,991	1,942,281	1,978,067	2,097,719	1,999,117

It will be seen that the improved, or cultivated, land is increased only to the extent of about 231,000 acres since 1850. As the total upland area of the State is 4,500,000 acres, it will be seen that this is but 5 per cent. of the upland area, and it will also be noticed that the total land in farms has actually decreased. Since 1860 the amount of improved land has increased by an amount which is equal to only about 1 per cent. of the entire area. Robert Gordon made an estimate, which indicates that 76 per cent. of the entire area was in farms in 1833. This was, probably, rather high, but still the indications are that there has been no important increase of cultivated land for over 50 years, consequently, any change which may have been noted in the streams, in the memory of people now living, is not likely to have been due to a decrease in forest area.

The question which suggests itself next is whether the character of the forest has changed. We have a large amount of evidence to the effect that when the forges were running, all over the State, the cutting of forests was very severe, in order to procure coal for the forges and fuel for other purposes; as before the general introduction of anthracite coal, and, indeed, for a good many years after, the use of wood for domestic purposes and in many industries was much more common than it is at present. The Highlands forests were then generally cut at the age of about 20 years, and we find at present a very large amount of Highlands forest which dates from about 1850, consequently, it would seem to be indicated that the forests in that section of the State, at least, are now older and heavier than they were in 1850, when, it is said, large areas of the Highlands presented an extremely bare appearance. Nevertheless, it is quite possible that, on the whole, a considerable amount of heavy timber throughout the State has disappeared since that date, and been replaced by a younger growth. This is, perhaps, true to a greater extent on the portions of the Delaware water-shed which lie outside of New Jersey than on any of the water-sheds of this State.

We have also to remember, in considering the early navigation of our streams, that this was usually in flatboats, drawing very little water, and it is true that for considerable portions of the year these streams could still be navigated in this way, where no artificial obstructions have been introduced. When they were navigated there were no railroads, and the highways were in very poor condition; consequently, facilities for transportation by water, which would now seem ridiculously inadequate, were then adopted as the best means at hand. We shall see, as we proceed, nevertheless, that there may be some ground for the popular opinion that the streams are, much of the time, lower than they formerly were.

We will proceed to examine the large amount of data as to stream flow which we have at hand, in order to see what may be discovered as to the effect of forests from this. Much of the data which we shall refer to has been given in the Report on Water-Supply of 1894. First, the examination of the longest and best rainfall records shows a tendency to gradual increase in the rainfall of the State from 1825 up to about 1870, since which time we have passed through some remarkably dry periods and the rainfall has fluctuated. The severest of these dry periods extended from about 1875 to 1886, and a number of years from 1875 up to the present date have had severe droughts, although we have also had, during that period, some extremely heavy rainfalls for certain years. These changes in rainfall, which are probably not permanent, may have a considerable bearing upon the alleged falling off in the flow of the streams.

The next important matter to be investigated is whether our recorded stream flows indicate any effect of forests upon evaporation from the surfaces of the water-sheds. There have been a good many claims, apparently well-grounded, that forests diminish this evaporation as compared with cultivated areas. One class of data on which this is based, however, must be rejected. We refer to experimental measurements of evaporations from the soil within the forest. Such experiments cannot even approximate the conditions which exist in nature, and moreover, our problem must include all of the evaporation; that is, not merely the water which is evaporated direct from the soil, but that which is taken up into the trees, either to be again exhaled to the atmosphere, or permanently incorporated in the substance of the tree.

We can conceive of no way which will so accurately measure the evaporation from a given area of the earth's surface as to measure for a series of years the total rainfall upon that area, and simultaneously, the total amount of water which runs off in the streams. We have found that only an insignificant amount of water is taken permanently into the ground on ordinary water-sheds, so that the difference between the total rainfall and the total run-off represents direct evaporation by the atmosphere, together with the water taken up by vegetation to be either ultimately evaporated into the atmosphere or incorporated into the plant. There may be difficulties in making such measurements, it is true, but they are nowhere near so great as the difficulties in the way of more limited experiments, for we, in this way, preserve natural conditions; moreover, it has been found possible to make these measurements sufficiently accurate for all economic purposes, and any influence which forests may have upon evaporation which cannot be detected in this way is too unimportant to have any economic bearing. Therefore, if we have a large number of good gaugings for water-sheds, varying considerably in the proportion of forest area, or otherwise in the character of their vegetation, we ought to be able to discover in this way whether this vegetation has any important influence on evaporation.

In the Report on Water-Supply we investigated, in this way, records of rainfall and flow-off on eight streams in the eastern United States, the length of the records varying from 7 to 17 years. Our investigations led us to the discovery that the important factor in determining the amount of evaporation was the average temperature for the water-shed, and we found that evaporation increased or decreased through the range of our observations at the rate of 5 per cent. for each increase or decrease of one degree in mean temperature. We tested this law by applying it to the 8 streams of the eastern United States, and to 6 streams in the Mississippi valley, and found that it held good for temperatures from 47 to 60 degrees. We then applied the law to gaugings of 12 New Jersey streams, and found that it held good for these also. It is evident, therefore, that we can make no correct comparison of evaporation from forested and deforested water-sheds without allowing for difference in temperature, and, indeed, without such allowance we shall find that in many cases forested water-sheds show a much larger evaporation than those almost entirely deforested. For instance, the evaporation on our Raritan water-shed, which has only 13 per cent. of its area in forest, is more than 10 per cent. less than on the Great Egg Harbor, which has 88 per cent. of its area in forest. In the table accompanying, I have used some data which are fuller and better than I had at the time that the Report on Water-Supply was written, but for the most part they are taken from that report. The table shows the mean temperature of each water-shed, the per cent. of its area in forest, the ratio which the observed evaporation from that water-shed bears to the observed evaporation of our own Passaic water-shed, the latter being taken as 100, and in the last column the same ratio as determined from the mean temperature by the previously referred to law of increase and decrease, and I may here remark, that this law of increase and decrease is one which has long been an established law of physics, although it has never been applied to evaporation from the surface of the earth, so far as is known to us, until it was so applied in the Report on Water-Supply.

COMPARATIVE TABLE OF EVAPORATION FROM WATER-SHEDS.
EVAPORATION FROM PASSAIC WATER-SHED = 100.

	Temperature. Degrees.	Per cent. of forest area.	Observed ratio of evaporation to that of Passaic catchment.	Ratio to Passaic catchment, computed from temperature.	No. of years of record.
Passaic	49.7°	58	100	100	17
Ramapo	48.5°	75	103	94	2
Pequannock	47.4°	78	87	88	3
Musconetcong	48.4°	39	92	93	2
Pequest	48.4°	18	91	93	2
Paulins Kill	48.4°	27	97	93	2½
Hackensack	50.6°	60	104	104	8
Raritan	50.6°	13	104	104	4
Delaware	47.4°	53	82	88	1
Great Egg Harbor	52.5°	88	120	114	3
Batsto	52.5°	88	115	114	1½
IN OTHER STATES.					
Sudbury, Mass	49.7°	14	100	100	16
Croton, N. Y.	49.7°	30	100	100	14
Connecticut	47.0°	53	86*	86	13
Neshaminy, Pa.	51.7°	7	107	110	7
Perkiomen, Pa	50.7°	25	105	105	7
Potomac	52.0°	52	109*	111	6

We have, however, to allow for the fact that evaporation varies somewhat with rainfall, although not in direct proportion thereto. The relation was carefully determined for the Passaic in the Report on Water-Supply, and is expressed by the following formula relating to yearly rainfall and evaporation, all expressed in inches:

$$\text{Evaporation} = 15.5 + .16 \text{ rainfall.}$$

In order to compare the evaporation on a given stream with that of the Passaic, as in the table, we ascertain the average rainfall, and deduct from it the average run-off for the stream in question, taking the difference as evaporation, and then computing what would have been the evaporation on the Passaic for the same average annual rainfall by means of the above formula. The two columns of the table showing the ratio of evaporation as actually observed, and as it

* From gaugings published by Cyrus C. Babb, in Transactions of American Society of Civil Engineers, being longer and fuller than those given in the Report on Water-Supply.

should be when the difference of temperature is allowed for, may be compared to determine the effect which a larger or smaller percentage of forest area may have upon the evaporation from the given water-shed. If the observed ratio is larger than the computed, it will indicate greater evaporation, and if it is smaller it will indicate less evaporation. It will be seen that, as a whole, the agreement is remarkably close, and especially so with the longer series of gaugings, the length of the record being shown in the last column. The table fails, absolutely, to indicate any effect upon the evaporation due to such forests as prevail over the Eastern United States. It should be said that, where we have no other data, the per cent. of forest area is computed by taking the difference between the total area and the area of improved land, as given in the census, and then deducting from this 10 per cent., which we have found to be the proper amount to represent highways, town sites and fallow lands. In New Jersey, forest areas are measured by actual survey. It will be noted that the range of forested area is from 7 to 88 per cent. of the whole catchment.

We may now turn to some facts which are matters of general observation, and see how these support this conclusion. If forests require so much less water than cultivated areas or grass lands it would seem to follow that they should be found flourishing where the rainfall is too light to support other vegetation, but, taking the country as a whole, this is by no means true. It has been generally observed that, for a temperature of about 50 degrees, like that of our own State, forests cease to be abundant when rainfall becomes less than 32 inches per annum, and practically disappear when the rainfall becomes as low as 26 inches. It has also been observed that less than 20 inches of rainfall is accompanied by an exclusively pastoral country, and that at 14 inches vegetation practically disappears. These facts do not seem to indicate that forests thrive with less moisture than other vegetation. It will also be noted that in both cases the difference between abundant forest and no forest, or fair vegetation and no vegetation, is 6 inches of rainfall, and this 6 inches of rainfall is exactly the amount which we determined in our Water-Supply Report to be needed by vegetation alone on the Passaic water-shed, where, during an average year, the rainfall is 45 inches, and the total evaporation 22.7 inches, including the 6 inches allowed for vegetation. We also know that in 1881, a very dry year, when the rainfall fell to about 32 inches in Northern New Jersey, the spring and summer rainfall together amounting to 15.70, our forests began to die on the tops of the mountains, and again in 1894, the spring and summer rainfall amounting to 15.67, the forests turned brown over the Highlands and began to perish. In Kansas the limit of abundant forest is, as we have noted, at about 32 inches annual rainfall; and it would appear, therefore, that our own forests would begin to die out if our rainfall should sink as low as this limit; consequently, the evidence is that 32 inches of rainfall annually is necessary to support healthful forests at this temperature. This seems sufficient evidence that there cannot be less loss of water from forested areas than from cultivated.

We shall next investigate the influence of forests upon the greatest floods and the lowest dry-season flow of streams. We have prepared a table showing, in connection with the percentage of forested area, the rate of greatest and least flow for our own streams and others in the Eastern United States. As the greatest flow is always at a less rate in proportion to the drainage area on large streams than on small

RELATION OF FOREST AREA TO GREATEST AND LEAST RATE OF FLOW OF STREAMS.

CATCHMENTS LESS THAN 200 SQUARE MILES.

	Catchments in square miles.	Per cent. of area in forest.	Flood flow in cu. ft. per second per sq. mile.	Lowest flow in cu. ft. per second per sq. mile.
Sudbury, Mass	78	14	41.4	0.036
Croton, West Branch, N. Y	20	56	54.4	0.020
Ramapo, N. J	160	75	66.1	0.140
Wanaque, N. J	101	75	48.9	....
Pequannock, N. J	85	78	52.7	0.130
Rockaway, N. J	119	82	40.7	....
Musconetcong, N. J	156	39	12.8	....
Musconetcong, N. J	68	85	15.9	....
Paulins Kill, N. J	175	27	23.0	0.130
Swartswood Lake, N. J	16	22	65.8	....
Pequest, N. J	158	18	12.5	....
Pequest, N. J	83	18	9.6	0.170
Pequest, N. J	35	18	18.7	....
Pequest, N. J	2	...	25.3	....
Tohickon, Pa	102	28	54.3	0.001
Neshaminy, Pa	139	7	41.4	0.009
Perkiomen, Pa	152	25	34.9	0.050
Hackensack, N. J	115	60	.....	0.190

CATCHMENTS 200 TO 2,000 SQUARE MILES.

	Catchments in square miles.	Per cent. of area in forest.	Flood flow in cu. ft. per second per sq. mile.	Lowest flow in cu. ft. per second per sq. mile.
Concord, Mass	361	...	12.3	0.17
Charles, Mass	215	...	......	0.20
Housatonic, Ct	790	...	......	0.17
Croton, N. Y	339	30	74.9	0.15
Passaic, N. J	797	59	24.2	0.19
Passaic, N. J	822	58	22.2	0.19
Raritan, N. J	879	13	59.3	0.14
Great Egg Harbor, N. J	216	88	22.0	0.27
Schuylkill, Pa	1,800	...	......	0.17
Potomac, Md	920	52	19.5	0.02
Greenbrier, Va	870	...	......	0.12
Shenandoah, Va	770	...	......	0.17
Neuse, N. C	1,000	...	......	0.19

CATCHMENTS OVER 2,000 SQUARE MILES.

Merrimack, Mass	4,599	...	20.9	0.31
Connecticut, Ct	10,234	53	20.3	0.31
Delaware, N. J	6,790	53	37.5	0.17
Ohio, Pa	19,900	...	......	0.11
Potomac, Va	4,640	52	22.2	0.08
Kanawha, Va	8,900	...	13.5	0.12
James, Va	6,800	...	......	0.19

ones, while the dry-season flow is usually proportionately larger, it is improper to compare very large water-sheds with very small ones, therefore, we have grouped the streams according to the size of their drainage areas. This table shows the comparative violence of floods and lowness of dry-season flow in the last two columns. No relation is apparent between the proportionate forest area and either the greatest or least flow, and it is evident that these are both controlled by other conditions. In the case of floods, the controlling influence is topography, and in the case of dry-season flow it is the surface geology, that is, the character of the soil and sub-soil. All notes which we have of the severest floods show that they have occurred in such exceptional conditions as warm rains falling on a heavy accumulation of snow, or from heavy rains on frozen ground, or, in summer exceptionally heavy rains on ground already saturated with water. It ought to be apparent that forests cannot effect such conditions as these to any great extent.

The lowest flow occurs after the streams have been, for a long time, drawing upon their springs, and have extracted the water from the ground to a considerable depth below the surface. Our investigations show that such flow is usually reached in our State when the water has been drained from the sub-soil to an average depth of over 4 feet. Indeed, at such times we have actually observed an entire absence of all moisture in soil to about this depth. It is evident that when the water is coming from below this point, the humus or other surface conditions of forest can have little effect upon the rate of its drainage into the streams.

Historically, we have found little or no evidence that the very highest floods rise any higher than formerly. On the Passaic there is no record of a greater flood than that of September, 1882. On the Raritan there have been three great floods during the century, namely, November 24th, 1810; July 17th, 1865; September 24th, 1882. Of these, the first and the last were of almost exactly equal volume, while that of 1865 was a little lower. On the Delaware we have records of a great flood in 1692, which had not been equaled up to 1765. Smith's History, Chapter XII. This is said to have been due to the melting of snows. Another great flood occurred in 1786, the height of which is recorded, and of which we estimate the volume at Lambertville at 175,000 cubic feet per second. In 1801, 1814, 1836 and 1839 there were floods reaching from 140,000 to 150,000 cubic feet per second. On January 8th, 1841, a disastrous flood occurred, reaching 255,000 cubic feet per second. On June 8th, 1862, there was one of about 224,000 feet per second; the others since 1841 have not reached as high a point as that of 1862. It is evident that there is nothing in the history of these floods which clearly indicates any progressive increase in the volume of floods, but it is alleged, and is probably true, that floods of a less volume, or say from 150,000 to 175,000 cubic feet per second, are more frequent than they were formerly.

We also have investigated some recorded heights of the Delaware since 1831, at extreme low stages. These seem to indicate that the recorded flow in September, 1881, which we have given in our table at the rate of .19 cubic feet per second per square mile, is the lowest stage reached by the river since 1831, but it is also true that the drought of 1880 and 1881 is the severest of which we have any record during this period. We certainly have no record of any progressive falling off in the very lowest stages of the Delaware, but it is alleged, and probably with some truth, that stages which are low, although about 50 per cent. greater than the lowest recorded, last longer and are more frequent than they were formerly.

It must be remembered that in the foregoing examination we have spoken only of the very highest and very lowest stages of rivers, and we have done so because it is frequently attempted to show by these highest and lowest stages as recorded the injurious effects of cutting off the forests. We believe this to be an error, and that no effect can be discovered in this way, but it must be remembered that such stages are not important ones on a stream. We have seen that the very greatest flood on the Delaware has not been equaled again during the century, and so on the Raritan there have been but two such floods during the century; while, if we take the record of gaugings on the Passaic river for 17 years we find that the highest rate of flow, of 24 cubic feet per second per square mile, has been reached but once, and then only lasted for about 3 hours, while the lowest rate of flow, of .19 cubic feet per second per square mile, has not been reached probably more than two or three times for a few days in each case; whereas, the river has stood during this period between .4 and 1.34 cubic feet per second per square mile, an average of 112 days, and between 1.34 and 3.35 cubic feet, also an average of 112 days during each year, while it has been over 14.7 cubic feet per second per square mile only 8 days in the whole 17 years. It is evident, therefore, that what is really of importance on the Passaic is anything that affects the stages between about .3 cubic feet and 2 cubic feet per second per square mile, and that such cause would be infinitely more important economically, and its effect would be much more noticeable than causes affecting the extremely low or the extremely high stages. It is in those stages of the river which prevail during six months of an ordinary dry period that we believe the beneficial effects of forests are really found. The soil and sub-soil of a water-shed hold a large amount of water which is fed out as drainage, in the form of springs and seepage, to the stream during dry periods. It is a matter of common observation that at such times rivers continue to flow when rainfall is very much less than the evaporation, and, indeed, for long periods when there is no rainfall at all. Anything which tends to increase this amount of water which is held in the ground, and to regulate its discharge into the streams, tends to give a larger flow, and to shorten the periods of very low water in the streams during droughts, and with this increased capacity of the ground to absorb rain comes also less frequent floods. The more water that is drained out from the soil the more can be absorbed when the heavy rains come at the end of the droughts. Humus in the forest forms a great sponge, and of itself holds a large amount of water, while it and the inequalities caused by tree roots, &c., tend to prevent the water flowing over the surface, and the roots of the trees provide channels by which the water percolates into the sub-soil readily. In this way the forest will easily absorb a larger amount of water than open lands. A high state of cultivation also has a tendency to increase the capacity of the ground to absorb water because of constant loosening of the surface and the facilities provided for ready drainage. In this way cultivation, like forests, tends to render floods less frequent, but the effect of the drainage of the soil is that the ground water absorbed is fed out more rapidly to the streams during the early months of a dry period than is the case in forests; consequently, the ground water is sooner exhausted, and the duration of the low stages of the rivers during protracted droughts is thereby lengthened. Barren water-sheds offer much less capacity for absorption of rainfall. There is no humus or other matter on the surface to retain the rain, and the ground becomes hard and resists free percolation. The difference between forested and deforested water-sheds is very well illustrated by the Passaic and the Raritan respectively, while some of our small red sandstone water-sheds are good types of barren country. We have, in the following table, contrasted these three types, the data being obtained from the Report on Water-Supply. This table shows in inches of rainfall the amount of water which would flow off to the several streams from their water-sheds for each month, during a drought of such a character that all additions from rainfall, or depletions from evaporation, to the ground water are suspended, the water here shown being entirely water of drainage.

YIELD OF SPRINGS ON VARIOUS TYPES OF WATER-SHEDS DURING DROUGHT.

IN INCHES OF RAINFALL.

Month.	Passaic. Type of forest water-shed.	Raritan. Type of highly-cultivated water-shed.	Type of barren water-shed.
First	1.16	1.43	.94
Second	.54	.64	.38
Third	.40	.45	.26
Fourth	.33	.35	.20
Fifth	.32	.30	.14
Sixth	.31	.27	.12
Seventh	.30	.25	.10
Eighth	.29	.23	.08
Ninth	.28	.22	.07
Total	3.93	4.14	2.29

It will be observed that while the Raritan and the Passaic show nearly the same total amount of drainage, the Raritan gives up this water faster in the early months, and, therefore, its springs become sooner exhausted and it runs lower toward the last of the drought. The barren ground, having absorbed much less water, has less flow from springs throughout. How important this is upon the dry-season flow of these streams becomes apparent from the following table:

FLOW IN GALLONS DAILY PER SQUARE MILE DURING THE LAST EIGHT MONTHS OF THE DRIEST YEAR (1881).

	Passaic. Forested.	Raritan. Cultivated.	Barren water-sheds.
April	597,000	754,000	631,000
May	297,000	325,000	145,000
June	272,000	272,000	139,000
July	207,000	134,000	22,000
August	140,000	89,000	22,000
September	139,000	87,000	23,000
October	129,000	84,000	22,000
November	127,000	93,000	23,000

The conditions here shown are believed to be illustrative of the effect of forests upon stream-flow, and the comparative effects of cultivation and barrenness. We have found it a rule that the heavier forested catchments furnish a steadier flow, better sustained during dry periods, and that while they are subject once in a great while to severe floods, nevertheless floods not quite so severe are less frequent than upon deforested catchments not highly cultivated. Flood-flow, it must be remembered, however, is largely a matter of topography, and while floods are heavy and frequent upon the deforested Raritan and Neshaminy, the same is true of the well-forested Ramapo and Pequannock, while they are extremely light upon the lightly-wooded Pequest. The economic importance of the effect we have noted lies in the greater value of forested streams for water power, and the smaller storage reservoirs needed thereon to furnish a given daily supply of water to cities. Illustrative of this, the Passaic will furnish for 9 months of the year from 100 square miles of water-shed, 45-horse power on 10 feet fall, whereas the Raritan will furnish but 41 and the barren water-shed 28-horse power. During the other 3 months the Passaic will furnish an average of 36, the Raritan 32 and the barren water-shed 20-horse power. To collect 570,000 gallons daily per square mile of water-shed, we shall need storage reservoirs of the following capacity: Passaic 84,000,000, Raritan 110,000,000, and barren water-sheds 126,000,000 gallons. The difference in cost of collecting a supply at the above rate per square mile, therefore, upon the type of streams selected to represent the forested and upon those representing the barren conditions, would be about $8,400 per square mile. Both the Passaic and Raritan exceed 800 square miles in catchment. For this area the saving would be $6,720,000.

Taking the same area, we find the excess of water power on the forested stream would be for 100 feet fall, 1,360-horse power, the value of which, at a rental of $35 per horse power per annum, would be $47,600, or the iuterest at 5 per cent. on $952,000.

We do not advance these figures as exact measures of the value of forests, but they may be taken as indicative of the possible financial loss which might result in stream-flow alone from deforesting such of our water-sheds as are not adapted for cultivation.

It will also be seen how amply this effect of forests in increasing the stream-flow for 5 or 6 months during the latter part of a dry period justifies popular opinion as to a falling off of streams when the forests are cut off. Such effect is very much more likely to impress itself upon the popular mind than an increase of evaporation, for this would tend to decrease the total run-off for the year without being very apparent to ordinary observation. Being a much more enduring effect, it would also be more noticeable than any change in the very greatest or very least rate of discharge.

Most of the portion of the State now in forest is not adapted to cultivation. It should remain in forest, because it will in no other way yield revenue; because it is needed to maintain the equable flow of our streams, and because it renders beautiful what would otherwise be an unsightly waste. Unless the State is prepared to assume the ownership of forest lands, the continued good condition of the forests can only be secured by instructing the owners how they can improve this condition, and, at the same time, increase their revenues. It is especially important that our Highlands forests, for the future gathering-grounds for our city water-supply, shall continue to be preserved and improved, as they undoubtedly have improved during the last quarter century.

Devastation caused by fire in a white cedar swamp, Gravelly Run, Atlantic County.

REPORT ON FOREST FIRES FOR SEASON OF 1895.

BY JOHN GIFFORD.

Professor J. C. Smock, State Geologist, Trenton, N. J.:

The following is mainly a report of progress. A more detailed report, relating to forest fires in South Jersey, to the "Plains," an interesting pitch-pine coppice in Ocean and Burlington counties, forest planting along the seacoast and methods of fixing moving sand, and the cultivation of the white pine, white cedar and other trees for financial profit, is in preparation. Since the presentation of the preliminary report, relating, in a general way, to the forests of South Jersey, besides a reconnaissance tour in the northwestern part of the State, the forestal conditions along the seacoast and tree planting on the beaches have been studied and facts relating to forest fires in the southern interior have been collected. The forest-fire question has received special attention, with the hope of suggesting a practical plan for the checking of this great evil.

Unless this wholesale destruction of useful property is reduced the coastal plain of New Jersey will soon approach a condition little better in appearance than a desert, but, as in England, owing to its almost insular position, the general climate is probably slightly affected by the destruction of a forest cover. Nevertheless its removal will be, if not already, seriously felt in the irregularity of the water-flow and the exposition of sandy soils to the force of winds and rains and the scorching rays of the sun, to say nothing of the extinction of several industries directly and indirectly dependent upon the forest. Never before, to the knowledge of the writer, owing to the extreme drought, have fires been more destructive than during the season which has just ended. In other years they have burned over larger areas of upland, but recently, for many days, they consumed the humus and litter in the bogs and swamps, the dampness of which is usually sufficient to stay their progress.

Parts of the northern section of the State suffered also from fires. They are almost as frequent and, indirectly, as destructive on the Kittatinny and Bearfort mountains as in the sandy pine regions of the southern part of the State. The soil on these mountains is so thin and poor, if not wholly lacking, that trees have difficulty in growing. The forest cover is therefore light; the pitch-pine, with a scrubby undergrowth, predominating.

There are signs of frequent fires on the Green Pond, Bowling Green and Copperas mountains. In fact, throughout the whole of the wooded part of the northwestern section of the State fires are not infrequent during dry times. They are due both to carelessness and maliciousness. It is claimed that many are set carelessly by hunters, and by wood thieves in order to destroy the stumps and branches, which are evidences of their mischief.

The mountains of Northern New Jersey are justly noted for their beauty. The revenue from tourists alone soon amounts to as much as the woods are worth. Forests are probably of as much pecuniary value in adding to the attractiveness of these regions as in their yield of timber. The same is so of the pine regions in the southern part of the State, which, in their present condition, tend to repel rather than attract the tourist.

Owing to the extreme dryness, however, fires have occurred almost everywhere. On the slopes of the Watchung mountain, and even in wood lots in almost deforested areas in Central New Jersey, fences and crops along railroads were destroyed, rendering it necessary to furrow the ground for the protection of farms.

To obtain accurate information on this subject, blanks were prepared and men were paid to visit fires and prepare a description explaining how, when and where they started, how long they burned, the areas devastated, the nature of the timber, and the efforts to subdue them.

Owing to the frequency of fires throughout the State it was impossible to obtain a record of everyone, so an area of land embracing Atlantic, part of Burlington and Ocean counties was selected, since this region has been exposed to the ravages of fire for many years. A map showing the area burnt over is in preparation.

On the average, fires are more frequent in Atlantic and Cape May counties. This is, probably, mainly due to the facts that the forest area is large and continuous, and the region is traversed by several railroads over which many trains pass in the course of a day in summer, in transporting large numbers of people to the seashore. One of these railroads has taken very few precautions, and, judging from the way sparks are showered into the air, it is indeed a wonder that any combustible property is left along its line.

In Ocean county fires did little damage this year. This is due mainly to the fact that, after the severe fires of the season of 1894, there is little combustible matter left to burn on thousands of acres in the region of the plains and southward to the Mullica river.

Fires burned as follows in the pine lands of Ocean, Atlantic and Burlington counties:

1. March 18th, 1895.—Lasted two days; set by spark from locomotive; medium-sized pine and small oak; pine slightly damaged, oak killed; 100 acres; near Dacosta.

2. March 20th, 1895.—Lasted one day; set carelessly by a tramp; small oak; seriously damaged; 60 acres; near Walker's Forge.

3. March 22d, 1895.—Lasted two and a half days; cause not known; medium-sized pine and oak; 3,000 acres; between Harrisville and Green Bank; loss in timber estimated at $8,000.

4. March 26th, 1895.—Lasted five days; set by spark from locomotive; damaged 2,400 acres of oak and pine timber; loss estimated at about $2,000; near Estelle Station.

5. March 28th, 1895.—Lasted three days; incendiary; pine and oak timber; badly damaged; 2,000 acres; near Washington Tavern.

6. March 29th, 1895.—Lasted one-half day; spark from locomotive; slightly damaged 50 acres of pine and oak timber; near Egg Harbor City.

7. March 31st, 1895.—Lasted one day; haymen were burning salt meadows, which is customary at this time of the year, and the wind suddenly shifted, and they were unable to keep the fire out of the neighboring woods; it burned through Griscom's Swamp, an interesting and valuable hard-wood forest in the southernmost corner of Atlantic county; it contained beeches, tulip trees, hollies, pines, white cedars, sassafras and some very fine swamp white oak, bilsted and willow oak; burned over 900 acres; damage estimated at about $3,000.

8. April 11th, 1895.—Lasted one and one-half days; set from a burning brush-heap; 600 acres; oak and pine; badly damaged; near Estelle.

9. April 11th, 1895.—Lasted one-half day; spark from locomotive; 100 acres; near Elwood; timber of little value, having been burnt over many times before.

10. April 17th, 1895.—Lasted one-half day; spark from locomotive; 300 acres; small oak; on Weymouth tract.

11. April 18th, 1895.—A succession of fires for six days; sparks from locomotives; near Elwood; 3,000 acres; medium-sized oak and pine; badly damaged.

12. April 18th, 1895.—One day; spark from locomotive; 1,000 acres; small pine and oak; oak killed; three miles below Egg Harbor City.

13. April 19th, 1895.—One day; spark from locomotive; 1,500 acres; pine and oak; oak killed; near Egg Harbor City.

14. April 19th, 1895.—Slight fire near Bulltown; attributed to carelessness with tobacco pipe.

15. April 20th, 1895.—A slight fire near Pleasant Mills; attributed to careless smokers.

16. April 21st, 1895.—Lasted five days; spark from locomotive (?); medium-sized oak and pine; 15,000 acres; near Tuckahoe. Several houses were saved with difficulty, and $1 per acre is a low estimate of the damage.

17. April 21st, 1895.—Lasted one day; supposed incendiary; near Bakersville; 700 acres; medium-sized pine, with heavy growth of underbrush; killed.

18. April 21st, 1895.—Lasted one day; cause not known, although rumor has it that an intoxicated man was near the fire when it started; near Newtonville; killed small oak and pine on about 1,000 acres.

19. May 10th, 1895.—Two days; accidentally set in clearing a safety strip around a cultivated cranberry bog; near Cedar Bridge; burned over about 2,000 acres, part of which was in thrifty oak and pine from 3 to 10 inches in diameter. The timber was killed, and having little commercial value, owing to its distance from a railroad, will rot in the woods to breed insects or furnish fuel for future fires. In addition, about one acre of cranberry bog, $200 worth of fencing and a large prospective huckleberry and cranberry crop were

destroyed. It burnt over to the eastern edge of the West plains, where it was whipped out without much difficulty.

20. August 5th, 1895.—Lasted one day; spark from locomotive; 60 acres of young oak and pine; near Doughty's Tavern.

21. August 9th, 1895.—Slight fire near Doughty's Tavern; caused by railroad; promptly extinguished.

22. August 10th, 1895.—Slight fire on Millville road; spark from locomotive; promptly extinguished.

23. August 14th, 1895.—Slight fire near Dacosta; caused by spark from locomotive; promptly extinguished.

24. August 14th, 1895.—Slight fire near Elwood; caused by spark from locomotive; extinguished by section men. About this time there were innumerable petty fires along railroads, most of which were extinguished by the section men.

25. August 15th, 1895.—Lasted one-half day; spark from locomotive; near Elwood; 300 acres; medium-sized pine and small oak; oak killed, pine slightly damaged.

26. August 15th, 1895.—Lasted three days; origin not known; near Brigantine Junction; 350 acres; pine and oak; oak killed.

27. August 16th, 1895.—Lasted three days; spark from locomotive; near Brigantine Junction; 3,000 acres; medium-sized pines, with thick undergrowth of young oak; very badly damaged; 100 cords of wood, cut and ranked, were also destroyed.

28. August 19th.—Lasted two days; spark from locomotive; pine and oak of medium size seriously damaged on about 500 acres. This fire occasioned considerable excitement. A strong wind swept the fire at a rapid rate toward the town of Gravelly Run, which was in jeopardy for some time. By back-firing along a road, under the direction of an experienced person, and by hard fighting the houses were saved.

29. August 19th, 1895.—Slight fire on Taylor's meadow property, near May's Landing; carelessly or purposely set; promptly extinguished.

30. August 19th, 1895.—Lasted two days; spark from locomotive; three miles north of Pleasantville; 300 acres; low oaks and pines.

31. August 19th, 1895.—Lasted about twenty hours; incendiary was convicted; burnt over about 1,000 acres; destroyed 50 acres of cranberry bogs; one-half mile east of Jackson pond to head of

Atsion meadows. Two smaller fires in the same section were started previously but were promptly extinguished.

32. August 22d, 1895.—Six hours; on Atsion road from Hammonton; accidentally or purposely set by berry-pickers; fire was extinguished without much damage having been done.

33. August 23d, 1895.—Five hours; on Atsion road from Hammonton; 300 acres; set either accidentally or purposely by berry-pickers.

34. August 23d, 1895.—Three and one-half days; near Buena Vista; spark from locomotive; 1,100 acres of oak, pine, cedar and maple; said to be damaged $2 to the acre.

35. August 24th, 1895.—Lasted one day; set by spark from locomotive; near Buena Vista; 500 acres; pine slightly injured; oak killed.

36. August 25th, 1895.—Lasted one and one-half days; spark from locomotive; near Egg Harbor City; 2,000 acres; pine, small oak and white cedar; killed; some cut lumber and rails on Senator Gardner's place, near Goose Pond, were burned.

37. August 26th, 1895.—Lasted one day; spark from locomotive; started two miles below Folsom, near the swamp on Great Egg Harbor river; deciduous swamp; 100 acres; damage slight.

38. September 4th, 1895.—Lasted ten days; supposed to have been carelessly set by cranberry pickers; started at Crane Pond, not far from Carmantown; 1,200 acres; burned everything before it; cedar swamps, pine woods and oak fit for cord-wood. In spite of two showers and constant watching, several fires started in the meantime in the region very mysteriously. This fire did a very great deal of damage; a large quantity of saw timber was consumed.

39. September 4th, 1895.—Lasted one day; started in an old field near Carmantown; entirely destroyed thrifty young pine and oak on about 300 acres; this fire was carelessly set by a feeble-minded man while burning brush.

40. September 12th, 1895.—Lasted twenty-six days; started by party clearing land; they were burning turf and brush and were unable to control it; near Green Bank; although the timber was not very valuable, the greater part of it, on about 10,000 acres, was killed; a few acres of cultivated, and many acres of wild cranberries and huckleberries were seriously damaged.

41. September 14th, 1895.—Lasted five days; escaped from a work-

man while burning brush; near Bakersville; 4,000 acres, covered with timber fit for market wood; completely ruined; 50 acres of cranberry bogs were burned, destroying the entire crop.

42. September 14th, 1895.—Lasted one day; set by a feeble-minded person while lighting his pipe; consisted of oak fit for cord-wood; some white cedar and pine fit for saw timber, and several acres of cranberry and huckleberry swamps; killed everything on about 1,400 acres; destroyed $500 worth of fencing and a stable; a recently planted chestnut orchard and about 100 cords of wood, cut and ranked, were saved with a very great deal of difficulty; in many places the surface of the earth was burned clean, leaving nothing but stump holes to indicate that trees ever grew there.

43. September 15th, 1895.—Slight damage; set by mistake near Weymouth in back-firing.

44. September 15th, 1895.—Slight damage; near Bulltown; set by careless smokers.

45. September 22d, 1895.—Lasted three days; set by Italians accidentally while working in the woods near Weymouth; 2,000 acres of cedar, pine and oak seriously damaged. A barn was also destroyed. The village of Weymouth was in jeopardy from the flying sparks.

46. September 27th, 1895.—Lasted two days; on the Atlantic cranberry bogs; either carelessly or maliciously set by berry-pickers; 1,200 acres of cranberry land destroyed, including gates, turf banks and about 5,500 bushels of berries on the vines. Loss estimated by a competent person at $20,000.

47. October 4th, 1895.—One day; incendiary; near Atsion; 500 acres of young timber destroyed.

48. October 15th, 1895.—About ten days; set by spark from locomotive near McKee City. This fire was held in check for some time by the section men. It was burning in such a way in the swamp land that they were unable to extinguish it. It swept over about 2,000 acres. It destroyed a very great deal of fine cedar fencing and a sawmill belonging to Colonel John McKee. It entered Gravelly Run cedar swamp and caused a very great deal of destruction, not only consuming some of the finest white cedar in the State of New Jersey, but burned the corduroy roads which lead into the swamp. Old woodmen claim that they have never seen it equaled for havoc. Many trees from 10 to 18 inches in diameter, close

together, very straight and free from limbs 35 feet from the ground, tumbled over in every direction, forming large, impenetrable masses of charred timber.

During the season of 1894 the region of McKee City suffered from a severe fire caused by a careless workman, and many years ago, it is said, the village was completely destroyed by fire.

49. October 22d, 1895.—One day; spark from locomotive; about five miles east of Atsion; mostly savanna land of little value. The small pines on about 300 acres were killed.

Besides these mentioned above there were many destructive fires in Cape May county, an account of which will be sent to you as soon as possible.

SUMMARY.

First fire occurred March 18th; last fire, October 22d. The forest fire season usually begins about the middle of March and ends about the last of October.

There were forty-nine fires in all. Several were burning at the same time, and one lasted for twenty-six days.

Many not mentioned in this report were promptly extinguished without doing damage; others burned unhindered for several days, causing no end of destruction.

There were 7 in March, 11 in April, 1 in May, none in June and July, 18 in August, 9 in September and 3 in October.

March.	Three caused by sparks from locomotives. One by a careless tramp. One, cause not known. One, incendiary. One, escaped from haymen burning meadows.
April.	Six caused by sparks from locomotives. One, careless workman burning brush. Two, careless smokers. One, incendiary. One, cause not known.
May.	One, escaped while burning a safety strip in order to protect cranberry bog from fire.
August.	Thirteen, sparks from locomotives. One, incendiary. Three, carelessly or purposely set by berry-pickers. One, cause not known.
September.	Two, carelessly set by feeble-minded persons. Three, carelessly set while burning brush. One, set carelessly or maliciously. One, set by an Italian back-firing in the wrong way. One, set by careless smokers. One, set accidentally by Italians cooking in the woods.

October. { Two caused by sparks from locomotives.
One, incendiary.

Sparks from locomotives, 24.
Maliciously, 4.
Accidentally and carelessly, 20.

To this list, mainly to show the causes of fires, one due to lightning may be added. This fire did no damage, however, since the rain which soon followed extinguished it.

It is interesting to compare this record with that of the whole State, prepared by Professor Cook, for the season of 1880. There were 54 fires in all; 28 were due to locomotives, 13 were caused carelessly and 7 were caused through malice.

Of course, it is impossible to say that all these fires were positively set in the ways mentioned above. It is a difficult matter to determine the causes of many fires, and no doubt many are of incendiary origin for which railroads and careless individuals are blamed.

Wherever railroads have taken ordinary precautions in the way of spark-arresters, a cleared strip along both sides of the road, with furrows along the edges, and by ordering their men to check all fires in their incipiency, the number and destructiveness of fires have been very materially reduced.

The area devastated by the fires recorded above, in Atlantic county and a large part of Burlington and Ocean counties, amounts to about 60,000 acres. Including cranberry bogs and other property destroyed, besides the timber, the average loss per acre is placed at $10 by several very competent land-owners. It is, however, an impossibility to estimate the damage. This much is certain, however, that several hundred thousand dollars worth of useful material was consumed. It is also certain that this destruction is rapidly depopulating certain sections.

Three fires, the causes of which are not at all known, seemed to flare up spontaneously. The contents of a pipe, a lighted cigar stump or a combustible gun wad is probably accountable for the mischief.

In a region of berries, although perhaps a mystery at the time, it often becomes known later, that fires were set to improve the berry crop. An observer from Ocean county writes: "The natives are suspicious of me, thinking that I will have them punished for starting a fire. Many of them think that fires improve their berry crops, and like to see them burn." There is no room for doubting that fires are set in that way; in fact, some do not hesitate to acknowledge that they have set fires for that purpose. When a land-owner refuses to let people pick wild berries on his property, fires are often started out of spite.

Usually, owing to the dampness of the swamps where the swamp-berry grows (*Vaccinium corymbosum*), the lower parts of the bush are but slightly affected by fire. This plant often attains the size of a small tree, and a fire in passing, during moist times, causes little more than a severe trimming. During the past season, however, owing to the extreme dryness, the bushes were entirely killed. The destruction of the wild huckleberry and cranberry crop will be seriously felt next season by the very persons who have been careless with fire heretofore. There are several indications that people have set fire in times past in order to get the job of helping to extinguish it. For years colliers fired the woods so that they could buy the wood cheaply. The charcoal industry, although at one time a very important one, amounts to very little at present in South Jersey. If a man has no money and is out of a job and knows that the owner of the land will pay him for helping to extinguish a fire, it is a simple matter for him to make work for himself. This, it is claimed, has occurred not very infrequently on large tracts belonging to well-to-do non-residents. Two very serious fires were set in Atlantic county by two feeble-minded persons. They are hardly fit for an asylum, yet not altogether responsible for what they do. Incendiary fires are usually the most destructive, and there is no way in which the cause can be better served than in the conviction and imprisonment of malicious and reckless fire-setters. Fires set by sparks from locomotives, although frequent, are generally not so serious for at least two reasons: The land along railroads has been burnt over so many times that there is little food for fire left, and section men usually endeavor to put out fires caused in that way.

One man in Ocean county set fire to the woods accidentally while endeavoring to burn a safety strip around his bog. Several fires of a very serious nature were caused by burning brush in a careless manner.

The leading industry in the southern part of the State, the cultivation of the cranberry, has been seriously crippled by fire. It is a constant menace to the bogs during the dry season. Wide, cleared strips around bogs and storage reservoirs cannot be too strongly recommended. The destruction of the forest cover has interfered with the regularity of the water-flow to such an extent that water is often lacking when most needed. The cutting of cedar swamps, which are usually full of springs, has also seriously affected the water flow. Several cranberry growers have surrounded their bogs with wide strips of cleared land, and constructed reservoirs in order to insure a supply of water in times of drought.

The soil must be very dry and the fire unusually fierce to burn a swamp of white cedar. Although seldom completely destroyed, the cedars on the edges, at least, are usually killed. This can be very easily prevented by surrounding the swamps with a strip of cleared land.

The hundreds of black boles, which remain to rot in the woods after a fire, in former years were used for the manufacture of charcoal. They are not only ample warnings to capitalists and an obstruction to new growth, but form a nidus for the propagation of pestiferous insects. Many pines have been killed this season by the pine-beetles (mainly *Dendroctonus terebrans*). The following is quoted from *The Forester*, a treatise on forestry by Brown and Nisbet:

"All dead branches and the *débris* of thinnings should, in all cases, be removed from woods and plantations, and should not, under any pretext, be allowed to lie upon the ground for any length of time after they are cut off from the fallen trees. In plantations, fallen branches and the remains of a course of thinning are often left lying to rot upon the ground without any attention being paid to gathering them up or burning them. Such a system cannot be too much condemned, as it is not only opposed to good management, but such dead and decaying branches are also just the breeding places where most of the dangerous insect enemies of forest trees are generated. By removing these branches, and either burning them or converting them into faggots for firewood, a great benefit to the plantation will be the result. In thus keeping all plantations free from small material of this kind, it will be found that they will not be liable to be infested with injurious insects. The after-health of the growing crop will fully compensate for any expense that may be incurred in the operation of clearing and destroying the branches, even although the latter can be put to no profitable use. All foresters, therefore, who wish to have the woods under their charge in a good state of health and as free from the ravages of insects as possible, should use every possible means to have all small poles, branches and brushwood cleared away as soon after thinning as possible."

This does not refer to the living underbrush. The decaying leaves on the surface and living underwood are essential. The main injury caused by a ground fire is the destruction of this surface covering, which exposes the soil to the action of the sun, wind and rain. After cutting, masses of decaying wood remain on the ground. Every woodland owner, after cutting, ought to be prevailed upon to destroy this decaying material at once. This should be done under the direction of an officer of the State, in case it is at a time when there is the slightest danger from fire. By leaving this material to rot on the ground, one person injures his neighbors' properties in two ways: (1) Increasing the danger from fire and (2) by breeding insects which may infest the neighboring woods.

Persons living in small towns in forest districts, if not already, will feel the effects of this destruction by fire, since woodland owners are justified in demanding a reduction in the amount of taxation.

Much could be said of the work of fire in the swamps and bogs during the season which has just ended. The swamp bottoms, through which many streamlets usually percolate, became as dry as punk. It required but the slightest spark to ignite this mass of tinder. Many of these fires burned slowly, one lasting for almost four weeks in spite of a hard shower in the meantime. At night they smouldered. Both sand and water, with which to fight it, were lacking in the swamp, while beating with brush and shovels only increased its severity. In such places it is often necessary to dig trenches through the swamp to stop its progress. The air was filled with dense clouds of smoke, on the particles of which, at night, the moisture of the atmosphere congealed, causing it to float near the surface of the earth. During the month of August, in spite of the heat, even in the larger towns in South Jersey, it was necessary to keep all windows and doors closed in order to keep out the smoke. Along the coast it occasioned a fog. It was not uncommon during the month of August to see smoke rising from four fires at once. These fires burned several feet under the surface, destroying in a short time the humus which has been many years in accumulating. Good authorities claim that this covering of decayed vegetable matter forms at the rate of one foot in from one to four centuries.

Here and there throughout the woods there are shallow ponds with clumps of swamp huckleberry bushes and cranberry vines around their edges. During the drought the water evaporated and the mud on the bottom became so dry that the fires in passing left nothing but white sand and ashes.

In many swamps consisting mainly of deciduous trees the parts of the trees above ground were not burnt, but the roots were destroyed, killing the trees, of course, in consequence. Large numbers have fallen in every direction, forming large piles of dead wood. Others are blown down by every wind. In several places fallen timber has obstructed public roads. Another dangerous fire may start at any time in this mass of *débris*.

For several miles it is impossible to find a green tree of any size. The ground is covered with charred sticks and fallen tree trunks. Here and there a patch of pure white sand is visible. In many places large stump-holes are the only indications that trees ever grew there. It is difficult to imagine a more desolate spectacle.

It requires no argument to convince every thoughtful person that the reckless destruction of useful property is wasteful. The difficulty, however, is in suggesting effective and inexpensive preventive measures. It is evident to all that, in order to put an end to forest fires, they must be prevented or checked in their incipiency rather than to lose time and money in fighting them after they have become formidable. In other words, the remedy is preventive and not curative. At present the main difficulty is that a fire in the woods, in many cases, receives no attention whatever until it becomes dangerous. The reason that woodland owners have taken no precautions for the prevention of fires is mainly that they are willing to take the risk, as great as it is, rather than expend money on their properties. After the damage is done they are, of course, still less inclined to pay for the construction of fire lanes for the protection of property which is worth very little, and which will yield no revenue for several years. Every woodland owner knows the efficacy of the proper kind of fire lanes.

In many regions a fire is left to itself until night, when it smoulders. If the owner of the property is away and no one is left to care for it, fire may sweep over it, and the majority of people in the region will pay little attention to it until their own properties are endangered. Even if watched for years, at an unexpected moment an incendiary may start a fire on your neighbor's property, if not on your own, and not only your wood, but 50 years of watching and fire fighting count for nothing. With no protection whatever, with a slight chance for reimbursement, which is meagre at best, and with a tax rate which is high in proportion to the yield of ordinary woodland, there is little wonder that many land-owners are discouraged, and that forest property is passing into the hands of non-resident capitalists, who are able to hold it with other objects in view than the growing of forests.

In speaking of a severe fire in the region of Weymouth, an observer says:

"Much of the land burned over in this region during the past season was covered with a growth of from 25 to 50 years of age, which, with great care and at great expense, had been preserved from fire all these years. A liberal tax has been paid, and it is only reasonable to expect that the present owners will demand a reduction of assessment, which will make a very perceptible difference in the local tax rate."

In the majority of cases there is a lack of method in subduing a fire. There is a general indifference to fire for several days; there are mistakes in fighting, resulting from fear and lack of experience; there is always a lack of organization and judgment with volunteer fighters; there is the frequent undoing of work already accomplished, because of the absence of watchers after the flames have been controlled; there is often discouragement, and one party of fighters may leave without informing the other party or parties; there is difficulty in arousing the people even when danger is imminent; there are many instances where fires are permitted to sweep by vantage points, such as roads or streams, through indifference or a lack of knowledge of the geography of the region; and in back-firing trouble is often caused when one man's property is sacrificed to save that of others. In spite of the smoke and heat it is remarkable, however, what one man can do, with nothing but a branch of a tree for a weapon, in "whipping" out fire. Many ground fires can be quite easily extinguished in that way. An experienced woodman, with a bush for a weapon, can whip out fire as he walks along its edge. At other times an army of men is powerless to check its advances in any other way than by back-firing from a stream, road or other point of vantage.

Mr. T. P. Price, of Tuckerton, speaks of the attempts to subdue the great fire which swept over a large part of Ocean and Burlington counties in 1894, in the following words:

"On Friday (July 13th, 1894) the fire raged across the country. I rode out into the woods to investigate. The main body of flames had swept by upon Stafford Forge and Manahawken, but the long flank was left, mile after mile of fire backing down toward Tuckerton. A northwest wind would, therefore, bring us instant and most alarming peril. An attempt was made to rally a fighting force, a harnessed team going at evening into the village, the danger and opportunity being both presented. The men acknowledged the truth of all that was said, but firmly took the stand that they ought to be paid.

"Are they not right? They do not own a foot of forest. The owners are capitalists living in New York, Philadelphia and other states and cities. Why should boatmen and laborers spend a night in severe and dangerous toil without compensation, fighting fire for absent owners? And again, Why should absent owners pay men to fight fire when they go out, an undisciplined mob under impromptu leadership, and when it is often too late to save the property? And again, Who shall telegraph the owners and get them to act?

"If anyone thinks townships can act, I reply, this fire burnt property in at least eight townships. For them to act as townships would be a wasteful and confusing policy.

"If the State acts by means of large districts, we shall have unity. This fire could have been put out a dozen times by a small State force, paid, officered, disciplined and known to have authority. The State taxes forest property and also the exposed towns. Does it not owe them protection? One cent per acre, annually, under wise organization ought to pay the cost.

"But Tuckerton was not rid of her fire. Nature has encompassed her with bays and rivers, and a merciful Providence held the wind continuously in a quarter from the sea. Still the fire slowly inclosed her.

"Alive to the folly of sitting still, another effort was determined upon. Knowing two good men who were willing to fight, it was decided to go out with these alone, if necessary, but there were hopes that the example would have inspiration. So it proved. We started one evening at six o'clock and by nine had fifteen or twenty men. Three or four miles of fire were subdued, and when we returned, wearied, at three o'clock in the morning, it was expected a fresh force would finish the arduous battle. But the fresh men never came, and the mile of fire left burning within forty-eight hours undid the work accomplished. Another proof of the need of organization.

"Other days pass, and again one afternoon the smoke arises black and near. I hasten forth, to find a Jew in the outskirts has been seized with a panic and has set a fire nearer, hotter and more dangerous than the one that frightened him. The new fire sweeps wildly before the wind, whereas the old fire had to burn against the wind.

"Fifty men sit looking on. Two things are evident. One is that nine-tenths of the people are mere spectators, the other is that a section gang sent by a railroad, being paid for their time, expect to work. These men go into the line of fire, but the task before us is hopeless unless we can find a strategic point from which to fight. Fortunately, it is found at last, just in the nick of time, and by hard work and back-firing we gain the day.

"This fire, so narrowly brought under control, ought to have been watched, but with no system who is to do the watching?

"In a few days there is peril again, with the enemy at still closer quarters. Two bodies of men go out and begin by direct assault on each extremity of the fire. They are, perhaps, a mile apart. The thermometer in the woods is above a hundred degrees and the flames are like a furnace. The men lie down again and again from exhaustion. There is no drinking water. The woods are a tangled thicket of undergrowth and briars. No tidings come from one company of men to the other. No one knows whether the fight is maintained elsewhere, or how large a body of fire remains to conquer. Discouragement appears. Then a volunteer of one company undertakes to determine the situation. He finds two-thirds of the fire put out; the other company of men completely discouraged and on their way home, and a plucky worker fighting, single handed, in the middle of the line of fire, though ignorant of other helpers.

"A knowledge of the situation cheers everyone, and all return to work with a will. Drinking water is brought by a team, and in a brief space of time the battle is over. Many lessons appear, but they sum up in this: There must be organization and it is especially desirable to have good leadership."

In just such ways the majority of fires are fought in South Jersey. It is as difficult to get good men as it is to put out the fire. Everybody who will go is taken to the fire; a few work but the majority are spectators. Very often they forget to take drinking water. On one occasion, during the season which has just ended, the fighters had whiskey and crackers in abundance but no water.

In order to prevent forest fires there are three requisites: *Co-operation of the people*, especially woodland owners, *wide fire lanes* and *paid wardens*.

It is difficult to properly adjust communal and individual interests and rights. The conservation of the forest cover for the sake of the community is highly important. Fires are so destructive, wood so cheap, the time that invested capital must wait so long and the communal spirit in thinly settled regions so weak that a great deal of persuasion is necessary in order to induce woodland owners to change their methods or spend one cent more than is absolutely necessary on their forests.

Nevertheless, this is the first and most important step. Landholders may be divided into three classes: The farmers with their wood lots, the speculators in land who hold it temporarily, and the lumbermen and manufacturers. Unfortunately a large part of the land in South Jersey is in the hands of the second class. The first and third classes are the most important. Their co-operation is essential. In order to gain their influence it is necessary to convince them that the reckless destruction of forests is in the end as detrimental to their interests as to the welfare of the whole community. To respect trees we must know trees. Interest can be aroused by instituting courses of lectures throughout the State, by freely distributing literature on the subject, by introducing it to a limited extent in public institutions and by the appointment of a person or persons to furnish information on the subject to woodland owners.

Forestry associations, some of which have been aided by the States in which they are located, have already accomplished a very great deal in this line. If every person interested in forestry practices it on his or her own property it will have an appreciable effect. If a few construct fire lanes around and through their properties others will soon do likewise. It is gratifying to note that in the northern part of the State several persons are contemplating putting their forests under forest regulation. Mr. Theodore Havermeyer, on his estate near Mahwah, has employed Mr. F. R. Meier as forester. The work of thinning and planting is well under way. If the owners of large tracts in the southern part of the State would employ practical foresters to direct the work of cutting, attend to the regeneration of depleted areas and to the prevention of fire the problem would be almost solved.

One of the most practical steps toward the prevention of fire is the construction of fire lanes. The forest covers such broad areas in South Jersey that a fire can travel many miles without meeting with cleared areas of any extent. Even if a fire lane or cleared strip is not wide enough to stop the progress of a fire, it is always of value as a point of vantage in back-firing. General Elias Wright, of Atlantic City, describes a fire which occurred during the month of April, a few years ago. It "jumped" the Mullica river where it is 600 to 800 feet wide. By "jumping" is meant, of course, that the sparks flew to such an extent that they ignited the woods on the opposite side of the largest river in South Jersey. For all ordinary fires a strip of cleared land 50 feet wide, if kept clear from combustible matter, would be very effective. In the case of ground fires, which do a great deal of damage and burn for several days without being noticed, a path through the woods, if the wind is not blowing, often serves to check their progress.

Fires lanes along railroads have proved very efficacious in South Jersey, especially those which have been furrowed along their edges. By keeping these lanes free from combustible matter the most prolific source of fires can be materially reduced. At present these lanes are insufficient, although the companies usually clear about 40 feet on each side from the middle of the track. At certain times sparks are thrown long distances.

Railroads are essential even to the woodland owner. His wood would be worthless without a means of transportation. There are many reasons why he should co-operate with the railroad and clear and keep clean about 40 feet along the railroad. The leaving of a strip of deciduous trees between the lanes is advocated by several. It beautifies the country and acts as a screen, preventing the sparks from flying over the outside lane. The expense of clearing such a strip would not be great. If spark arresters are used, ashes deposited in places especially prepared for the purpose and double lanes constructed, one by the railroad and the other by the land owners, fires from locomotive sparks would be much less frequent. In Europe there are fewer fires caused by railroads than any other cause except lightning. Mr. B. E. Fernow, in speaking of forest fires in Europe, says: "On the 6,000,000 acres of forest belonging to the Prussian government, during the 10 years (1882–1891), 156 fires occurred; 96 were due to negligence, 53 to ill will, 3 to lightning and 4 to locomotives." Seven years out of the 10 are without any record of fire due to the last cause. These 156 fires burned in all about 800 acres. This was considered a heavy loss from fire.

Public wagon roads will serve for fire lanes, if they are properly trimmed out and kept free from combustible material for at least a distance of 25 feet from the middle of the road. The wider, of course, the better. It is not necessary to cut down the large trees. They serve to keep the road in order by shading it, and also furnish a shelter from sun and wind. In their present condition fires not only sweep over them without much difficulty, since on many public roads the brush is so dense on both sides that there is barely enough room for wagons to pass. Many fires are carelessly set by people in passing. A match or cigar is carelessly thrown from a wagon into the grass and leaves along the edge, and a fire is caused in consequence, without being noticed by the person who set it. This frequently happens. Instead of acting as lanes for the prevention of the spread of fire, railroads and public roads are the places where the largest number of fires start. Some have suggested that instead of employing several men to work at certain times on a road, that one man be given a piece of road to keep in order, not only busying himself with mending the small breaks before they become serious, but by patrolling the road continually, watching for and extinguishing fires which may be carelessly set, and by trimming the trees along its sides and burning the combustible material at the proper time. In that way what is now a source of danger may be turned into a lane which will effectually prevent the spread of fire.

Many land-owners have been consulted on this subject, and the opinion is almost unanimous that the widening, clearing and furrowing the edges of lanes along railroads, and the widening and clearing of certain public roads would be the most practical, efficacious and inexpensive step toward the prevention of fires.

Even in well-regulated forests fires cannot be wholly prevented. As in towns and cities, however, by organization the damage can be reduced to a minimum. It is even possible, in the course of time, to reduce the risk to such an extent that forest property may be made insurable.

Forest wardens are, of course, indispensable. The presence of an experienced person, with authority to act, is needed at every fire. Some one must have authority to say how, when and where to backfire. Some one is needed to apprehend and bring to court persons guilty of incendiarism, criminal negligence and wood thieving. Some one is needed to supervise the burning of brush and to see that the laws relating to the woods, and everything that concerns the woods, are properly enforced.

The following is a letter in reference to forest fires, from Mr. B. E. Fernow, Chief of the Forestry Division :

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF FORESTRY,
WASHINGTON, D. C., November 14th, 1895.

Mr. John Gifford, Mays Landing, N. J.:

DEAR SIR—The principles upon which effective forest fire legislation can be established are well known and tested by experience in certain portions of our country. You will find them discussed at greater length in the appended circular. Substantially these principles were embodied in the legislation, which now exists and is successfully enforced in the State of New York, enacted through the efforts of the late Senator Low, at whose request I drafted the bill. The same was copied, with modifications, to suit local conditions by the States of Maine, Wisconsin and Minnesota. Improvements, especially in the methods of carrying out the law are, to be sure, quite possible.

Organization is the keynote of success in dealing with the fire problem. We have recognized this in the cities and villages, where it was found that even the concentrated property interests did not afford protection without well-organized fire departments. Much more so is *organized* effort necessary in the country, where property is less concentrated and the single owner powerless to protect himself. In addition, the value of forest property being low per unit, although large in the aggregate, and its safety of more moment to the community at large than to the single owner, he feels both less capable and less inclined to exercise the care and incur the expense of securing its protection. Especially is this the case where, as in New Jersey, large tracts are held by absentees.

Fire legislation, no more than other criminal legislation, executes itself, hence the first requisite is a responsible officer charged with the enforcement of the law. This duty might be charged to one of the existing officers, but inasmuch as these have probably all the work they can attend to and as the organization of a fire service and the enforcement of the law will at least at first require close attention, a special fire warden is preferable. The organization of the fire service again could be by volunteers or by increase of duties of existing officers or by specially paid officers. At least in the less populated, most endangered sections and during the dangerous season only the latter class will be found effective.

There is no good reason why, therefore, in the northern hardwood and agricultural region the fire guards may not be unpaid volunteers —being paid only when actually employed in putting out fires—a system which has been successfully employed in some parts of Pennsylvania, while in the pineries of South Jersey the system of paid watchers should prevail.

A small force, properly stationed and instructed, ready at any time to put out incipient fires could unquestionably reduce the fire bug to insignificant size. These men should have sheriff's power to arrest suspected incendiaries and also to raise a posse for the purpose of fighting fires. To increase their effectiveness a districting of the area they are to watch by roads or in the absence of these by fire strips, which might be burnt over in early spring, thus confining the danger upon smaller areas, is advisable.

The first objection—in fact almost the only seemingly valid one—would be as to the expense; but when it is considered that notoriously every year damage to the extent of several hundred thousand dollars is done to property, not to count the damage to the commonwealth and the future in wasting fertility and taxable value of the soil, an expense of $25,000 per year for such service, which would be more than ample, must appear insignificant and well spent.

This expense should be levid on the forest owners themselves according to their acreage, a charge of one cent per acre sufficing to insure their protection.

I hope you will be able to formulate legislation upon such principles as here outlined fitting the particular condition of your State, and that your legislature will see the prosperity of at least an honest attempt of blotting out the worst enemy of New Jersey's prosperity, at least in the southern parts—the forest fires.

Yours for rational treatment of our resources,

B. E. FERNOW,

Chief of Division of Forestry.

The following is a part of a circular which is being distributed by the Division of Forestry:

FIRE LEGISLATION.

The most harmful avoidable waste comes from losses by fire. Not only are enormous quantities of timber killed or deteriorated in value by the annual conflagrations, but by the burning of leaf mould and seedlings the ground is made barren and given over to inferior vegetation and scrubs, and desirable reforestation is prevented. It would be in the interest both of lumbermen and of communities to stop this waste. This circular, therefore, appeals to lumbermen not only to enjoin upon their workmen the necessity of a more careful use of fire, but also to be instrumental, especially by associated effort, in bringing about the enactment and enforcement of proper fire legislation. There is no reason why forest property should not be as well protected by the community as any other property, and protection will be afforded if the owners insist upon it.

Following is the draft of a bill which can be applied, more or less modified according to circumstances, in every State, its main features having been drawn from the law enacted for the State of Maine in 1891, and there successfully applied. The writer would lay special stress upon the necessity of intrusting the enforcement of the law to an officer specially charged with and responsible for it. In several States fire legislation is in existence which is satisfactory, except that it lacks the proper machinery to enforce its application.

The principles most needful to keep in view when formulating legislation for protection against forest fires are—

(1) No legislation is effective unless well organized machinery for its enforcement is provided. The damage done by forest fires extending in many cases far beyond immediate private and personal loss, the State must be represented in such organization.

(2) Responsibility for the execution of the law must be clearly defined and must ultimately rest upon one person, and every facility for ready prosecution of offenders must be at the command of the responsible officer.

(3) None but paid officials can be expected to do efficient service, and financial responsibility in all directions must be recognized as alone productive of care in the performance of duties as well as in obedience to regulations. In the case of corporations the officers most directly responsible for any damage, as well as the corporation itself, must be amenable to law.

(4) Recognition of common interest in the protection of property can be established only by the creation of financial liability on the part of the community and all its members.

AN ACT FOR THE PROTECTION OF FOREST PROPERTY.

FOREST COMMISSIONER.

Section 1. Creates a forest commissioner, whose office may be either an enlargement of some existing office or, much better, a separate one, with adequate compensation in either case, to be appointed by and reporting directly to the governor.

Sec. 2. Prescribes the duties of the forest commissioner, namely, to organize, supervise and be responsible under the provisions of this act for the protection of forest property in the State against fire. In addition, he is to collect statistics and other information regarding the forest areas in the State, and the commerce of wood and allied interests, especially such information as will explain the distribution, value, condition and ownership of the woodland. This information and the results of the operation of this act, together with suggestions for further legislative action, to be embodied in annual reports.

Sec. 3. Provides for the giving of a bond by the forest commissioner for the faithful performance of his duties, and fixes fines for such neglect in performing the duties of the office as may be proven, and explains the manner of imposing and collecting such fines.

ORGANIZATION OF FIRE SERVICE.

Sec. 4. Constitutes the selectmen of towns, or the sheriff's deputies, constables, supervisors, or similar officers, as fire wardens. If preferred, special fire commissioners may be appointed by the forest commissioner, with the advice of county commissioners, or both methods of providing fire wardens may be employed together. The towns are to be divided into fire districts, the number and boundaries to be governed by the exigencies in each case, and each district to be under the charge and oversight of one district fire warden. One of these should be designated as town fire warden, to take command in case of large conflagrations. The town fire warden, and at least 50 per cent. of the district fire wardens, should be property owners in the county, unless a sufficient number of such cannot be found or a considerable number refuse to serve. A description of each district and the name of the fire warden thereof are to be recorded with the forest commissioner and the town clerk or similar officer.

Sec. 5. Provides for employment of special fire patrols in unorganized places in any county and during dangerous seasons, especially in lumbering districts, and for co-operation of forest owners. Wherever unorganized places exist in a county or so far distant from settlements as to make discovery of fires and speedy arrival of regular fire wardens impossible, or wherever forest owners whose property is specially endangered require, the forest commissioner may annually appoint special fire patrols to be paid at daily rates, the owner paying one-half the expense and the State the other half, such patrols to be under the regulations of this law, and to report to the nearest fire wardens. The manner of appointment and the matter of compensation and duties are to be formulated by the forest commissioner.

Sec. 6. Defines the powers and duties of fire wardens; to take measures necessary for the control and extinction of fires; to post notices of regulations provided in this law and furnished by the forest commissioner; to ascertain the causes of fires and prepare evidence in case of suits; to report each fire at once to the forest commissioner on blanks furnished, giving area burned over, damage, owner, probable origin, measures adopted, and cost of extinguishing; to have authority to call upon any persons in their district for assistance, such persons to receive compensation, as determined by the selectmen or county commissioners, at the rate of not to exceed 15 cents per hour, and to be paid by the town or county upon certification by the forest commissioner.

Persons refusing, when not excused, to assist, or to comply with orders shall forfeit the sum of $10, the same to be recovered in an action for debt in the name and to the use of the town or county, or for the fire protection fund.

Fire wardens shall be paid $10 a year as a retainer, besides days' wages at the same rates as sheriffs or similar officers for as many days as they are actually on duty, and shall be responsible for prompt extinction of fires and be amenable to law for neglect of duty. The district fire warden shall call on the town fire warden in case of inability to control fires, and the town fire warden shall have sheriff's power to enlist assistance, as provided in case of a mob.

FIRE INDEMNITY FUND.

Sec. 7. Provides for the creation of a fire indemnity fund, each county to pay into the State treasury $1 for each acre burnt over each year, the special fund so constituted to be applied in the maintenance of the system provided by this act and for the payment of damages to those whose forest property has been burned without neglect on their own part or on that of their agents.

The burned areas shall be ascertained by the county surveyor and shall be checked from the reports of fire wardens by the forest commissioner. All fines collected under the provisions of this law shall also accrue to the fire fund.

JURISDICTION AND LEGAL REMEDIES.

Sec. 8. Establishes jurisdiction and legal proceedings in case of prosecution of incendiaries and adjustment of damages, and imposes upon every district judge the duty, in charging the grand juries of his district, to call special attention to the penal provisions of this act and of any similar acts providing for offences against forest property.

Sec. 9. Charges the forest commissioner to issue and publish, by posters and otherwise, reasonable regulations regarding the use of fires, such regulations to contain special consideration of campers, hunters, lumbermen, settlers, colliers, turpentine men, railroads, &c., and to be approved by the governor.

Sec. 10. Makes it a misdemeanor to disobey the posted regulations of the forest commissioner, or to destroy posters, or to originate fires by neglect of the same; provides that the prosecution shall be prepared by the forest commissioner; and imposes fines and imprisonment in addition to damages. Fines should be double the actual damages, one-half to go to the fire fund, one-half to the person damaged.

Sec. 11. Makes it a criminal act, subject to indictment, to willfully set fires, and imposes fine and imprisonment.

Sec. 12. Any person whose forest property is damaged by fire not originated by his own neglect, and who is able to prove neglect on the part of the fire warden, may call on the forest commissioner for award of damages, whereupon the forest commissioner, in conjunction with the county authorities, shall investigate the case and shall refer his findings to the judicial officer of the district, who shall charge the grand jury to indict any offender against this act and adjudge any neglectful fire warden, or other officer, or any person refusing to act upon order of the fire warden.

Any neglect on the part of the forest commissioner to investigate and find in each case within one year from the appeal of the owner shall be followed by dismissal, unless reasonable cause for failure be shown.

LIABILITY OF RAILROADS.

Sec. 13. Charges railroad companies to keep their right of way free from inflammable material by burning, under proper care, before certain dates to be established by the forest commissioner. Failure to do so upon notification by the commissioner shall be followed by the arrest of the superintendent of the section, who shall be liable *prima facie* to procedure under Section 10.

Sec. 14. Provides for the use of spark arresters, failure to comply with this provision to be followed by arrest of the superintendent or other officer in charge of the motive power and by procedure under Section 10.

Sec. 15. Fires originating from the tracks of a railroad company shall be *prima facie* evidence of neglect on the part of the company, and the engineer and fireman shall be liable to arrest and procedure under Section 10.

Sec. 16. In all cases where a fire originates through neglect of a railroad company or its agents, both the company and its officers shall be liable for damages under the provisions of Section 12.

Sec. 17. Establishes special liabilities for damage by fires in case of railroads under construction.

FIRE INSURANCE AND STOCK LAWS.

Sec. 18. Provides for the incorporation of forest fire insurance companies. In States where cattle are allowed to roam provisions to stop this practice should be enacted.

FURTHER DUTIES OF FOREST COMMISSIONERS.

Sec. 19. Defines minor duties of forest commissioners, namely, to co-operate with superintendents of schools and other educational institutions in awakening an interest in behalf of forestry and rational forest use.

Sec. 20. Provides for salary and other expenses of the office of forest commissioner, which should be liberal in proportion to the responsibility of the office.

Sec. 21. Repeals all acts and parts of acts inconsistent with provisions of this act.

NOTES ON THE FORESTS OF NEW JERSEY.

BY GIFFORD PINCHOT.

The following notes have been gathered during a very hasty survey of certain of the forest areas of New Jersey, and they should in strictness be taken to apply only to those places which I visited. Consultation with others, however, whose acquaintance with the surface of the State is far more detailed than mine, and whose observation of the uniform character of each of its two forest divisions confirms my own, has convinced me that the conclusions I have reached are applicable, so far as they go, to the whole area of the State.

These notes consider the forest altogether from the forester's point of view. That is to say, this question has been asked with reference to each piece of woodland examined, assuming that its proper function is to produce forest and not agricultural crops: How can the forest be made to yield permanently the largest possible contribution to its owner and to the commonwealth? In other words, What is the best system of management for the forest in view of the particular surroundings in which it is placed? The answer must vary widely in its details, following the very diverse character and circumstances of different pieces of forest. Longer and more careful study is often required to frame a satisfactory reply to this question for a single forest than could be given to the present rough survey of the whole State. Consequently no attempt is made in this paper to do more than bring together a few of the more obvious facts, and then to formulate in brief some of the general requirements which they indicate.

The forests of the State of New Jersey may be divided into two classes, separated from each other by the well-known line running nearly north-east and south-west through the State between Salem on the Delaware and Long Branch on the coast. North and west of this line the forest is composed of deciduous trees, mainly the Chestnut and several Oaks, and practically the whole area is sprout land. That is to say, the great majority of the trees of this region have not grown from seed, but are shoots or sprouts from old stumps. The technical term for such forest is coppice.

Hitherto it has been the general custom, which still obtains wherever the fall of prices has not interfered, to cut these coppice woods clean as soon as they were ripe for hoop-poles, cord-wood, ties, charcoal, rails, or mine timber, as the case might be. The average age of cutting in the localities I visited is probably not far from thirty years. After the trees have been cut the old stumps sprout again, and the sprouts form the material of the new crop. If we suppose that the stumps are but ten feet apart each way, by no means an excessive estimate in this case, it appears at once that several years must elapse before the new sprouts spread sufficiently to shade the ground. During this time the covering of vegetable mould is dried up and dissipated by the sun and wind, and the ground becomes more or less thickly covered with grass. Heavy lower branches formed on the young trees in early youth live on for years during the comparative isolation of the individuals, and when they are finally killed by the shade of the upper branches they are so large that their rotting stubs persist for years on the trunk, and in the end form dangerous centers of decay. The space between the stumps is often more or less scantily occupied by young seedlings soon after the cutting of the old wood, but the rate of growth of coppice shoots is so much faster in early youth than that of seedlings that it is comparatively seldom that one of the latter succeeds in forcing itself into the upper story of growth. Before cutting, the shade of the old sprouts is usually too dense to permit much advance growth beneath them. Seedlings from this source, which would be better fitted to withstand the competition of the sprouts, are consequently rather scarce. As a result the same stools serve for generation after generation of sprouts.

While I cannot yet speak with certainty on this point, I am inclined to believe that a considerable part of the disease so common in the older coppice woods is due to this lack of new blood.

Another unfortunate result of the small number of stools is the very irregular distribution of the trees. There is probably a considerable loss from this source, because the dominated trees, unevenly distributed and of uneven size, are often valueless for that very reason. It is often not worth while to cut from year to year a few poles scattered here and there, whereas a regularly distributed crop of thinnings, such as proper management secures, would pay for itself under the same circumstances merely from the convenience and economy of handling it. And in addition there is the marked improvement of the remaining trees which is the natural result of good thinning.

The reasons against the present form of coppice forest are, then, the deterioration of the soil, the shorter life and greater liability to decay of the coppice shoots as compared with seedling trees, and the defects in the trunk which arise from the open condition of the forest in early youth. On the other hand, from such information as I have been able to gather, I believe it probable that the relative scarcity of saw timber, and the great supply, limited demand, and consequent low price of the product of small trees, will be found on examination to furnish a sound financial reason for allowing forest trees in northern New Jersey to attain a greater age.

It is probable that one form of the group system, a method of management which consists in cutting a small hole in the forest and gradually extending it as the uncovered area is seeded by the surrounding trees, would be one of the kinds of treatment most applicable to these forests for the production of large timber. More careful study is required, however, before a definite opinion can be pronounced upon this point. And in any event the present method, while it is not by any means the best attainable, still does not result in the immediate destruction of the forest. In northern New Jersey the question is not so much that of saving the forest, since that is already being done to a very considerable extent, but of the proper treatment of it. Adequate fire protection must here be the result of proper forest management. In southern New Jersey fire protection must come first.

Before passing on to consider the forest south of the Long Branch-Salem line it may not be out of place to mention three general rules, of easy apprehension and application, which apply to all the hardwood forests of New Jersey. These are, first, never cut out underbrush unless it is actively interfering with the live crowns of the trees above it; second, in thinning a forest, never allow light enough to reach the ground to produce a growth of grass; third, thin by the top only. Trees which do not interfere with each other in the crowns do not interfere at all.

The woodlands east and south of the Long Branch-Salem line present a totally different set of problems. Here the one vital and immediate question is the prevention of fires. Any attempt at the proper treatment of these forests must depend altogether on the successful elimination of this source of danger. Once that is accomplished, the prospect for producing timber at a profit in southern New Jersey is perhaps better than in the northern part of the State, at least as respects a certain class of lands. But in the absence of fire protection forest management is here impossible.

The forest in this part of the State was originally composed of coniferous trees to the more or less complete exclusion of broad-leaved species. Conifers are still distinctly the predominant trees of the region, but the action of fire has served to increase the proportion of hardwoods to a very considerable degree. The Oaks and the Chestnuts, by which the Pines and Cedars are often succeeded, sprout freely from the stump, and therefore very often survive in spite of the deadening of the whole growth above ground by fire. The Pitch Pine also sprouts from the stump, but the shoots are slender and short-lived, and never succeed in forming trees. Neither the Short-leaf Pine nor either of the Cedars comes up again from the old roots when the trunk of any individual is killed.

The action of fire is three-fold. It burns up the accumulation of vegetable matter on the ground, which is the manure of the forest, weakens or kills the trees themselves, and exerts a powerful influence on the composition of the succeeding crop. In all three of these directions its influence in southern New Jersey is for harm. So serious and so insidious is the damage done when a forest-covered swamp with peaty soil takes fire, that I saw in November near Weymouth, in Atlantic county, a piece of swamp with the forest on it completely dead, and yet with no trace of fire visible anywhere for more than a foot above the ground. Already the trees had begun to fall before the wind. By the end of the winter it is likely that not a standing tree will be left upon this area, which is now, to the casual glance, a prosperous bit of woodland. The fire which did this damage occurred in September and October of this year and burned for six weeks.

Effective measures against fire in southern New Jersey must consist in the construction of fire lines and the dissemination of knowledge about them. The scheme outlined by Mr. John Gifford in his paper on the forest conditions of southern New Jersey in the report of the Geological Survey for 1894 goes to the root of the matter at once when it proposes that all public roads should be converted into fire lines.

The cutting and maintenance of roads or fire-lines on the sandy soil of this part of the State will be a matter of comparatively small expense. To clear an area on each side of the public roads, many of which are mere wheel tracks through the woods, so that the barrier to fire would range in width from 40 to 60 feet according to the height and density of the growth on each side, would reduce the danger from this source to a marked degree. Such fire-paths not only serve to check the fire in themselves, but they afford invaluable lines of defence from which to start back-fires and otherwise to resist its progress. It seems evident that the effectiveness of fire-lines combined with moderate watchfulness is not adequately realized. The same fire problem, under not less difficult conditions, has been successfully solved in British India by means of them.* At first the general public opinion, there as here, was that the fires could not be stopped, and that it was useless to attempt it. But now that the thing has been done, the sentiment of the people, once indifferent or even hostile, is in hearty sympathy with fire protection and keenly aware of the benefits which they derive from it.

An example, which is always the most effective way of teaching, would probably do more to bring the practicability and usefulness of fire protection to the attention of the owners of woodlands in this region than any number of circulars or reports. Nevertheless, and perhaps also as a means to this end, I believe that the extensive circulation of a succinct statement of the damage fires are doing, the way to fight them, the construction, location and cost of fire-lines (with diagrams), and the results of fire protection, would be exceedingly useful. Such a statement would unquestionably influence the public mind, and as soon as public sentiment is sufficiently alive to compel effective and united action against fire on the part of the railroads, a very large part of the battle will have been won.

As soon as a reasonable degree of safety against fire has been secured south of the Long Branch-Salem line the question of forest management for profit will become important. The elements of success in this direction are present here, over considerable areas, to an unusual extent. White Cedar (*Chamæcyparis thyoides*, L.), one of the most valuable timber trees of eastern North America, grows rapidly,

* Where not less than 24,000 square miles of forest are successfully protected against fire every year at a cost of less than $3 per square mile.

abundantly, and with magnificent reproduction in the frequent swamps of this region. At present, so great is the haste to harvest what may so easily be burnt, the White Cedar is usually cut in very early youth. At the only saw-mill I visited none of the "logs" on the skids were over twelve inches in diameter; the majority were not over eight inches, and very many were less than four inches in diameter at the large end; a few were not over three. Yet these "logs" had been cut at the surface of the ground, and the measures given include the root-swelling in every case.

The rate of growth of both White and Red Cedar (*Juniperus virgiana*, L.) is far less rapid than that of the Pitch Pine (*Pinus rigida*, Mill) and the Short-leaf Pine (*Pinus echinata*, Mill), locally known as Yellow or Smooth-bark Pine. I have no ring measurements for the White Cedar, but it appears from an examination of Red Cedar stumps, posts, and post timber grown on white sand on the shore of Great Egg Harbor below Mays Landing, that in similar situations this tree, in rather open forest, may be expected to produce posts worth thirty-five cents in about thirty years, and posts worth seventy-five cents in forty to fifty years, on the basis of present prices. These prices, I understand, correspond approximately to diameters on the stump of six and ten inches respectively. The rate of growth of Pitch Pine, standing free in the same locality was remarkably fast. Four trees were measured, of which the least rapid in growth, twelve inches in diameter on the stump, had twenty-five annual rings, and the most rapid, eleven inches in diameter, had eighteen annual rings.

After the fires have been checked it is very probable that planting or sowing will be required to reforest parts at least of the fire-barrens, and it is extremely fortunate that such valuable species as White Cedar, Red Cedar, Black Walnut, and the Short-leaf Pine are available for use in this hitherto remarkably unfortunate region. But for the present the whole question of the treatment of these sandy lands, thinly covered with a growth of small and scattered trees, must remain secondary to the pre-eminent need of protection against fire. Meanwhile it is encouraging to believe that the task of re-establishing the forest when the fires are gone will be an easy one, at least so far as the areas which I have visited are concerned. That certain valuable kinds of trees will grow rapidly and well on these deep, loose sands seems evident, and among these the two Cedars and one of the Pines, whose abundant seeds are distributed by birds and by the wind, are already on the ground.

PUBLICATIONS.

The demand for the publications of the Survey is continuous and active, and several of the reports are out of stock. So far as possible, requests are granted by giving the reports to such requests.

The sales of the topographic maps are slightly larger than in 1894. The amount realized by these sales for the fiscal year ending October 31st, 1895, was $400.

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, notably those of 1868, 1873, 1876, 1879, 1880 and 1881, 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 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 third volume is now being distributed from the office of the State Geologist. 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, as usual, distributed without further expense

than that of transportation, except in a single instance of the maps, where a fee to cover the cost of paper and printing is charged 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, 8 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, Out of print.

A PRELIMINARY CATALOGUE of the Flora of New Jersey, compiled by N. L. Britton, Ph.D. New Brunswick, 1881, 8vo., xi.+233 pp. 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, 8vo., x.+642 pp.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. II. Part II. Zoology. Trenton, 1890, 8vo., x.+824 pp.

REPORT ON WATER-SUPPLY, by Cornelius Clarkson Vermeule. Vol. III. of the Final Report of the State Geologist. Trenton, 1894, 8vo., xvi.+352 and 96 pp.

BRACHIOPODA AND LAMELLIBRANCHIATA of the Raritan Clays and Greensand Marls of New Jersey, by Robert P. Whitfield. 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, by Robert P. Whitfield. 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 1 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, should be made to Mr. Irving S. Upson, assistant in charge of office, New Brunswick, N. J., who will give all orders prompt attention.

REPORT OF PROFESSOR GEORGE H. COOK upon the Geological Survey of New Jersey and its progress during the year 1863. Trenton, 1864, 8vo., 18 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.

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.

ANNUAL REPORT of the State Geologist of New Jersey for 1876. Trenton, 1876, 8vo., 56 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., 199 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.

ANNUAL REPORT 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.

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.

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