GEOLOGICAL SURVEY OF NEW JERSEY.

ANNUAL REPORT

OF THE

STATE GEOLOGIST,

FOR THE YEAR

1880.

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1880.

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*Since deceased.

RUTGERS COLLEGE,
NEW BRUNSWICK, NEW JERSEY,
December 9th, 1880.

To His Excellency Governor Geo. B. McClellan, ex-officio President of the Board of Managers of the Geological Survey of the State of New Jersey:

SIR:—Herewith I have the honor to present my annual report on the progress of the Geological Survey of the State.

With high respect,

Your obedient servant,

GEO. H. COOK,

State Geologist.

REPORT.

The work of the Survey, in its various branches, has been prosecuted throughout the year. At the meeting of the Board of Managers, in December, 1879, it was resolved that, in view of the continued demand for information in regard to our agricultural, mineral and other natural resources, application should be made to the Legislature for a renewal of the annual appropriation to the Survey, for another period of five years. The application was made and granted with scarcely a dissenting voice. This action of the Legislature provides for the expenses of the survey to the close of the year 1885, and the plans for its prosecution are made with the expectation that, by the close of this period, the various branches of it will be put in such form that the Survey may be closed; or, if continued, its operations may be reduced to the business of a Bureau of Information on our natural resources. Something of the kind last mentioned may be found profitable for the State as a permanent organization.

The work which has been done in the Survey during the past year is presented in this report under the following heads:

I. United States Geodetic Survey.
II. Topographical Surveys.
III. Map of Progress.
IV. Paleontology.
V. Surface Geology.
VI. Iron Ores.
VII. Clays.
VIII. Soils.
IX. Drainage.
X. Water Supply and Wells.
XI. Statistics of Iron Ore, Clay and Marl.
XII. Publications of the Survey.
XIII. Expenses.
XIV. Persons Employed.
XV. Appendix—Climate.

ERRATA.

On page 155, 7th line from bottom, for "twelve per cent.," read twelve-hundredths per cent.

On page 176, in Assay 15, for "15.100 oz.," read $\frac{15}{100}$ oz.

I.

U. S. GEODETIC SURVEY.

The operations of the United States Coast and Geodetic Survey in New Jersey have been vigorously and successfully prosecuted during the past season. This department of the general government service is authorized by Congress to aid States which are making Geological or Topographical Surveys by furnishing them with accurately determined latitudes and longitudes of prominent places. The appropriations for this important work, for our State, were secured by the efforts of the representatives from New Jersey, among whom the members from the Third and Sixth Districts were particularly active.

This work is absolutely essential to the accurate construction of maps, and our Topographical Surveys cannot be correctly mapped until a sufficient number of points are ascertained. There were points determined at Springfield, Weasel near Paterson, Mount Rose near Princeton, Beacon Hill and Disbrow's Hill in Monmouth, Mount Holly in Burlington, Newtown in Pennsylvania, and some others in the centre of the State by the Coast Survey several years since. Many had also been ascertained along the shore of the sea, and of Delaware bay and river, but much of the northern and southern ends of the State were not covered by the United States Coast Survey triangulation. The work recently done has been in the extension of the triangulation into the northern part of the State. The country has been thoroughly examined and the location of thirteen new primary stations decided upon. These are so located that they will form a net work of triangles that will cover the whole of that part of the State, and there are perhaps sixty tertiary points selected to be observed from. The reconnaisance for them has been laborious and long continued. The old Coast Survey Stations—Mount Rose and Newtown—were first occupied, and observations were made from them upon the new stations farther northwest. Five new stations, viz.: Goat Hill, Pickles, Mount Olive, Mount Horeb and Haycock, have also been occupied, and the observations upon them completed. There have also been observations made upon thirty tertiary points, which are conspicuous objects and easily accessible, and which, when their true latitudes and longitudes are computed, can be used for reference points for surveyors and map makers. The old maps now in common use are, in many cases, erroneous; it is not uncommon to find them out of their true positions to the amount of a half mile. As fast as this triangulation progresses these errors can be worked out.

The locations of the stations can be seen on the map.

II.

TOPOGRAPHICAL SURVEY.

The Topographical Survey has been continued, and an area of two hundred and ninety square miles in the northern part of the State has been surveyed, and lines of level determined over it. It is proposed to extend this Survey over the whole State, and it is hoped that it can be done before the present appropriation is expended. The maps, when completed and published, will find constant and important use in the planning and carrying out works for public and private improvement. The map covering eight hundred and forty-seven square miles of the most thickly settled portion of the State is already drawn, on a scale of three inches to the mile. It has been reduced to a scale of one inch to the mile, and put in the engraver's hands. The levels for this Survey and map are all referred to the mean tide of the ocean. The initial mark for this system of levels has been fixed by the United States Coast and Geodetic Survey, from a continuous series of tidal observations at Sandy Hook. These observations have been continued for almost twenty years, so that the mark for mean tide may be considered as accurately determined. By the favor of those having this matter in charge this mark is to be transferred to the main land, when we propose to establish bench marks at various points along the shore, which can be used for reference in works requiring a fixed level. They can also be used hereafter for more accurate determination of any change of level between the land and the sea on our coast.

Two other maps, on a scale of two miles to an inch, and covering the whole State, are also begun, and as fast as the Geodetic and Topographical Surveys progress the material collected is drawn on them. It is, however, proposed to continue the maps on a scale of three inches to a mile over those parts of the State where mining is carried on, and where immense interests are involved in small tracts of country.

III.

MAP OF PROGRESS.

The Map of Progress, which accompanies this report, is brought up to the times as nearly as possible. In its civil divisions it has added all the new townships. The total number of which in this State, is two hundred and forty-three. In the means of communication it has all the lines of railroad, including those which are just being completed, of which there are seventeen hundred miles. All the main roads in the State are on it, so that it is a good traveler's guide. It has marked on it the places where Meteorological Observations have been taken, so as to get records of our weather and climate. It also has marked on it the station at which observations are taken, and angles are measured in making the Geodetic Survey of the State. The locations of the numerous iron mines and the zinc mines are indicated by small arrows.

IV.

PALEONTOLOGY.

In the Geological work of the Survey, it is proposed to prepare and publish something on the paleontology of the State, and considerable work has been done during the year in collecting fossils and making the proper arrangements for this purpose. Heretofore nothing has been done in this department, though some of our ground is classic to American Geologists, and it is due to the cause of science that we should contribute our share to its advancement. Geologists from New York, Philadelphia and more distant places have been in the practice of visiting New Jersey localities to collect fossils, and have carried them away for preservation and description, so that they have been scattered everywhere, and the descriptions, so far as published, are to be found in scientific reports, journals and monographs, and there is probably no single library where all of them are to be found. This has been going on now for fifty or sixty years past. It is proposed to collect, as completely as possible, this scattered material, to add to it such new matter as can be obtained, and to publish the whole in geological order. This work is begun. Collections of the fossil fishes, the footmarks, and the plants of the Triassic red sandstone have been made. A large collection of the plants of the Cretaceous, Tertiary and Post Tertiary Ages has also been brought together. And the collection of the invertebrate fossils of the Cretaceous and later formation is begun. The fossils of the Devonian and Silurian rocks, in the northwestern part of the State, are the same with those in rocks of the same age in the State of New York. In that State they are found over a much greater area, and they have been so fully described by Prof. James Hall, the Paleontologist of that State, that we cannot hope to add anything to what he has already published. The preparation of these works requires much time and labor. It is hoped that some of them will be ready for publication in the course of the next year, and that all, at present proposed, can be done within the next five years.

A list of the plants growing without cultivation within the State is being prepared for distribution among the botanists of the State for their notes, criticisms and corrections, so as to get ready a complete catalogue, with localities, of the plants of New Jersey.

V.

SURFACE GEOLOGY—REPORT OF PROGRESS.

INTRODUCTION.

The nature and extent of the various Geological formations of the State, and especially the rocky strata beneath the soil or superficial earth, have been described in the several reports of the Geological Survey, and their outlines have been represented on the Geological maps accompanying these reports. These maps do not, however, indicate the nature or extent of the surface earth. The earths, sands, gravels and boulders, more or less mixed, and irregularly distributed upon the older beds and strata, constitute an important feature of the surface and give character to the soil throughout large areas. Over large areas they cover the rock so deeply as to conceal it and render the determination of the older formation extremely difficult. And the tracing of Geological boundaries is, in places, done with much uncertainty on account of these thick surface deposits. The earth and imbedded rock fragments which result from the decompositions and disintegration of rocks *in place* must not be confounded with them. The former are native; the latter are foreign—erratics. The modification of the original Geological features consists in the rounded and polished ledges or *roches moutonnèes;* in the softened contour lines of hills and mountains, as well as in the rocky slopes clothed with loose materials. And the soil and the flora are also determined to some extent by the superficial covering. The description of these surface beds and deposits and the modified outcrops of the older formations, constitutes what may be termed the Geology of the Surface. In this report the consideration of the earth's originating *in place* is omitted.

The surface deposits here considered belong to what is termed by Geologists the Post Tertiary or Quaternary Period.

For convenience of reference, the facts will be arranged somewhat geographically, describing first the features which are most marked, and then the others in their relations to this most prominent one. In this order the Glacial Drift is first described, then the Modified Glacial Drift, and, lastly, the Pre-glacial Drift. During the Glacial epoch the north polar ice cap, now confined within the frigid zone, extended southward into the north temperate zone, and covered much of the northern portion of our country. The great ice sheet was several thousand feet thick in New England and New York. Near its southern limit, in our State, it diminished to less than one thousand feet, and did not cover the higher crests. The subsidence of the land at the close of the Glacial epoch, and the moderation of the climate, were attended by the melting of the ice sheet and its irregular recession northward, giving rise to flooded streams which filled the old valleys and basins with sediment. The river border, lake border or lacustrine and sea border formations were laid down during this middle epoch of the Post Tertiary Period, the Champlain epoch of Dana. The upward movement and gradual emergence of the land raised the sea beaches and river flats of the champlain. And the beginning of the epoch of elevation marks the commencement of Dana's Terrace division of the Post Tertiary, continuing to the present or Historic Period. The several formations belonging to these epochs of Geological time may be embraced under the general designation of *drift*, although this term is more properly limited to the unsorted materials deposited by the glaciers of the Glacial epoch. Used in the wider sense, it includes, with the unsorted or unstratified deposits, the laminated and stratified beds. The former constitute the Glacial drift; the latter the modified or stratified drift. This division does not correspond to any essential differences in the nature of the materials. Clays, sands, gravels, cobble stones and bowlders are found in both states of arrangement, and, frequently, in one and the same bank, one over the other. In the unsorted or true drift there are no extended lines of stratification. The materials appear to have fallen or rolled down from the front of the glacier in irregular heaps, or to have been pushed forward by it and mixed with the debris from its surface, or to have been ground down underneath it by its huge mass. Hence the name glacial drift. The stratified materials, whether large bowlders and coarse gravels, or fine sands and clays, owe their arrangement to the action of water. The deposition may have been in the bed of a rushing torrent, or on the bottom of a placid lake or broad estuary. In the one case the moving and transporting agent was ice; in the other it was water. In places there was a commingling of the drifts made by streams flowing from beneath the glacier, or from its surface, into fissures, and depositing their sediments in narrow limits among the great mass of ice-carried debris. And short lines of stratification, and small deposits of stratified drift are found associated with the unsorted glacial drift. But stratification is a distinguishing mark, and it divides the drift into two natural groups. The stratified drift is found in all parts of the State. The glacial drift is confined to the northern and northeastern parts, and the southern limit is marked by a line of accumulated heaps or mounds, and hills and ridges, which is known as the terminal or frontal moraine. The line of this moraine was indicated in the annual report of the Geological Survey for 1877. The full description of the great continental moraine across New Jersey is here presented.

GLACIAL DRIFT.

ITS TERMINAL MORAINE.

Boundaries, Elevations and General Description.

The southern boundary line of the great terminal or frontal moraine across New Jersey has a general north-northwest course from the mouth of the Raritan river, at Perth Amboy, to Morristown; thence a north course to Denville, where the direction changes to the west, which course is maintained to the Musconetcong valley, where it again turns, and thence bears west-southwest to the Delaware river, at Belvidere.

At Perth Amboy the Raritan river flows along its southern foot. Here the low bluffs, which are cut on the south by the river and on the east by the waters of Staten Island sound, consist of unsorted glacial drift. The south bank of the river and the upland of South Amboy are all of stratified materials, or sedimentary beds, in which the red shale and sandstone and other characteristic rocks of the glacial moraine are entirely wanting. And nowhere along the line, as it is traced across New Jersey, is there so marked a difference in the superficial deposits (or covering) as at this place. On the one side there is the red shale earth, which has given character to the soil and the vegetation, whereas, on the other, are the light-colored sands and clays and gravels, constituting soils of different classes, and each covered by its own peculiar forest trees and vegetation. And Perth Amboy stands on the southernmost point of this great continental moraine. Both eastward and westward the moraine line bends towards the north. Here the ice reached its most southern limit, and, as it melted, left this impress upon the surface.

Beginning at Amboy, the line of the glacial drift, as represented by this terminal moraine, is easily traced northwest to Metuchen, and thence by Netherwood and Scotch Plains to the First or Springfield mountain. It follows closely the river bank to Eagleswood, then, leaving the river, it crosses Crows Mill brook, near the clay pits of the Woodbridge Clay Company, runs just west of the Crossman Clay and Manufacturing Company's banks, to the Fairfield and Bonhamtown road, which it crosses one hundred yards west of the Easton and Amboy railroad. Thence it runs obliquely across the railroad, and approaches the Metuchen and Amboy road near the intersection of the latter with the straight New Brunswick and Woodbridge road. Thence to Metuchen it runs east of the main road, and not far from it. From Perth Amboy to the northern limit of the plastic clay formation, this line is plainly marked in both the surface materials and the shape of the country. The red shale constitutes the mass of the drift material. In the form of earth and small fragments it is the matrix in which occur the glaciated pebbles, cobblestones and bowlders of shale, sandstone, trap-rock, gneiss, granite, syenite, conglomerates (of all the Green Pond mountain series) magnesian limestones and slates.

The predominance of the shaly material gives character to the soil and makes it look like the red shale country to the north of the clay belt. There is a sharp contrast between it and the soils of the latter, which are more sandy and of a light yellow color. The configuration of the country is also very strongly contrasted on the opposite sides of this line. The country on the southwest has more regular slopes and much uniformity in its structure—the result of drainage upon stratified deposits. The surface of the *moraine* is characterized by the absence of all regularity and uniformity. The hills are irregular in outline, and of uneven slopes. They are short,

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and hence that part of the moraine from Fairfield by Metuchen to Scotch Plains is often known as the Short Hills. The highest of these is Poplar Hill, near the Woodbridge and New Brunswick road. It is two hundred and forty feet high. The moraine surface is also marked by circular and irregular shaped depressions. Some of these are partly filled with water, and there lie as ponds among the hills. West and southwest of this line there are no such natural ponds or lakes. The structure of the drift of the moraine is well exposed to view and study in many of the clay banks west of Woodbridge and northwest of Perth Amboy. Its thickness, as cut in these excavations, does not exceed twenty feet, but in the higher hills it must be greater than this, amounting, in Poplar Hill, to one hundred feet at least. In places this drift is spread directly upon the beds of the plastic clay formation, but more generally it reposes upon the sands and gravels of the older pre-glacial drift. And these two drift formations are seen at many of the clay banks west and southwest of Woodbridge, as also in some of the cuttings on the line of the Easton and Amboy railroad, near Ford's Corners, and between that point and Perth Amboy. The local details as to the thickness of these drift formations may be found in the descriptions of clay pits, &c., Part II, Chapter 1, of the "Report on the Clay Deposits of Woodbridge, South Amboy and other places in New Jersey," Trenton, 1878.

At Metuchen and eastward the inequalities of the moraine are seen along the tortuous line of the Pennsylvania railroad, which winds about among the hills as it crosses them between Metuchen and Menlo Park. A straight line across the moraine was not practicable on account of the exceedingly uneven surface. Hereabout, as elsewhere, it makes the beautifully diversified surface which is so capable of ornamentation and so adapted to the purposes of the landscape artist, and upon it are the many beautiful residences and grounds of Metuchen and vicinity. From Fairfield to Metuchen, to Scotch Plains, and on to Springfield mountain, the Short Hills constitute the water shed between the tributaries of the Rahway river on the east and those of the Raritan river on the west. And the several railroad lines crossing it have their summits—between the Raritan and tide-water—in these hills. Thus the summit of the Easton and Amboy railroad (one hundred feet) is near Fairfield; that of the Pennsylvania railroad, one hundred and ten feet, is east of

Metuchen. The Central railroad attains an elevation of one hundred and seventy-five feet near Fanwood. On the west of these hills Dismal brook and Cedar brook, flowing in opposite directions and uniting at New Brooklyn to form the Bound brook, run parallel to the line of the moraine from Metuchen to Scotch Plains. The actual boundary line of the moraine is very near the Metuchen and Oak Tree road. In Union county the moraine limit is quite near Cedar brook and west of Netherwood. Here the course is to the north and then northeast, meeting the Springfield mountain about one and one-half miles east of Feltville, and not far from the Westfield and Feltville road. The moraine ascends the mountain obliquely, and at the Springfield Signal Station of the Coast Survey attains an elevation of five hundred and twenty-two feet—more than twice the maximum height of the Short Hills. Across this mountain the line is plainly marked by the accumulation of bowlders and bowlder earth which here covers the trap-rock of the mountain. From the crest of the First mountain this drift line has a north-northwest course across the valley, lying between the First and Second mountains, to the latter, near Summit. It sweeps around the north end of the higher part of this range and south of Summit Station. Here the elevation is not very different from that of the railroad depot, three hundred and eighty-one feet. The characteristic Short Hills and their accompanying depressions, are very noticeable along the line of the D., L. & W. railroad east and northeast of Summit to Milburn and Springfield. There was a great accumulation of material in this gap in the trap-rock ridge, and there are several ponds here, filling the hollows between the hills. The thickness of the drift about Milburn was such as to entirely conceal the underlying strata, leaving an apparent break in the continuity of the rock of the First mountain. All travelers on the D., L. & W. railroad are familiar with the aspect of this country, and the peculiar surface of the moraine here so well exhibited. And they can now understand that its origin was due to the glacier which stopped here and left these great heaps of confused earth, bowlders and gravel. Here, too, we find a water-shed, the drainage from the valley to the north coming out of the mountains at this place through the Rahway river and that to the south following the valley between the mountains passing Feltville at the gorge of Green brook, near Scotch Plains.

From Summit the line is traced in a westerly direction to the

Passaic river, southwest of Stanley Hall. The New Jersey West Line railroad cuts into the drift hills west of New Providence Station. In one of these there is a vertical section forty feet deep where the materials are somewhat sorted and stratified, and there is much red sand and gravel in this cut. These southermost hills of the moraine have evidently been modified by the action of water. They may be of later age than the unsorted drift north of them, as it is exposed along the D., L. & W. railroad. On the First mountain, and on the Second mountain, and across the valley between them, and also in the valley along the Passaic, between the Second mountain and Long Hill, the moraine hills contain much trap-rock, derived from the north. This occurs in the form of large and quite angular masses, smaller bowlders and fragments. The number of gneissic and other crystalline rocks from the highlands is greater, as also the bowlders, while the amount of Green Pond mountain conglomerate and red shale earth is a little less than it is in the Short Hills. It is here, however, sufficient to give character to the surface, and it constitutes the earthy matrix in which the other materials are imbedded, as cobble stones, bowlders, gravel, &c. The soil on these hills is like the red shale out-crop, excepting the bowlders that are abundant in it. Along the Passaic river the drift mass does not appear to be so thick as it is about Milburn and Springfield, or as it is in the Short Hills. The cut on the D., L. & W. railroad show it twenty-seven feet at least at Stanley. West of the river the moraine appears wrapped around the northern point of the narrow Long Hill. As viewed from a standpoint on the east side of the Passaic, the drift mass is seen rising from the bottom of the valley on Green Village and New Providence road, near George Sheppard Page's residence, to an elevation of three hundred and fifty feet on the northern point of the ridge passing just above the cemetery and crossing the end of the hill a short distance south of the Bonnell's Mill road. There are a few scattered bowlders up to three hundred and ninety feet or quite to the top of the ridge, but the great mantle of drift does not reach the crest. The trap-rock on this end of the ridge is very much altered and crumbling, indicating that the glaciation on this point was very slight. The moraine boundary runs southwest, slanting along the western side of Long Hill to the Green Village road. Thence its course is, in general, northwest, coinciding very nearly with the northern margin of the Great Swamp, after leaving which it follows the foot of the hill or ridge near Loantaka brook, and near the northeastern limit of Morristown to the Washington mountain at Morristown. The ridge from Long Hill to Morristown is a very prominent feature in the topography of that part of the State, and is noted for its commanding views and its almost continuous succession of beautiful park-like grounds. Madison is partly on it. The road thence to Morristown runs on it. This ridge also is a watershed between the tributaries of Upper Passaic on the south and the branches of the Whippany on the north. It differs from the Short Hills and the more southeastern part of the moraine in its level top and more uniform slopes. Generally its southward slopes are steep. Towards the north it more gradually disappears in the lower grounds of the Passaic valley. It does not, however, altogether lack the uneven surface, having near Morristown several quite large hollows, one of which, the "Punch Bowl," is about sixty feet deep, and is a vast, dry amphitheatre. The top of this ridge is quite level, particularly the south resembling a terrace level. It is three hundred and sixty-six to three hundred and eighty-two feet high, and one hundred to one hundred and twenty feet higher than the valleys south of it, and one hundred and forty feet above the general level of Chatham and Madison on the plain country on the north. The more uneven drift north of Convent rises to a height of four hundred and fifty-seven feet. The upper portion of this ridge appears to be generally stratified, and consists largely of sand, gravel and cobble stones, with earth derived from various sources. The soil on its southern side is everywhere quite sandy. The nature of the materials occurring in this ridge can be studied in the pits where gravel and stone are obtained for road making. One of these is near the Kitchell place, on the southern slope of the ridge, and about two miles west of Madison. At this point a yellowish sand forms the mass of material; in it the gravel is mostly of quartzites and conglomerates with red sand-stone and gneissic rocks. The thickness of the drift mass in this ridge must everywhere be over one hundred feet, since nearly all the wells on it are of that depth. At the Drew Theological Seminary a well was dug one hundred and fourteen feet by the late William Gibbons, and then a boring two hundred feet deeper, it is said, did not get through the loose materials.

In Morristown the line of the glacial drift runs near the southern limit of the corporation, on a northwest course to the Basking Ridge road, and across Market street to the gneiss ridge. Here it turns northerly and runs northeast of the court house; thence across the western part of the town by the residence of A. W. Cutler, and to the west end of Speedwell lake. The larger part of the town is on this drift formation. The higher part about the court house and the Fort Nonsense ridge are gneissic surface, free from drift. The elevation of the moraine corresponding approximately to that of the Morris Green is three hundred and seventy feet, which is not very different from that near Madison (three hundred and sixty-eight feet), or the summit of the south part of town (three hundred and eighty-two feet.) And this is, on an average, one hundred feet above the valley of the Whippany on the northeast (two hundred and eighty-three feet and two hundred and sixty feet.)

From Morristown to Morris Plains the drift limit coincides with the division line between the gneissic rocks of the Highlands and the red sand-stone of the Triassic Age. It is difficult to trace the out-crops of the latter rock, as it is so deeply covered by the drift. North and west of Speedwell lake there is an interval extending to the Headley place—about one mile—where no true unmodified moraine material is seen. It may be covered by the stratified sands and gravels which form the bottom of the valley of the Whippany. At the Headley place, and thence northeast and northward to Morris Plains it is recognized in a series of gravelly hills and deposits which border the foot of the mountain. More accurately the line may be said to run west of the Burnham and Johnson ponds, east of the Asylum, near Pierson's saw mill, and so along the foot of the Watnong mountains to the D., L. & W. railroad, about a half a mile north of the Plains depot. The level of Morris Plains has been made by the modification of moraine material and the excavations along the railroad, about one-half mile south of Morris Plains Station, and west of it, at Johnson's mills, show it to be an immense bed of sand, gravel and bowlders. The larger percentage of these are of gneissic rocks. Next to these in number are the rocks of the Green Pond mountain series, and then the Triassic sand-stones. The height of the plains is four hundred and five feet at the Plains depot. Horse Hill, one mile southeast of the Plains Station, is higher (four hundred and eighty-eight feet.)

From Morris Plains to Denville the boundary line of the drift runs northward along the railroad west of the same and George W. Howell's residence, and west of Mount Tabor. For a half mile southward from the charcoal mill there is an interval where the drift is wanting in the valley. Mount Tabor is a moraine hill. Denville is also drift, and its elevation above tide level is five hundred and twenty-two feet. Towards the east the drift has a very uneven surface, and Ketchum's pond occupies a hollow in it. The Boonton Branch railroad cuts across one of these depressions, and here the moraine height is five hundred and forty-six feet. Along the valley of the Den brook, south of the D., L. & W. railroad, and in the Rockaway valley northeast of Denville, the moraine has been so modified by subsequent changes that it does not appear continuous across this more recent stratified valley formation. In the latter there are no large bowlders. Travelers along this road from Denville to Powerville can see this latter formation, which has probably come from a remodelling of the older moraine drift left here by the glacier. A remnant of the moraine lies on the western foot of the hill east of the Den brook and south of the depot, between the old railroad line and the new double track route. West of this, in the valley, there are low knolls of sand and fine gravel. As the glacial drift is seen on the west of this valley, on the north end of Snake Hill, it is probable that it was originally continuous across the valley. There is, at Shongum, three and one-half miles up this valley of Den brook, a deposit of glacial drift, which does not appear to be connected with these accumulations lower down and near Denville. The Shongum drift in the valley, and north of the pond, is crossed by the Millbrook road. It appears to have filled the valley excepting the narrow gorge for the outlet brook. According to barometric observations this local moraine or drift body is seven hundred and forty feet above tide level, or two hundred feet higher than the similar deposits about Denville. As there is a little drift at Ninkey and Franklin it is possible that there was an extension of the glacier in this valley reaching to this point.

On Snake Hill the moraine appears wrapped around the north end, and attaining, on the point of the ridge, an elevation of six hundred and seventy feet. The upper limit of all bowlders is about one hundred feet, or seven hundred and seventy-feet; the crest of the ridge has a maximum height of nine hundred and ten feet. The limits of the moraine are very plainly marked on this ridge, and here both the southward extension and thickness of the ice are recorded. In the valley on the west of Snake Hill the moraine is not traceable entirely across to the next ridge. But it is seen on the eastern and northern end of the latter, and is wrapped around it somewhat as it is on Snake Hill. It can be traced on it southeast of the D., L. & W. railroad, and its southern boundary line crosses the Rockaway and Union School road at a point half-way between the two lines of the Delaware, Lackawanna and Western railroad. It is here about six hundred and seventy feet high, and it is recognized by the number of erratics and the inequalities of the surface. Thence the line runs south-southwest, and the double track line of the Delaware, Lackawanna and Western Railroad Company cuts into it, exposing to view large bowlders of gneissic and other crystalline rocks and many Green Pond mountain conglomerates. The drift mass here is ten to fifteen feet thick, and reposes upon gneiss. From this point the line is traced with difficulty in a general southwesterly course, crossing the Dover and Morristown road west of the Union school house, and returning west of Rock Eatam, a rocky knob on which there are no glacier marks or drift deposits.

Here the line comes to the southwest extension of the valley of the Rockaway, Horse Pond brook and Mill brook, whose elevation is about five hundred and sixty feet. Here, as in Den Brook valley, the moraine appears to have been partly obliterated. There is, however, a part of it left on the western side of the Mill brook, near the Dover and Shongum road, stretching from the brook westward to within two hundred yards of the cross-roads, about a third of a mile long from east to west. It is a bow-shaped deposit, and curves northward at each end. The surface is very sandy. The road cut shows bowlders of gneiss, conglomerates, and cobble-stones and gravel, with angular rock fragments from near localities. This section of the moraine seems disconnected east and west, but it marks the southern limit of the ice in this valley.

Going westward, the next moraine hill is east of Mines' brook and west of the Pleasant Valley and Rockaway road. The hill is six hundred and forty-five feet high, has steep and smooth slopes on north, west and south, and the material, as seen in a gravel pit on the north side, is sand, gravel and cobble-stones. These are mostly of gneissic rocks, with many of quartzites and conglomerates. Eastward the slope is more gentle to the above-mentioned road. As there is no drift on the north face of the hill, east of Dover, and south of the railroad and Rockaway, between the hill and the town, the moraine line is represented as running northwest to that stream, and following it to the town. The valley north of the stream is drift, and evidently of glacial origin.

The greater part of the town stands on the same superficial formation, and its southern limit is south of the railroad depot, and passes around a small pond and the old cemetery, and then, curving northwards, approaches the main street, and follows that and the main road over the northern glaciated foot of Clinton Hill. On the north side of the town there are many very good sections showing the materials of this formation. One of these is at the side of the Mount Pleasant turnpike, north of the rolling mills and pond. This section shows finely the confused, unsorted nature of the drift. Here are seen bowlders of all sizes of gneiss, granite, syenite, sandstone conglomerates of the Green Pond mountain series, with a very few of blue limestone, white limestone and of slate ; also, but more rarely, magnetite. With these bowlders there are cobble-stones and pebbles of all sizes. The same moraine mass is cut in a shallow pit near the cemetery and at the side of the Mount Hope road. At this point there appears to be a finer pebbly drift under the coarser bowlder mass. And the former may be stratified. The surface of the moraine east of the cemetery is exceedingly uneven and full of sink holes and some pond holes. It is about seventy feet higher than the flat along the Rockaway, or six hundred and forty feet high. This inequality of surface is well exhibited along the road to Mount Hope, and the highest of the hills along that road, but near to Mount Hope, is more than three hundred feet higher, or nine hundred and sixty feet.

Going westward from Dover the line of drift is somewhat tortuous, following quite closely the contours of the valleys south of the Rockaway and around on the foot of the hills. The gneissic ledges at the quarry on the northern point of Clinton Hill show the glacial marks. Southward and higher on this hill there are no traces of glacial action or drift deposits. Thence westward the line curves around southward and crosses the valley of the Jackson brook, meeting the Mine Hill road near the brook, about one-eighth of a mile west of Roman

Catholic church. In this little valley or cove, shut in by the hills on the southeast, south and west, the moraine mass appears to have been modified so as to form a very beautiful terrace. It is crossed by Union Hill road, and the residence of Alfred Beemer, the St. Mary's school and the Roman Catholic church are on it. According to the barometric observations it is fifty feet above Dover or six hundred and forty-five feet high, corresponding to the general moraine surface near the surface just north of Dover. The same terraced drift appears northwest of the Roman Catholic church at John Hance's, and around the hill to Port Oram, where its elevation as determined by the canal level is six hundred and sixty-eight feet.

A remnant of the moraine is seen in the drift covering the northern face of the Randolph hill ridge, below the Jackson Hill Mine. Here the upper limit of the drift rises to a height of six hundred and ninety feet. The many openings and the bare ledges above this level on the hill show the absence of all glacial agencies. The moraine is traversed by the road from this mine to Port Oram, and its boundary runs west of said road quite to the village, where it turns to the west and runs south of the road near the Hurd Mine, and to the foot of the King Mine ridge, near the line of the High Bridge Railroad. Here the line meets the long and deep Berkshire-Succasunna valley, and sweeping around the base of the King Mine Hill, it makes a detour to the south, bounding the tongue of drift which was shoved southward in this valley. The moraine lying across the great depression forms a water shed between the Rockaway and the Black river, which constitutes the limits of the Berkshire valley southward, and the Succasunna plains northward. Probably nowhere in the State can this terminal moraine be better studied in all its relations than across this valley. To the northward is the level southern part of the Berkshire valley; on each side are rocky hills, around the north end of which the moraine has been wrapped; between them is seen the wonderfully uneven surface with its hillocks and short ridges and sink holes and little ponds; southward these appear less marked until they are lost in the plain surface of the Succasunna plains. In detail the boundary line of the moraine may be described as following the western base of the King Mine ridge to a point a short distance southwest of the Scrub Oak Mine where it changes its course and thence runs in a northwest course, coinciding closely with the line of clearings to the canal and the foot of the McCainsville sandstone ridge. The canal crossing the moraine has an elevation of seven hundred and twenty-eight feet and the drift knolls may rise thirty feet above that level.

The cuttings on the lines of the High Bridge Railroad and the Scrub Oak Mine Railway expose fine sections of the drift. Near Lock No. 3, E, it is seen covering strata of hornblendic gneiss. Near Plane No. 4, E, and southward the drift mass is made up of an unusually large proportion of bowlders, cobblestones and pebbles, the drift earth being relatively very slight. The crystalline rocks as gneiss, granite and syenite constitute nearly three-fourths of the whole mass of bowlders, the remaining fourth are quartzose rocks from the Green Pond mountain and Potsdam sandstones, with a very few hard grit rocks and an occasional small bowlder of brown hematite. Farther south there is a partial stratification observable in the arrangement of the smaller bowlders, cobblestones and gravel. In places this sorted structure appears under the unsorted, confused drift mass. Going still southward the uneven surface disappears and the gravelly, sandy level of the plains is reached.

Resuming the tracing of the line of the moraine, west of the canal it is found pursuing a northeast course along the eastern side of the sandstone ridge, to the north end of the same, where it turns to the west over the foot of this ridge. Thence it bends to the southwest and runs on the lower western slope of the ridge about half a mile, beyond which point its course is west and northwest across the valley to the Drakesville depot. The sandstone ridge north of McCainsville is, as it were, an island in the plains-valley and the moraine on the west of it corresponds in its surface features as well as in the nature of its materials with the eastern segment, above described. The level here, on the south of the drift knolls, is more stony than the plains northeast of McCainsville, being paved with small bowlders and cobblestones. They diminish in number and size as we get southward, and the thick stone walls about some of the fields testify to their number on the surface. Duck Pond, east of Drakesville station lies in one of the hollows in the moraine. According to barometric observations the highest of the drift hills east of Drakesville is eight hundred and seventy feet above tide level. Along the Delaware, Lackawanna and Western Railroad between White Rock cut and Drakesville there are several fine sections of the moraine. At one of these, fifty feet deep, and one-half mile from the latter place, there is some stratification of the materials near the top of the hill. And there is here a noticeable quantity of the Green Pond mountain rocks, so characteristic and common in the moraine to the eastward, showing that the drift materials had generally come from the north and northeast and had not been derived from points much east of north. The Green Pond mountain conglomerate is so plainly marked that this evidence seems to be decisive as to the general direction of the glacial mass. Here also the blue and magnesia limestones begin to be more abundant, amounting to one per centum of the bowlder mass. There are also a few sandstones (Potsdam), Oriskany sandstones, white, crystalline limestones, Trenton limestones and slate rocks, all, apparently, of a north and northwest origin.

At Drakesville there is a gap in the continuity of the moraine. On the sandstone hill south of the station there are no erratics, nor any glacial markings; nor are there any on the gneiss hill immediately to the southwest of it. The railroad cuts and other exposures do not show any such marks. It is possible that the drift has been removed from this gap or depression, through which the railroad finds its way westward. The mountain side on the north has much smooth rock surface, but these have been so worn by water as to obliterate the ice marks, if ever thereon. Three-quarters of a mile west of Drakesville there is a long and curving cut, where the drift, unsorted, is finely exhibited. The surface also is that characteristic of a moraine. About ninety-nine per cent. of the stones in the drift earth here are of crystalline rocks. None of the Green Pond mountain rocks were seen and a few only of blue limestones and slaty grit rocks. Southward the moraine extends to within fifty yards of the District Number Four school house and the Drakesville and Stanhope road. But it was not recognized east of the Mountain Pond brook. The moraine boundary from this point is very easily traced across the Shippen Port road about one hundred and fifty yards north of the corner of Stanhope road; thence, westerly by ex-sheriff King's residence, along the brook and pond, to the Stanhope road about one-eighth mile north of the Mount Olive road corner. Proceeding west from the Stanhope road, the line runs a few degrees south of west, intersecting the next northeast and southwest road near G. S. Slaight's home, and then, the Flanders and Stanhope road near A. Wolf's; thence parallel to and a short distance south of the road leading to Budd's Lake, until this road turns southward, and crosses it, and then assuming a westerly course approaches the lake on its northeast shore near the corner of the road to Stanhope. Throughout this distance the moraine consists of heavy bodies of unsorted bowlders, cobblestones, gravel and earth, and these lie in irregular-shaped hillocks and ridges. And here, as to the westward, across the whole top of the Schooley's mountain range, it is the watershed between the streams flowing northward into the Musconetcong and those flowing to the south and constituting the headwaters of the Raritan. And Budd's Lake appears to have been formed by the moraine dam, which is across the old brook, raised the water behind it until it found an outlet in the opposite direction, southward, into the south branch of the Raritan river. The original outlet was towards the northeast, and probably, through Wells' brook into the Musconetcong. The slight ridge near the road crossing the outlet brook may have been the old watershed. As the lake is said to be one hundred feet deep, and the drift hills on the north are at least twenty-five feet higher than the lake surface, we have a measure of the glacial dam which diverted the waters of this part of the valley. On the Stanhope and Drakesville road the moraine is crossed at an elevation of one thousand feet. The highest hills near it, also in the moraine, are one thousand one hundred and ten feet high (barometer observations). North of the lake and near the road to Waterloo the higher moraine summits range from one thousand and twenty feet to one thousand two hundred and fifty feet. These points are from one to one and one-half miles distant from the lake.

The southern boundary of the moraine has a west-northwest course from the lake, crossing the Waterloo road a few rods south of J. Thompson's, and then the next north and south road near the top of the mountain. From this point it bends toward the south, and not far beyond descends gradually on a long oblique course into the Muscónetcong valley, coming to the creek near the distillery, one mile north of Hackettstown.

The moraine across Schooleys mountain is characterized by its great elevation, its thickness, its exceedingly irregular surface and the unsorted, confused nature of the materials. The road from Waterloo, southward, quite to the lake, affords good examples of the peculiar surface inequalities. The ridges are in places scarcely more than wide enough for a good broad road, while on each side are deep hollows, beyond which are ridges and so on without any apparent order of arrangement. The inequalities are here on a grander scale than they are in the valley eastward, or than they are further west. The bowlders in this part of the moraine are large, and among them there are many of the blue limestone as well as of other rocks which are in place in the country to the north and west. The largest of these is on the Osborne farm, one mile northeast of Budd's Lake, at the side of the Stanhope road. It has been supposed by many to be a ledge, and has been worked for years past as a limestone quarry. As exposed, it measures thirty-six feet by thirty feet, and the quarrying has gone twenty feet in depth. Its vertical diameter is unknown. Around it there are many gneissic bowlders and other drift materials.

A reference to the map will show at a glance the southward trend of the moraine as it descended from the table lands of Schooleys mountain into the deep Musconetcong valley. And in this valley, as in those eastward, which have been referred to in this description, the moraine extends further south on its eastern side, so that the southern boundary line across the valley has a north-northwest course. That is, it does not run at a right angle across the trend of the valley. From the creek, near the distillery, it has been traced to the Waterloo road, seven-eighths of a mile from Hackettstown, and thence at the foot of the ridge along the Morris Canal to the Allamuche road north of the Wagner place. In the Musconetcong valley the moraine drift is in sharp contrast with the smooth cultivated country south of it, and it makes a soil quite different from the clean limestone soil. Full of bowlders and cobblestones and diversified by hillocks and hollows, it is neither so easily tilled nor so productive as the limestone ground.

The canal is in the moraine as far as the Warrenville road. There the moraine runs westerly and its boundary line is traced west-southwest across the Petersburgh road by A. R. Day's residence; thence, on the same general course to the Hackettstown and Vienna road, north of the tannery; thence, in a southwest direction in a hollow to the Danville and Beattyestown road, near John I. Schenck's farm house, and one and one-half miles southeast of the Pequest creek. Thus far from the Musconetcong valley the moraine is a continuous range of hills and irregular drift heaps. And it has so covered the rock strata of the hills as to obscure their geology, and has produced a surface whose irregular slopes and inequalities are in sharp contrast with the regular lines, uniform slopes and the gneissic soils of the hills and mountains south of it. The line of demarcation is as well defined here as it is on the limestone in the Musconetcong valley. All who have been at Hackettstown and have gone westward over the hills to Vienna, will recognize these distinctions and be able to locate our line.

The heights of the moraine in this part of its course, as determined by the barometer, are as follows: In the Musconetcong valley, near G. Smith's, six hundred and fifty feet; on the ridge northwest of A. R. Day's, Petersburg road, nine hundred feet; on the highest peak, three-quarters of a mile west of Day's, one thousand feet, and on mountain side north of Amos Hoagland's residence, six hundred feet.

In the drift on the mountain between the Musconetcong and Pequest valleys there is much blue magnesian limestone in bowlders of all sizes, and also as cobblestones and irregular-shaped masses and fragments. They are often gathered and used for making lime. Next to the limestones in quantity, but more numerous, are the hard gray sandstones and conglomerates, apparently from the Kittatinny, or Blue mountain. Then comes the gneissic and other crystalline rocks. There is also much slate, generally in smaller bowlders, cobblestones and gravel. Red (Medina) sandstones, gray grit-rocks and chert also abound. There are many places where these moraine materials can be seen, but one of the best sections is along the stream by the side of the road to Danville from Beattyestown and not far from the grist mill. From this side of the mountain there are fine views of the moraine to the west and southwest, in the valley of the Pequest river.

Resuming the description of the moraine boundary, it is traced from the John I. Schenck place westerly around the northern end of a rocky hill south of the grist mill and brook, and thence in a west-southwest course east of the Townsbury road along the side of the mountain to the Mount Bethel and Oxford road, one-third of a mile north of Amos Hoagland's residence. Thence the course is northwest and almost straight across the valley to the Pequest just below Townsbury. The moraine occupies the whole bottom of the valley, excepting the gorge, sixty to eighty feet deep, which the Pequest has cut for itself through it at that place. And its surface is characterized by knolls and hollows, in contrast with the smooth valley south of it. As viewed from the south the moraine looks like a great bank across the valley. In all these particulars the valley of the Pequest here at Townsbury resembles very much that of the Musconetcong north of Hackettstown. According to barometric observations the height of the moraine east of Townsbury is five hundred and eighty feet, or eighty feet above the valley flat south of it. On the west side of the river at this place there is a shelf of drift which is higher, or one hundred and forty feet above the creek level (six hundred and sixty feet). There is here a long and good exposure of the drift on the side of the Townsbury and Butzville road and also one of the best points for viewing the moraine in this valley, and the terraced hills south near Amos Hoagland's and the county poor farm.

One of the results of the glacier in the valley of the Pequest was the formation of a lake basin, now occupied by the Great Meadows behind the moraine. The evidence of a higher water level is found on the sides of this basin, as for example, on the hill back of Danville church, which is forty-nine feet above the meadows, and on the east, not far from Long Bridge, where there is a terrace forty feet above the meadows, or five hundred and forty feet, which is nearly as high as the moraine at Townsbury. Terrace beds occur in the plain country north of the meadows along Bear Brook, Trout Brook and the Pequest river. The terrace formation can be traced northeast from the meadows to Springdale, south of Newton, and by Tranquility, Huntsville, Brighton, Andover, Strubles Pond and almost to Pinkneysville. Near Andover the height of this level is about five hundred and eighty feet; Strubles Pond is five hundred and seventy-three feet, and the Pequest bridge on the Sussex Railroad five hundred and seventy-nine feet, all of which correspond with the top of the moraine at Townsbury, and indicate the former extension of a body of water from the terminal moraine over the Great Meadows and northward to these limits. The lowering of the Pequest channel gradually drained the lake.

Tracing the moraine boundary for a few miles beyond Townsbury is difficult, and its exact location uncertain. On the road going west from the village, over the mountain (Mt. Mohepinoki) there is no moraine drift on the steep eastern face of this mountain, above the shelf one hundred and forty feet up from the Pequest, nor on the crest of the monntain, which is about five hundred feet above Townsbury. The latter consists of angular gneiss fragments and earth derived from the disintegration of rock in situation and there are no erratics to be seen. Descending towards the southwest the glacial drift is seen at an elevation (barometric) of nine hundred and fifty feet, or fifty feet below the mountain crest. He we find an upper limit of both moraine and bowlders. Of the moraine mass the prevailing stone are gneissic. There are some sandstones and conglomerates, probably from the Kittatinny or Blue mountain, some chert and many blue limestones. Fromes Hill, southwest of Townsbury, appears to be covered to its top by the glacial drift. At the eastern foot of this ridge and on the west side of Pequest creek there is a line of low drift hills which extends southward quite to the Oxford township line. These may be considered as belonging in the moraine, and as its southwestern extension from Townsbury. South of these hills and east of Pequest Mine, drift, in the form of large gneissic bowlders, appears on the southern slope of a limestone ridge. But the otherwise smooth and uniform slopes of the ridge do not look like a glacial drift surface. Southwest of this limestone ridge are the Furnace Creek Meadows belonging to the Union Farms. These are alluvial, and probably owe their origin to insufficient drainage, resulting from the glacial drift accumulations along the Pequest near the mouth of this tributary to it.

Going southwest there is a noticeable drift hill bounded by the Furnace creek in the east and crossed by the Oxford Furnace and Butzville road. It rises to a height of over two hundred feet above the Pequest valley. On the opposite side of the creek and north of this hill there is a heavy covering of glacial drift concealing the strata underneath. There are good sections of this drift in the ravines coming down the creek. The greater number of the bowlders are sandstones and conglomerates (Blue mountain), but the larger and less rounded masses are gneissic. These latter have come but a short distance, from the Jenny Jump mountain. Blue limestones are large and abundant. In addition to these there are red sandstones, slaty rocks, chert, etc. Many of these are beautifully striated. The railroad cut, one-half mile west-northwest of Butzville, presents a very good section of the drift. The upper portion of the hill, as seen in the cut, is quite sandy. Of the bowlders exceeding three feet in diameter the greater number are rocks of the Blue mountain. Among the smaller bowlders there is a greater proportion of blue limestones than among the larger sizes, but of these most are silicious rocks. The gneiss and other crystalline rocks are present as cobblestones, and these are less numerous than the sandstones, conglomerates and other quartzose rocks. Most of the pebbles and bowlders here are finely striated. The locality is an unusually good one for the study of morainic materials. The surface of the ground on all sides is very uneven. The comparatively small amount of gneissic and other crystalline rock material at this place shows that the general movement of the carrying or propelling agent was not so much from the northeast as from the north and northwest. The moraine along the Pequest has shut in the valley of Green's Pond. This pond, swamp-like in depression, lies between the southern part of Jenny Jump range and the Frome Hill or mountain, and its natural outlet is southward to the Pequest. The incomplete drainage has made a part of the basin a very pretty lake.

The boundary of the moraine south of Butzville is near the cross-roads, three-fourths of a mile from the village. Thence it runs westward one-fourth mile, and then turns and runs north-northwest along a small brook west of the Oxford Furnace and Butzville road to the narrow valley of the Pequest. Thence its course is again westerly along the foot of the Raub Hill, and south of the creek to the northwestern point of this hill, near and southeast of Bridgeville. Here it leaves the Pequest depression or valley, and enters the great Kittatinny valley; and at this point it makes a bend towards the southwest, and thence runs along the gneiss ridge east of the Bridgeville and Oxford road, at length crossing it and then following it to Oxford. That part of the moraine which lies at the foot of the gneiss ridge between Bridgeville and Oxford consists of sand, earth, gravel, cobble-stones and small bowlders, principally of slate, blue limestone and Blue mountain rocks, forming hills whose outlines are smooth and whose slopes are steep and wanting the greater inequalities so common to glacial drift. The highest of these hills on the west of the road has an elevation of four hundred and ninety feet above tide level. One east of the same road is five hundred and twenty feet high. Very few bowlders on the surface are over two feet in length. The greater number of the cobble-stones and bowlders are rocks from the Blue mountain. There are very few gneiss or other crystalline rocks. The southern end of this range of hills is cut near the school house by the road leading from

Oxford eastward. At this point there is considerable sand in the mass, and some stratification is noticeable. The hills south and southwest of Oxford are bare of all glacial drift, so that it is the southernmost limit of that formation in the western part of the State.

Towards the west the drift hills continue from near Oxford and south of the Pequest to the Belvidere line, about one-third of a mile south of the H. J. Butler farm house. The top of the hill is about five hundred feet high, which agrees with the height of the hills near the Oxford and Bridgeville road. The hill is of blue limestone, covered in places by a quite thick mantle of unsorted bowlder drift. Of the loose stones herein perhaps ninety-nine per cent. are from the slate of the valley and the sandstones and conglomerates of the Blue mountain. There are some blue limestone and a few cherty stones, and occasionally Helderberg limestones and Oriskany sandstones are seen. Some of the bowlders at this locality are large, four to five feet long. From this point the line of the moraine has been represented as crossing the creek and following the foot of the bluff along North Water street to the Delaware. In consequence of the changes in the surface made by water and the partial obliteration of the moraine there is some uncertainty in the line as it is drawn through Belvidere. There are here, and extending eastward, south and also northward, several terraces from the present river flat or flood plain up to a height of four hundred and five feet. The latter borders the Beaver brook depressions, and Sarepta and Bridgeville are on it. The plain west of Oxford, and stretching south to Roxburg is also a part of the same general level. Belvidere (south of the creek) stands on a lower terrace. These terraces indicate a period of floods and broad streams which swept away the moraine near the river and re-deposited its material on these broad flats. It is possible that the moraine, as left by the great glacier, extended a little farther south down the valley of the Delaware. The drift on a low hill one mile south of the town and west of the Harmony road may be a part which has not been altogether modified. But there are no traces of it on the slate hills west and southwest in Pennsylvania. And these appear to have limited it on the south, as it is not seen on them. The extension of the line, in order to connect the Belvidere hills with the similar deposits west of the Delaware, must follow the river to the valley of the Jacobus creek, whence it has a westerly course near Bangor to the Kittatinny mountains near the Wind Gap.

We have a measure of the thickness of the ice or the upper limit of the moraine on the sides of the Manunka Chunk mountain, two miles south of Belvidere. This is a high slate hill, whose upper portion is cone shaped. Its elevation is six hundred and fifty feet. The bowlders and bowlder earth are in mass to within about ninety feet of the summit. On the higher part of the hill or mountain, the bowlders are comparatively few in number and small. Nearly all of them are either sandstones or conglomerates from the Blue mountain. In the drift on the lower slope these rocks constitute the larger portion. With them there are blue limestones, chert and slate, but no gneiss rocks. The absence of the latter would appear to indicate that there was no movement of ice from the northeast, or from any point east of that quarter.

Elevations above Mean Tide of Glacial Drifts on the Line of the Terminal Moraine.

		Feet.
1.	Poplar Hill, Woodbridge	240
2.	Summit, Second mountain	380
3.	Long Hill	(350)
4.	Madison, (ridge southeast)	366
5.	Southeast of Morristown	382
6.	Green in Morristown	370
7.	Morris Plains	405
8.	Ketchum Pond, (Boonton Branch Railroad)	556
9.	Snake Hill, (north end)	(670)
10.	Southeast of Rockaway, (between two lines of Morris and Essex Railroad)	(670)
11.	Gravel Hill, southeast of Dover	(645)
12.	Dover, (moraine north of the town)	(640)
13.	Near Mount Hope	(960)
14.	Canal level, Port Oram	668
15.	Jackson Hill Mine	(960)
16.	Succasunna Plains, (north of)	(760)
17.	Hills east of Drakesville depot	(870)
18.	Hills near Drakesville and Stanhope road	(1100)
19.	Hills southeast of Waterloo, (one and one-half miles north of Budd's Lake)	(1250)
20.	Valley north of Hackettstown	(650)
21.	Ridge near A. R. Day's, northwest of Hackettstown	(900)
22.	Side of mountain near Amos Hoagland's	(600)
23.	Townsbury	(580)
24.	Side of mountain at Townsbury	(660)
25.	Mount Mohepinoki, west of Townsbury	(950)
26.	Hill south of Oxford Furnace	(600)
27.	Hill east of Oxford and Bridgeville road	(520)
28.	Hill west of Bridgeville	(490)
29.	Hill east of Belvidere, (H. J. Butler's place)	(500)
30.	Manunka Chunk mountain	(560)

MORAINES OF RECESSION.

Descriptions and Localities.

That portion of the State which lies north of the great terminal moraine is very generally covered by a glacial drift, and this drift constitutes the surface formation, excepting those tracts of wet meadows and some of the valleys and other lowlands, which are either alluvial and recent or belong to a post-glacial epoch. As the continental glacier melted away at the south and retreated northward it left the materials carried on its surface, and these were deposited somewhat as they had been grouped on the ice. A gradual recession strewed more or less the whole surface with the bowlders and bowlder earth, which made the mantle or drift sheet reposing upon the underlying rock formations. Whenever this retreat was for a time stopped and the glacier halted there was an increased accumulation at its foot, and thus a succession of terminal or frontal moraines, but of limited extent, would be formed. The distribution of the glacial drift over this part of the State is very uneven. It is not a continuous formation, nor is there any uniformity in its thickness. And there are, in many places, no bowlders and scarcely any bowlder earth covering the rocks in place, or the earth derived from their disintegration and now constituting the surface layer. The higher hills and ridges—the peaks and crests are generally quite destitute of drift, excepting a few scattered bowlders, and these even are wanting upon some of the higher points. The top of the Kittatinny or Blue mountain, many of the beautiful and smooth slate hills of the great Kittatinny valley, the crest of the Bearfort and Green Pond mountains, Hickory Hill near Mount Hope, Sheep Hill near Boonton, and the trap-rock hills west of Paterson and many others, are all quite bare and show their rocks in many outcropping ledges. Others are so deeply covered that it is often difficult to ascertain the nature of the rocks in them.

The sheet of glacial drift is thicker upon the sides of the mountains and hills, and the slopes of the drift on them are generally quite uniform and more gentle than those of the internal rock mass. That is, the accumulation of drift is thicker near the bases. In many cases these drift slopes are quite as regular and uniform as are seen in the smoother country south of the limit of this formation. The glaciated stone and erratics point to its origin and leave no doubt as to whence it came.

The drift in the valleys north of the terminal moraine is generally stratified. The great volume of water from the melting of huge bodies of ice flowed in these valleys as broad streams or filled them as lakes. And in this way much of the ground, or fundamental moraine, and parts of the terminal moraines, which marked the recession of the glacier front, were worked over and redeposited in water. This rearrangement of materials was probably in progress to a very limited extent during the whole glacial epoch. Warmer seasons or periods must have been marked by the melting of great masses of ice, and a recession for a time, attended by large streams flowing from beneath the glacier and carrying to lower levels an immense quantity of sediment. Subsequent advances of the glacier would move over some of these sedimentary deposits and mingle with them, or cover them with its unsorted debris. No doubt such alternate advances and recessions produced some of the drift phenomena now observed. The final retreat and disappearance of the glacier appears to have given rise to great streams and large lakes which, in part, obliterated the great terminal moraine and deposited glacial drift over wide areas south of it. These beds of stratified drift found in many of our northern villages and on the plains of the central part of the State, are consequently of later age than the terminal moraine or the sheet of glacial drift covering the surface north of it. The size of the streams and the force of water are measured by the wide-spread gravels and bowlders and the disposition of the stones in many localities. The decreasing size of the gravel pebbles and the fine sediment evenly deposited in thin layers show the lessening force of the water as it flowed forward in broad channels and emptied into broader lakes and bays. As the trend of nearly all of these valleys is approximately northeast and southwest, and, as towards the north they were choked by the receding barriers of ice, it is safe to assume that the general course of the rivers draining away the waters from the melting ice front, was a southerly or southwestern one. And we may consider our existing river system as a diminutive representative of that marking the close of the glacial epoch. The valleys of the Hackensack, Passaic, Ramapo, Ringwood, Rockaway, Pequannock, Succasunna, Berkshire, Musconetcong, Pohatcong, Pequest, Wallkill, Paulinskill and Delaware all served as outlets and channels for the rivers of that epoch. And for a long period they may have continued to receive sediments derived from sources to the north and from the higher lands bordering them. The waters finished the transporting work begun by the ice, levelling, sorting and distributing over a wide area the uneven glacial drift. The terrace epoch was a time of elevation, when the land gradually rose and the streams and lakes were lowered by the erosion of their beds and outlets deeper in the drift which was deposited during the Champlain. As there were no longer any glacier-fed streams, the volume of water was diminished and broad river-beds were left dry, and the streams withdrew to the deeper channels. Many of the lakes were drained off or dried up in part, and the whole drainage system of the country began to assume the proportions of the historic period. These changes have been going on ever since, slowly modifying the surface, although retaining the general features which marked the Champlain epoch.

The following notes of localities illustrate the preceding general statements and enable us to form some conception of the surface configuration of our State in the glacial and the succeeding geological epochs. Their order of arrangement is from northeast and east to southwest and west.

1. Jersey City.—The glacial drift can be seen at a few places only in an undisturbed condition. It contains sufficient red shale to give color to it, and with the shaly earth there are large blocks of trap-rock from Bergen Hill, of hard, indurated, banded shale; also from Bergen Hill, white, angular, feldspathic sandstones, gneisses, granites and syenites, cobble-stones of the same rocks and pebbles and angular fragments of a great variety of rocks. West of Jersey avenue, between Twelfth and Thirteenth streets, the drift lies on a reddish stratified sand. The trap-rock blocks are not much worn or rounded on the edges, and are, in a few specimens, ten to fifteen feet long. The other crystalline rocks, and some of the grey sandstones, are well rounded and striated. A few of the trap-rock bowlders appear much decomposed and quite friable. They may represent the rock of the original surface of Bergen Hill. This drift is thin—not more than three feet thick in places. On the hill in the western part of the city the more common bowlders are trap rock, red sandstone, gneisses and indurated shales. The natural drift surface can

be seen about Communipaw, along the line of the Central Railroad of New Jersey. The artesian wells which have been bored in the city have found rock at varying depths from fifteen to ninety feet. At Mathiesen & Wiecher's sugar refinery the surface earth was found to be twenty feet thick; at Cox's brewery, on Grove street between Seventh and Eighth streets, there was bowlder clay and earth to a depth of seventy feet; at the steel works, Lafayette, the rock was ninety feet deep. Constable's Hook is an upland island, surrounded by marsh and water, and is a reddish-yellow stratified sand drift with many bowlders of trap rock, altered shale, red sandstone and gneiss rocks. The sand is in thin, gently undulating layers. The bowlders appear to have been dropped here by floating ice, and they resemble in general the rock of Bergen Neck. The drift on Bedloe's Island, in New York harbor is very much like the surface of Constable's Hook. They are, apparently, of the same origin. The shallow excavations on the latter have failed to strike the rock.

2. Palisade Mountain and the Great Sandstone Valley.—The broad Red Sandstone Valley of Bergen, Essex and Hudson counties, lying between the Palisade mountain and Bergen Hill on the east, and the Ramapo and Watchung mountains on the west, is furrowed by narrow and deep valleys, which trend south-southwest. The roads running east and west cross the ridges and depressions, whereas, those up and down the valley follow the valleys, or the ridges. One of the best roads for observing this feature of the surface is from Nyack to Sufferns in Rockland county, New York. Another is that connecting Englewood and Paramus. On the first-mentioned road these ridges are high and comparatively broad, attaining a height above tide of about six hundred feet. And the depressions are narrow. The ridges become lower towards the southwest and the valleys widen out into flats, coalescing about the southwestern ends of the ridges which here disappear. The junction of the west and of the middle branches of Saddle river near the New York line is at the south end of a ridge. Tea Neck near Hackensack and the Arlington ridge disappearing at East Newark are other examples. This feature of topography has determined somewhat the extent and character of the drift covering. On the eastern side of this great valley, we see the top of the Palisade mountain, covered in places by a thin sheet of glacial drift. Rock outdrops

are common, and these bear everywhere glacial markings. (For direction of striae and grooves see Annual Reports for one thousand eight hundred and seventy-seven and one thousand eight hundred and seventy-eight.) Scattered bowlders are very numerous, half imbedded in the drift soil or perched on the polished ledges. One of these known as "Sampson's Rock," in the rear of Wm. B. Dana's residence, Englewood, has attracted attention and was described in the American Journal of Science and Arts, volume XL., 2d Series. It is of coarse red sandstone, and is ten by seven by nine feet.

On the lower part of the western slope of the Palisade range and on the sandstone ridges of this valley the drift is unstratified, and on the latter it is so uniformly spread and so thick as to conceal the sandstone, excepting in a few very small outcrops. Generally its surface is smoother and corresponds more to the rock slopes than it does in the heaps and mounds of the terminal moraines. Between Closter and Englewood there is much drift in the form of *short hills.* Near the former place they stand in the border of the plain; southward they rise in the trap-rock slope. Their billowy surface is very prominent in the topography of that part of the valley. Some of them are at least one hundred feet high. They look as if they had been the lateral moraine of a glacier which filled the valley but no longer overtopped the mountain. The composition of the glacial drift varies greatly on the two sides of this valley. Near the Palisade mountain the drift earth is mostly red shale and sand from the red sandstone. The imbedded bowlders are sandstones then gneissic and granitic rocks. Going west the proportion of shale diminishes and the bowlder earth has a greyish white color and is largely derived from gneissic rocks. There are fewer standstones and an increased number of crystalline rocks with Green Pond mountain conglomerate. The gneisses and conglomerate make up ninety per cent. of the bowlders in the drift along the Ramapo mountain. And they are larger than those to the east. The largest which has been observed in this part of the country is in Rockland county, a few rods south of the Piermont Railroad, and one and a-half miles southeast of Sufferns. It appears to be mostly above ground. Its dimensions are forty-five by thirty, by twenty-five feet, and its estimated weight is one thousand five hundred tons. The rock is a feldspathic gneiss, traversed by veins of syenite. It may not have traveled far as the nearest outcrop of crystalline rock is not more than two miles away. While shales, sandstones, conglomerates, gneiss, granite and syenite are to be seen everywhere, no limestones have been observed in the unstratified drift of the valley. Glaciated pebbles and bowlders abound. In the northwestern part of Bergen county there is a great accumulation of drift, both assorted and stratified. The several cuttings on the New York, Lake Erie and Western Railway and the New Jersey Midland Railroad, expose fine sections. In one of these cuts, a little way north of Ramsey's Station, the drift at the southern end is glacial; whereas to the north of it there is a long section of greyish white, stratified sand and gravel. The country south of Paterson and east of the Watchung mountain, or Orange mountain, is very generally covered by glacial drift. It is here largely made up of red shale earth and red sandstone bowlders. The cuts on the line of the New York and Greenwood Lake Railroad, near Bloomfield, Montclair and the Notch, show good sections through the drift down to the glaciated ledges. Along the Newark and Paterson Railroad both forms of drift are seen. At the Newark brown-stone quarries the red shale drift earth holds many large bowlders of red sandstone, trap-rock, gneiss, Green Pond mountain conglomerate and a multitude of sub-angular fragments of shale. Flat pebbles of shale and sandstone are also abundant. The striae on many of the trap-rock and red sandstone bowlders are very finely cut. No traces of any stratification were observed. The mean thickness is about ten feet. The top earth is of a yellowish color; the lower drift is reddish brown. The grading for streets in East Newark and the railroad cuts give long and good sections of the drift. But here it is, in part, stratified.

Along the western foot of the Palisade mountain and Bergen Hill there is much variety in the forms which the drift assumes. At a number of localities the glacial drift is found lying upon a reddish sand, which in turn rests upon the polished and striated trap-rock. At Marion the following section was noted:

1. A gravelly bed	3 feet.
2. Glacial drift	10 feet.
3. Fine red sand	

The same series was beautifully exposed on the new straight line cut of the Pennsylvania Railroad Company, in Bergen Cut. The section at this point was:

1. Yellow, trappean clay soil and subsoil	2 feet.
2. Red shale, glacial drift	10 feet.
3. Coarse red sand and fine gravel	1 to 3 feet.
(4.) Glaciated trap rock	

At the west end of Bergen tunnel, the south side of the cut consisted of the following members, viz.:

1. Yellow, trappean clay loam soil and subsoil	
2. Glacial drift	3 to 6 feet.
3. Stratified sand, gravel and cobble stones	3 to 5 feet.
4. Glacial drift	5 feet.
5. Stratified, red sand at bottom	

In the glacial drift on Bergen Hill the bowlders of red sandstone and shale predominate. The percentage of trap rock is small, and there are few of quartzite and conglomerates. Of gneisses also there are comparatively few. At Bayonne, and elsewhere on the line of the Central railroad the glacial drift was cut through, twenty-five to thirty feet thick, down to the polished and striated rock. The cuttings for streets encountered the same drift. Many large and well rounded gneiss bowlders and angular blocks of indurated striped shale are found. The latter are evidently not far from the parent ledges. Trap rocks and red sandstone predominate in mass and there is much shale in smaller and angular fragments. No serpentine has been observed. The composition of the drift indicates here, as elsewhere in the red sandstone country, a southeastern movement. The alluvial formation of the Newark meadows is supposed to rest upon drift. Several wells in the marshes west of the Hackensack river near the Newark plank road go through the alluvium and into a drift. Four of them, sunk in eighteen hundred and seventy-one, get their supply of water from gravel at a depth of nearly two hundred feet. The well of Huyler and Rutan, near the river at Hackensack, passed through one hundred and four feet of meadow mud and blue and red clays. In Newark the well of Messrs. E. Balbach & Son at their smelting works, passed through about one hundred feet of sand and gravel and then entered the red sandstone. That of P. Ballantine & Sons, at their brewery, went through ninety feet of earth. The well at the works of Lister Brothers, on the bank of the Passaic, was sunk one hundred and ten feet in earth. These figures show the great thickness of drift and the depth of the rock basin.

The surface features of the drift from Newark and Orange, southwest through Union county to the terminal moraine, are very similar to those of the valley to the northeast, excepting that there is a little more shale and red sandstone in it.

WATCHUNG MOUNTAINS.—The three ranges of Watchung mountains, known as First, Second and Third mountains, and by other local names extended southwest beyond the southern limit of the glacier and determined its course towards the close of the glacial epoch and the distribution of the drift as it retreated northward. The drift sheet is more nearly continuous than it is in the country east of these ranges, and in places it is of great thickness, concealing except on the higher mountain slopes, the red sandstone and shale rocks. On the summit of High mountain, five miles north of Paterson, and eight hundred and seventy-eight feet above mean-tide level the ledges show a southward movement of the ice and there are many large bowlders, from three to ten feet in diameter, perched on the smooth ledges. The general course of the markings on these mountain ranges is southwest. But the materials have come mainly from the northwest. In the narrow valley between the Frst and Second mountains there is a great deal of unsorted glacial drift. Large bowlders of gneiss rock, twenty feet long, of quartzose and trap rocks are to be found in it, near Oldham creek, west of Paterson. A good exposure of this drift is had a few rods west of Great Notch Station, on the New York and Greenwood Lake railroad, southward to terminal moraine. Near Milburn the narrow valley has much drift on the foot of the First mountain down to the bottom. On the steep declivity of the Second mountain there is scarcely any drift, and the surface consists of the sandstone outcrops and the talus below it. At Verona there is a drift ridge stretching part way across the valley from the Second mountain, whose south slope is steep, and which appears to be a part of a moraine of recession, marking the limit of the ice as it halted at this point for a time. It is about a half a mile north of the present watershed of the valley. The knolls and ridges continue along the bottom of the valley to Milburn. The drift on the First mountain slope is more uniform, conforming more closely to the trap rock surface. Its materials are red shale earth, with imbedded trap rock, sandstone, gneiss and granite bowlders. Among the larger of these is a notable one of granite, twenty by fifteen, and ten feet out of the ground, lying on the south side of the Mount Pleasant turnpike.

PASSAIC VALLEY.—In the red sandstone district between the Second mountain range and the Highlands, the drift formation is in an almost continuous sheet, excepting the higher parts of the trap-rock ridges and the wet meadows, where it is covered by the later alluvial beds. Much of it is stratified. The glacial deposits have been modified by water. The western slope of the Second mountain is so covered by dirt that the boundary or division line between the trap-rock and the sandstone cannot be located accurately. Rock outcrops are very scarce. Bowlders and blocks of trap-rock abound, as also gneissic and granitic rocks, imbedded in a clayey matrix. Wells eighty feet deep at Centreville, on the mountain side, do not pass through this drift. A granite bowlder twenty by twelve, by eight feet lies on the surface near the road and east of the village, on the crest of the mountain. Thence southwest the amount of loose stone is so great as seriously to interfere with tillage. Near the terminal moraine the bowlders seem to be more numerous and the mass is red with shale fragments and earth. The materials composing the drift on the western side of this red sandstone valley or district differ from those of the eastern in the greater number of Green Pond mountain conglomerate and crystalline rocks derived from the Highlands. And the red shale no longer gives color to the mass, but the gneissic materials impart a greyish white tinge. But nearly the whole mass of the drift, below the level of four hundred feet, appears to have been modified by water into the form of level-topped hills and terraces, which rest upon the slopes of the mountains. About Parsippany and Old Boonton, in Morris county, the uneven surface and the many large bowlders show that the action of the water has not greatly disturbed the deposits left by the ice. Such localities may, however, owe their present surface to local causes subsequent to the Champlain epoch.

THE HIGHLAND RIDGES north of the terminal moraine and east of the long depression or valleys of West Milford, Longwood, Berkshire and Succasunna plains are covered by glacial drift in irregular shaped sheets and patches of varying thickness, leaving here and there outcrops of glaciated ledges and fields of rock. The higher peaks and ridges, which are between eleven hundred and twelve hundred feet high, are quite free from drift, except in the form of scattering bowlders. The lower slopes are generally made up of drift materials. Gneissic, granitic and other crystalline rocks of the country have furnished the greater part of the drift mass, but there are many bowlders and much of the finer material of the silicious rocks of the Green Pond mountain series. Slaty rocks, blue limestone and sandstones from the West Milford and Longwood valleys are also common, but in the form of gravel and small bowlders and fragments. Many of the bowlders are very large, and nearly all of them show glacial markings. The slopes towards the south and the southern ends of the ridges are more abrupt than those towards the north, and are, in many places, quite free from drift. The drift has been modified by water in some of the basins among the hills. And in many of them the stratified drift has been covered by later accumulations of peaty matter. There is a small valley at Macopin, in Passaic county, where the surface is a stratified, fine, gravelly loam, forming the flat on which most of the farms of the settlement are located. Echo lake, eight hundred and ninety-three feet high, lies in the slight depression at the foot of Kanouse mountain and on the western border of the flat. It may be the undrained part of the lake which once occupied this valley.

The cuttings on the line of the New Jersey Midland railroad give short sections of the drift in the Pequannock valley. One of the best of them is a short distance west of Charlotteburgh. At Boonton the Rockaway has worn a channel through the drift into the solid rock, and made good exposures of its material. In the right or southern bank of the stream there is, at the top, a stratified drift, which is in contact with the glacial drift underneath it. At the bottom the polished ledges of gneiss are to be seen. The road cut west of the village, on the Rockaway road, is another good exposure. Short and thin layers of sand and gravel appear in the mass of unsorted drift. The bowlders of Green Pond mountain conglomerate and gneiss rocks at this locality are remarkably large. On the summit of Sheep Hill, nine hundred and thirty-five feet high, there are many large blocks perched on the *roches moutonnèes* surface.

There are several ponds in this part of the Highlands, of which Splitrock pond and Green lake are particularly noticeable. Both of them are in high valleys, the elevation of Splitrock being eight hundred and fifteen feet, and that of Green lake one thousand and sixty-nine feet. The former is a natural pond, enlarged somewhat northward by a short dam, thirty feet high, and connecting ledges of gneiss rock at the outlet. From the shape of the valley, between the head of the pond and Charlotteburg, it is probable that the drainage was originally in that direction and into the Pequannock river, and not into the Rockaway. Green lake, in like manner, formerly emptied into the Pequannock. The descent northward, towards Newfoundland, is rapid, about three hundred feet in three miles. A short moraine lies across the valley, at the north end of the lake, between the Copperas and the Green Pond mountains. Its surface features are characteristic of glacial drift. Its eastern end is higher than the western, and the road to Newfoundland passes over it. A short cut at the foot of the Green Pond mountain would restore the drainage towards the Pequannock river. It is, perhaps, the best example of glacial lake in the State; and it is one of the most beautiful sheets of water among the many so formed, and a striking illustration of the change of surface made by that agency. The Green Pond mountain, west of the lake, is nearly one thousand three hundred feet high, and its topmost ledges are smoothed, but not polished and grooved to the same degree as the lower rock outcrops. There are many loose rocks lying about these ledges as if split apart by frost. Glacier striated ledges are to be seen two hundred feet down on the western side of the mountain. On the top the bowlders are small and few in number. They are of gneiss, conglomerate and sandstone. The quartzose conglomerate of the Green Pond and Copperas mountains, is in sharp contrast with the prevailing gneissic character of the drift upon them. Southward the ranges lower, and there the drift sheet is more uniformly spread on the western slope, excepting the steeper parts. Large bowlders abound. Two of hornblendic gneiss, near the Sparta turnpike, are each fifteen feet in diameter, and eight feet out of ground. In the country south-east and towards Mount Hope, the accumulation of drift is very generally spread over the ledges.

Musconetcong Belt of the Highlands.—The drift features of the Musconetcong belt of the Highlands, comprising the ranges west of the West Milford and Longwood valleys to the Vernon and Wallkill valleys, are very similar to those of the eastern Highlands already described. The distribution is uneven, but generally of greater thickness upon the lower slopes and in the valleys. The higher ridges are quite destitute of drift, excepting scattering bowlders and small patches lodged in slight depressions. And there were no peaks or summits so high as to overtop the ice or escape glaciation. The drift material differs somewhat from that on the eastern Highlands, in the absence of the quartzites and silicious conglomerates, characteristic of the Green Pond and Bearfort mountains; and in the presence of more slate and calcareous rocks. Blue limestones of the magnesian limestone epoch and white crystalline limestone are common, especially on the westernmost ridges, as the Wawayanda, Hamburgh and Wallkill mountains. Slate from the Kittatinny valley also is common. The rocks of the Kittatinny or Blue mountain and the Delaware river valley are represented by the well rounded and polished conglomerates, red and gray sandstones, fossiliferous limestones, slates and grits. The earthy material, or matrix in which these bowlders are imbedded, is rather more clayey and, possibly, more calcareous. In some of the valleys there are low ridges and knolls of sand and gravel. Such finer materials are accumulated in the narrow valley west of the Bearfort mountain. And here in what appears more like a modified drift there are conglomerates and sandstones, evidently derived from the ledges of that mountain, intermingled with those which have come from the west and north.

There are several small lakes which appear to be of glacial origin, as Hanks Pond on Bearfort mountain, Dunker Pond, near Stockholm, Canistear Pond, Wawayanda, or Double Pond, Sand Pond on Hamburgh mountain, besides others. Lake Hopatcong lies in an irregular shaped basin among the hills, nine hundred and fourteen feet above tide level, which was probably made by a drift-dam thrown across the old outlet. Canfield Island is a part of this glacial dam. The outlet of the lake was orignally west of the island, previous to the enlargement of the lake into a storage reservoir for the Morris canal. The pre-glacial drainage of the basin, or old valley, appears to have been towards the south into the Raritan. But the country has not been surveyed carefully so as to enable us to know the origin or the shape of the rock basin in which it is held. A large part of the present lake area, as is well known, is flowed land.

The main roads crossing the belt, from Vernon to Newfoundland, and from Sparta to Woodport and Berkshire valley, afford excellent opportunities for studying the drift phenomena in all its phases. Along the New Jersey Midland railroad, between Oak Ridge and Ogdensburgh, there are many low cuts in it. The D., L. & W. railroad cuts at Stanhope, and near Waterloo, expose very good sections. That east of Stanhope, forty feet deep, is particularly good in showing both the structure, and the composition of the glacial deposits. Bowlders of zinc ore are found on the mountain east of Sparta so numerous as to have led to mining there for the ore. The same characteristic ore has been found as far southeast as Dover. These bowlders have come from Mine Hill near Franklin, and Sterling Hill west of Ogdensburgh, and they indicate the southeastern course of the drift. Stratified beds of sand, gravel and bowlders, taking the form of flats or terraces, or smooth knolls or ridges, lie among the hill tops. The Seward meadows, north of Snufftown, is a good example of such stratified formation, partly covered by alluvium. They, probably, had their origin in the waters from the glacier surface, carrying the accumulations on this surface through crevasses and breaks in the ice down to the ground moraine. Of the hills there is a notable group, over one hundred feet in height, one mile northeast of Hurdtown, and near the Lower Longwood road. There are others on the Dover road, southeast of the same place. West of Stanhope, in the valley of the Musconetcong, there is another group of conical hills of drift.

THE POCHUCK MOUNTAIN, PIMPLE HILLS.—The Andover, Alamuche and Jenny Jump mountains, of the Pequest belt, the westernmost ridges of the Highlands, exhibit drift features very similar to those of the Musconetcong belt. There is the uneven distribution, the ever varying thickness, and the glaciated rock outcrops, common to the Highlands north of the terminal moraine. Many bowlders have been picked off wherever the surface was adapted to tillage, and many of the blue limestones have been burned into lime. On Pochuck mountain there is much drift on the northern end, and along the eastern foot. Bowlders from the Kittatinny mountain are abundant. The slate and limestone are also common and often of large size and but slightly rounded on edges. Roe pond and Decker's pond lie in basins formed by drift in part. On Mine Hill the various rock outcrops and the zinc ore beds still retain their polished and striated surfaces, wherever protected by a thin drift earth covering.

In the Vernon valley bordering the Pochuck creek, alluvial deposits cover the drift from the New York line southward to Vernon. On either side of the wet or drowned lands there is much glacial drift in the form of hills and ridges, and in a thick covering on the lower slopes of the Wawayanda and Pochuck ranges. The upper line of fields and clearings on the former marks the upper limit of the thick mass of drift, as above that line the mountain is steep and rocky. One mile southwest of Vernon there is a large bank of drift, through a narrow cut in which the Black creek finds an outlet. The southward slope of this bank is very steep. It is a *moraine of recession.* Also at McAfee valley there are hills of drift nearly filling the valley from side to side. Wherever cut into the sections are sand and gravel in strata covered by unsorted glacial drift. This series or range of drift hills trends southwest, east of Hamburgh. The railroad line is west of it, and Hamburgh is on the western foot of this drift. The railroad cut south of the village and near the residence of the late Governor Haines, presents an excellent section, sixty feet deep, of one of these hills. The earth, sand, gravel and bowlders are mixed together without order, excepting short and irregularly alternating layers of sand, gravel and cobble-stones in the middle of the cut. Many of the blocks are three to six feet long, and but little rounded on the edges. The smaller bowlders show more wear, and are very generally polished and striated, especially the harder rocks. Gneissic, granitic and syenitic rocks are abundant. The smaller stones are slate, blue limestone, sandstone, conglomerate, and white crystalline limestone. The gravel is made up chiefly of slate, blue limestone and quartzose rocks. The fossiliferous rocks of the Delaware river valley can no doubt be found. The composition of the drift here may be taken as representative of that of the Vernon valley also. The surface is marked by its inequalities with its sink holes and pond holes. The range is continued west of the Wallkill in a group of prominent and singularly shaped hills. They attain a maximum height of six hundred and forty-three feet, about two hundred and twenty-five feet above the Wallkill. The southwestern continuation of these hills, and their relation to the level on which the North church stands, are matters of further surveying and study. Possibly they are part of a great moraine coming out of the Vernon valley at Hamburgh and stretching thence westerly across the great valley to the Kittatinny mountain. A noticeable feature in them is the correspondence in their height and that of the Ogdensburgh moraine.

In the drift at Franklin Furnace, as cut into on the line of the Midland railroad, near the office of the Franklin Iron Company, bowlders of franklinite and of calcite with franklinite, from two to five feet in diameter, are quite common. Up the valley of the Wallkill there is not so much drift until the great bank at Ogdensburgh is reached. This drift bank was referred to in the "Geology of New Jersey," eighteen hundred and sixty-eight;* and again, as a "Moraine" in the annual report for eighteen hundred and seventy-eight. It is a conspicuous feature of the landscape, and affords beautiful views of the valley, both to the north and to the south. And it serves as an embankment for the New Jersey Midland railroad, crossing the valley of the Wallkill. Its height is 660 feet above the sea, and 100 feet above the meadow level along the kill. The village of Ogdensburgh stands partly on its eastern end. Its length, measured in a straight line directly across the valley, is three-fourths of a mile; but as it curves at each end northward, the actual length is considerably greater. Its breadth may average a quarter of a mile. The western end, as traced beyond the Wallkill to Mud Pond brook, is cut through to a depth of ten to thirty feet in the railroad excavations. On the eastern side of the valley it can be followed to the rock cut near Snake Den. The gravelly shelf or terrace in Munson's Gap, further north-east, about the same height, may be a part of the same great level. The thickness of the drift in this bank is, at the Wallkill, at least 100 feet. At the residence of John George, on the eastern end, a well was dug sixty feet in drift, and then sunk twelve feet deeper in the blue limestone. The slopes towards the south are steep. The cuts of the roads on each side, and the excavations of the railroad company have given good facilities for the study of its materials. The top is almost level, descending gently towards the west. The thin sandy and gravelly layers from that, at least the upper part, have been modified by water. On the south side the loose materials have

*The contour lines of the moraine are indicated on the map of the zinc mines, and published in eighteen hundred and sixty-eight.

been cemented into a stony mass by calcareous matter. White limestone and gneiss predominate among the larger bowlders. One of crystalline limestone, which was beautifully grooved and striated, measured twelve by ten by six feet; and one of syenite ten by ten by eight feet; one of blue limestone eight by six by six feet. A very few Oneida conglomerate, Medina sandstone and Potsdam sandstone bowlders have been observed. Round masses of zinc ore, three feet across, are also to be seen. They are not so smooth nor so well striated as the harder rocks, especially the sandstones and white limestones. Some of the masses of the latter rock are rough on one side and glaciated on the opposite, as if they had been held in the ice and ground on one exposed side only. The sand and gravel have come mainly from gneissic slate and sandstone rocks. And there is rather more of the latter than of the crystalline rocks. In the railroad cuttings west of the kill the ledges of white limestone at the bottom are finely polished and grooved. The drift over them is all unsorted, and in it there is a larger proportion of crystalline limestone than in the moraine east of the stream. A bowlder of Potsdam sandstone eight by seven by three feet was observed in it. This moraine of recession marks the halt of the glacier, which moved southward in the valley. The general absence of heavy bodies of drift in the valley to the southward seems to indicate that the retreat of the ice from this point northward was rapid until it again stopped at Hamburgh.

In the valley south of Ogdensburgh the eastern side is drift, covered most of the way to its head, south of Sparta. The drift at Sparta, stretching from the kill west to the Pimple Hills, may be the remains of another moraine of this valley, which has caused the alluvial deposits and the wet meadows south of the village to the Byram township line. The Newton road runs on the drift across the valley.

ON THE PIMPLE HILLS the drift sheet is in irregular patches and varies much in thickness from point to point. It is marked by the great number of blue magnesian limestone blocks, and in general by the bowlders of slate, sandstone and conglomerate from the Kittatinny valley and the Kittatinny mountain. The zinc ore has not been found outside of the immediate valley of the Wallkill, showing that there was no westward movement of material. The accumulation of the drift was particularly heavy on the westernmost slopes of Pinkneyville, Andover and Alamuche. East of the last-named place the drift sheet conceals the ledges to the top of the mountain.

STAG, PANTHER, CRANBERRY AND ALAMUCHE PONDS lie in drift made basins or hollows. The pond at Alamuche has, at the north end, a bank of drift which looks like a moraine thrown across the narrow valley. Green's Pond, within the limits of the terminal moraine, has been noticed on page 34. There are other but smaller ponds and depressions, which had a like origin in the drift banks thrown across their old outlets.

THE JENNY JUMP MOUNTAIN has been described in part under the description of the terminal moraine. Its westernmost, or main range, is rocky and is more free from drift. The lower eastward slope and the subordinate ridges on the east, along the border of the Great Meadows, are very generally drift covered. On the western side of the mountain there are large masses of blue limestone and many slate bowlders. Southeast of Hope the gap, traversed by the road to Smith's Mill, is filled with glacial drift from one valley across to the other. A bowlder of blue limestone stands out prominently above the gneissic, drift-covered surface, near the school-house northeast of the Kishpaugh mine. Its dimensions are approximately fifty by twenty-five, by fifteen feet, and its estimated weight is two thousand tons. It must have come at least a mile, and risen one hundred or two hundred feet above the outcrop of the nearest ledges of similar rock. It is rough and angular. And it is one of the largest known bowlders in the State.

KITTATINNY VALLEY.—The drift of this great valley has been modified over wide areas, and particularly in the lesser valleys of the Wallkill, Paulinskill, Pequest and others, embraced under this general head. It belongs more to the Champlain than to the Glacial epoch. The glacial drift is, however, found undisturbed on the higher grounds. On the slate ridges it is thin, and in many places there are but few widely scattered, small bowlders, so that at first sight they seem *driftless*. Many of the high slate hills in this part of Sussex county are so smooth and free from bowlders that they look like the slate hills of Pennsylvania south of the terminal moraine.

Smith's Hill, north of Newton, and the high ridges east of Marksboro and the smooth hills west and southwest of Hope are but thinly covered by drift. A very noticeable feature of the valley is the increasing number and size of the conglomerate, sandstone and slaty grit bowlders, and the greater thickness of the drift on the western side of the valley, near the Kittaninny mountain. And it is also noteworthy that these bowlders are more worn and more generally striated than the large, loose blocks and bowlders on the Highland ranges. There are no such huge blocks as have been referred to as occurring further east. Of course the material is such that it retains better the markings, and it appears to have suffered more wear or attrition. Cobble stones and bowlders, less than three feet in diameter, predominate. The fossiliferous rocks from the Delaware river valley are not uncommon. Bowlders from the characteristic labradorite porphyry of Beemerville have been observed at Balesville; also, the ophiolite of Augusta, and a single specimen of gneiss. All these show the movement of materials here to have been, in general, towards the southeast.

At the northeast, along the Wallkill, the drift and older formations are covered by the alluvium of the Drowned Lands. The drift on the borders of these lands, and on the islands in it, is mostly modified—beds of sand and gravel—and it represents the deposition in a large lake whose basin was formed behind the drift in the valley of the Wallkill, between Goshen and Denton. The old channel or outlet of pre-glacial times must have been further east, and probably near the present canal. The filling of this outlet by the drift diverted the stream to the west, over the slate edges at Hampton, and ponded back the water for twenty miles, to the head of the Drowned Lands near Hamburgh, forming a lake which was, in places, four miles wide. The depth of the mud is about twenty feet, the deposition since the close of the Champlain epoch. The outlet canal cuts through forty feet of drift near Denton. In times of freshet the old lake is restored in part.*

Of the natural ponds and lakes in the Kittatinny valley, Culver's and Long Ponds, near Branchville, and Swartout's Pond, in Stillwater township, Sussex county, are the largest. Many of the smaller ponds were formed by the glacial debris choking the outlets

*The description of the tract and a map of it can be found in the annual report for eighteen hundred and seventy-one, pp. 13–20.

and making basins which were not subsequently filled in the distribution of materials by the waters of the Champlain epoch. The old glacial dams were not disturbed beyond a levelling of their surface and a sorting of the materials at the top.

THE KITTATINNY OR BLUE MOUNTAIN is thirteen to eighteen hundred feet high, or five hundred to one thousand feet above the Kittatinny valley, and one thousand to fourteen hundred feet above the Delaware river. It is not like the Highlands, a high plateau with its ridges of uniform height, but a single, prominent ridge, with lower ridges on the west, except to the northeast and north of Culver's Gap it broadens and consists of several crests of nearly equal altitude. The glacier did not greatly modify this surface, except to grind down and polish the more prominent ledges. The height of the main crest was so great that the ice scarcely more than covered it, and left but little loose material on it. The accumulation took place in the low valleys on each side. And the ledges of the mountain contributed largely to the mass which was carried to these lower levels. It is possible that the ice lingered on these high slopes for a long time after it had disappeared from the valleys on each side and local glaciers may have continued to carry the drift down. Whatever may have been the movements we find scattering bowlders and patches of drift on the higher parts of the range and an increasing extent and thickness in the depressions and on the lower ridges, excepting the very steep and precipitous sides, which are generally bare rock, or with very little earth. The Port Jervis and Coleville road, that through Culver's Gap, the Newton and Flatbrookville road, and the Delaware Water Gap are good lines on which to study the drift of the range. Towards the southwest the thick body of drift appears to run down on the western slope. Thus at Culver's Gap its elevation is at about one thousand feet, and near the Water Gap it is from seven hundred to nine hundred feet above tide level.

DELAWARE RIVER VALLEY.—Descending into the valley of the Delaware and that of Flat brook and Mill brook the drift becomes so thick towards the bottom of the valley that there are no outcrops throughout a long and narrow belt, twenty-two miles long and one-seventh to a mile wide, from the New York line to Walpack Bend.

The location of the western boundary of the Medina sandstone is uncertain, as also that of the Oneida conglomerates. The drift has covered completely the rocks between the Medina sandstone and the Water Lime group, if they exist at all in the State. Very much of it along this line has been modified and now appears in terraces and level topped hills. A large percentage of the mass on the mountain is made from the red (Medina) sandstone. The Lower Helderberg limestones, Oriskany sandstone, Cauda Galli grit, Onondaga and Corniferous limestone are represented by many bowlders and fragments, and with them the harder rocks of the more distant Hamilton and Chemung groups of New York and Pennsylvania. The drift of the water-shed between the Little Flat brook and Mill brook, in Montague township, appears to be part of a *moraine of recession.* The very uneven surface, and the sink and pond holes from Isaac Bonnell's residence and Chambers' Mill brook, for a mile northeast in the valley, resemble those of the terminal moraine. Its height above ocean level is about seven hundred and fifteen feet. By reference to the map it will be observed that there are several ponds on the mountain. Lake Nascia, near High Point (the highest sheet of water in the State), Sand Pond near Coleville, Catfish Pond in Pahaquarry, and Sunfish Pond near the Delaware Water Gap, are all natural lakelets high on the mountain. All of them are probably in rock basins, shut in by glacial dams. At Sunfish Pond the cutting of a ditch through the drift at the south end has diverted the water into another channel, apparently on the course of the old drainage.

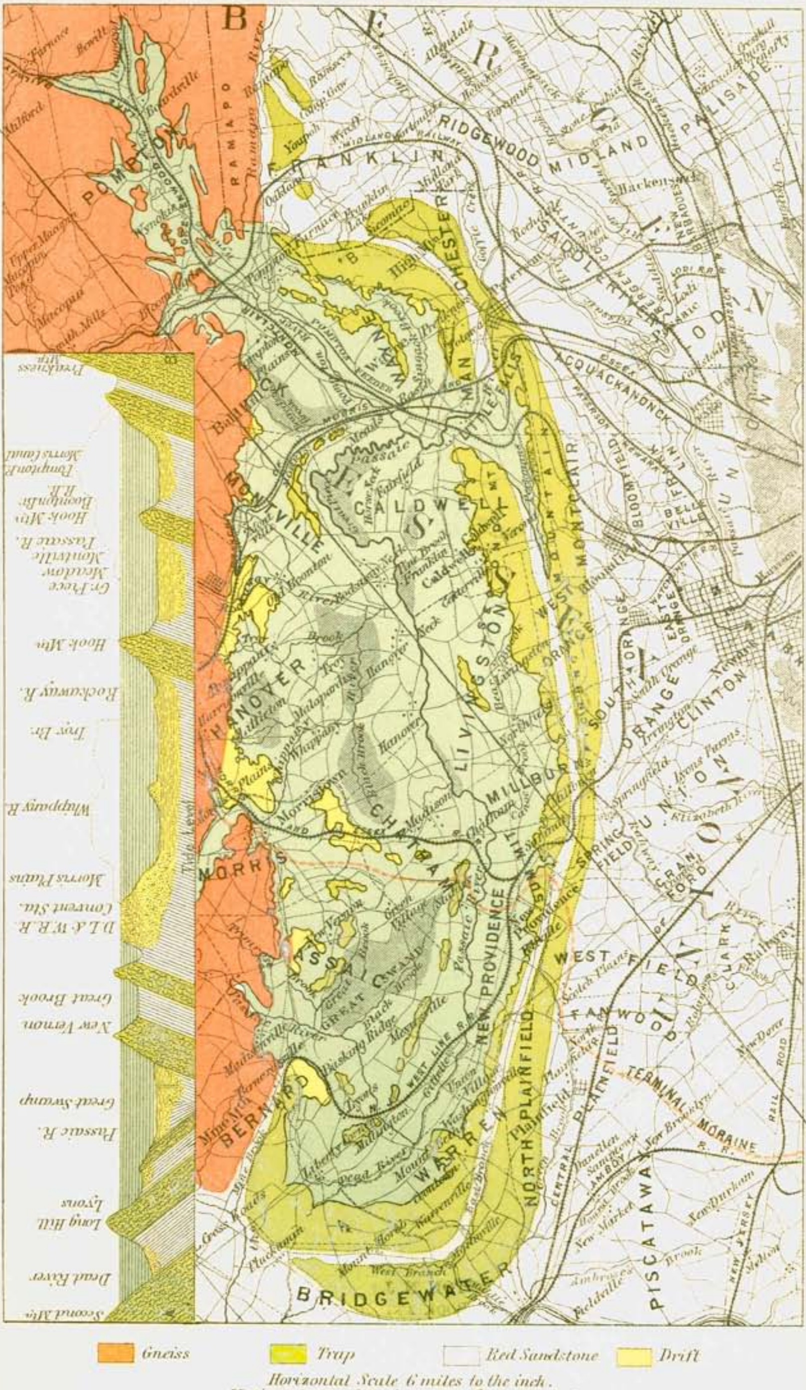
The broad ridge on the west of the Flat brook and stretching thence to the New York line and sloping westward to the Delaware, is quite free from drift on its summit, which is largely under cultivation. On the river side there is more drift and it increases down to the river flats and gravelly terraces of the Delaware.

MODIFIED GLACIAL DRIFT.

The moraines described in the preceding pages are not all now found in the form of ridges and hillocks with their rounded tops, and the closed hollows or depressions between them. There are some such, but in many other cases, they have manifestly been surrounded by water, or even entirely covered by it. And their rounded

LAKE PASSAIC.

[A GLACIAL LAKE]



Gneiss | Trap | Red Sandstone | Drift

Horizontal Scale 6 miles to the inch.
Vertical Scale of Section 1000 ft. to the inch.

tops have been brought down to uniform flat-topped terrace-like hills, and the little valleys have been partially or wholly filled up. The accumulations of water to produce these effects are due to one of two causes.

The first of these to be mentioned is a level of the ocean, higher than at the present time. This may amount to fifty or sixty feet, and the marks of it are to be seen wherever the ground was open to the sea, and to the unimpeded rise of ocean water. Streams or torrents meeting this body of comparatively still water would naturally drop in it any earth, stones or bowlders which they may have brought down from higher levels and would continue to do this till banks were formed nearly as high as the surface of the water. Such level-topped banks of this height are now to be seen at Trenton. They were formerly about the railway depot at New Brunswick; they are to be seen along the Passaic at Newark; there are very conspicuous ones on the Hudson near Peekskill, and Prof. Dana in the American Journal of Science, (third series, volume X., pages 409–438), mentions, though in a different connection, those of the same height in New Haven.

At later periods, when the land was rising higher above the sea level, other and lower terraces were formed, but those first mentioned are the highest which can be traced for any considerable distance along our tide waters.

The second cause for the production of these modified glacial drifts is to be found in the temporary enclosure of great bodies of water from the melting ice, in valleys and other districts partly surrounded by hills. Such enclosures would be easily completed by the deposit of great masses of glacial earth, to make a dam across one part of a valley, and then leave the receding glacier to fill the interval between this dam and its own southern edge with water from the melting ice. There were many lakes of this sort in New Jersey, which can now be traced by the marks which their water surfaces left upon their banks. One of the most remarkable and interesting of these is the one which was between the Watchung mountains and the Highland range. It was fully thirty miles long, from six to eight miles wide, and in most places two hundred feet deep. It covered the country where Madison, Chatham, New Providence, Basking Ridge, Hanover, Whippany, Troy, Pompton and Little Falls now stand. Long Hill, Riker's Hill and the Hook mountain were islands in it. And its shores were made by the Second mountain from Paterson to Bernardsville, by the Highlands from Bernardsville to Pompton, and from thence to near Paterson by the Second mountain again. The only outlet to this lake was by the valley of the Passaic at Paterson, and this was at that time closed by the ice of the receding glacier, and its then terminal moraine still fills most of the valley where the Boonton branch of the D., L. & W. railway crosses the Passaic. The sufficiency of these banks is plainly evident to any one familiar with the country spoken of, and the level of the water in it is to be seen everywhere by the sand and gravel banks which have been made by the natural wash from the surrounding country, which were carried down into the water and there deposited. The surface level of this lake was about 380 feet above the present level of tide water. The plain country between Madison and Morristown is of this height, and so is the moraine ridge from just south of Chatham, to Madison and Morristown. The terrace-like hills near Montville, those at the India rubber works above Bloomingdale, those at Preakness, the sandy banks near the top of the Hook mountain, and many others around this old lake border remain to give testimony for this hitherto unnoticed lake.

There are many other places where great bodies of water have been shut in for a time, and then burst out to remove or modify the great masses of glacial drift which were first deposited in the various terminal, lateral and ground moraines. To study out and make connected descriptions of these is one of the objects of this work, and the detailed descriptions which follow are the part which must first be done before safe and comprehensive conclusions can be reached.

THE GREAT RED SANDSTONE VALLEY.—As has been stated in the account of the glacial drift of this valley, the ridges are covered very generally by a thick mantle of unsorted drift, while the valleys lying between these ridges are lined with beds of earth, sand and gravel, excepting at their northern ends. As they widen southward these stratified beds form broader terraces and extensive flats. In a few of them, as along Spraat brook, along the Hackensack, from Old Hook to New Milford, and at the State line near Tappaan, the flats are so level as to give rise to swamps and wet meadows. The materials of this drift are finer going southward or down the valleys.

Northward there is more gravel and cobble stones; to the south reddish, sandy loams prevail. Vertical sections of these stratified drift beds are seen at Orange Mills, Rockland county, New York, near Westwood, at Paramus, Tenafly, Closter and at many other points, especially along the Northern, New Jersey & New York, and the Jersey City & Albany railroads. Near the Hackensack, between Westwood and Old Hook, there is a sandy level of considerable extent. But the largest of these stratified drift levels is that of Paramus, bordering on the west the Saddle river, and extending west to Hohokus, and nearly to Ridgewood, where it is a mile wide. The height of the level above tide is nearly one hundred feet. The Paramus Reformed Church stands on it. About a quarter of a mile north of the latter there is a long depression or sink in it, about two hundred and fifty yards long and twenty-five feet deep, the bottom of which is partially covered with water. Very few small bowlders from one to three feet long are to be found on the surface of the plain. The glacial waters flowing through the gorge of the Saddle river and the Hohokus creek here spread out in a broad, shallow stream, and a mile or two further south they met the sea level of that epoch. The lower levels, fifty to sixty feet high, probably represent a sea border formation and the shores of the same geological time.

The terraces along the Ramapo river, at Sufferns, New York, mark the successive heights of that stream. The highest of these is at the east side of the village, and the Episcopal and Methodist churches are on it. It is between ten and fifteen feet above the middle terrace, on which most of the business part of the village is placed. The third, or lowest terrace, is about twenty feet below the railroad level, or middle terrace. Following the valley of the Ramapo, we see banks and level-topped hills of sand, gravel and bowlders thickly disposed, leaving but little of the meadow flats on its borders. The drift hills average seventy to eighty feet high, and the wells dug in the drift are thirty-five to sixty-six feet deep. A boring made several years ago for coal, near the residence of Ex-Governor Price, struck the rock at a depth of one hundred and seventeen feet, showing that thickness of the valley drift. South of Oakland the valley becomes broader, and there are some remarkable level-topped hills and terraces. The upper one of them is about a mile square, and is approximately three hundred and fifty feet high.

On it are what are known as the Mud ponds—very shallow basins with abrupt sides about thirty feet deep, and with water four to eight feet deep in them. They are quite grown up with reeds, and look more like reedy marshes than ponds. They are in fact undrained sink holes. To the eastward there are lower terraces and much stratified drift. Oakland is on a lower terrace to the west, and the Crystal lake is in another south of this highest level or terrace. Of the drift materials in the Ramapo valley about ninety per cent. are crystalline rocks of the Highlands. Some of the bowlders of these rocks are very large. Many smaller bowlders and much of the gravel is made of slate and sandstone. A very few blue limestone and Oriskany sandstone bowlders have been observed. The Green Pond mountain conglomerate is recognized in a few specimens. The small proportion of red shale and red sandstone in the gravel is quite remarkable. This series of terraces, at such different elevations, points to a broad expanse of water—a large lake-basin which was gradually drained off southward down the valley of the Ramapo into the Passaic. The Mud ponds and the Crystal and Pompton lakes are the vestiges of the ancient lake.

The cut-in gravel at Mahwah, and the singular gravel ridge on which the Ramsey Reformed Church stands, are also connected in some way with the terrace formation of the Ramapo, but their elevations are not known.

Proceeding south and southeast in the red sandstone plain, we notice a long cut in stratified sands and gravel at Hawthorne, north of Paterson. The level-topped hills east of the New York, Lake Erie and Western Railway, in Paterson, are also a modified drift formation. The cuttings at the southern end show lines of stratification in the reddish sandstone gravel. At the top of the bank there are many large bowlders of gneissic and granitic and red sandstone rocks, with a few of Green Pond mountain conglomerate, of trap-rock and triassic conglomerates, all imbedded in a red, shaly earth. They appear also in lines in the earthy drift. These hills correspond in height to the sand and gravel hills northwest of the city, towards Haledon. They are one hundred and sixty feet high, and both are the remains of a terrace whose further extent has not yet been traced.

In the lower portion of the red sandstone plain, about Newark and Elizabeth, and along the foot of the Palisade mountain and

Bergen hill, there are flat knolls and levels of red, sandy loam, and fine gravel which may belong to the Champlain epoch, or may be more recent. Some of them are but a few feet above high-tide level. The excavations along the Newark & New York and the Pennsylvania Railroads show the nature and arrangement of the material. There is a good exposure near New Durham, on the side of the Hackensack turnpike, in a gravel pit twenty feet deep, and in which the reddish sand is inter-stratified irregularly with layers of gravel. The latter is mainly red sandstone, gneiss and white quartz pebbles.

PASSAIC VALLEY.—The modified drift of the Passaic valley, or that part of the red sandstone plain, bounded on the northwest by the Highlands and on the other sides by the sweep of the Second mountain range, from Pompton to Bernardsville, is remarkable for its extent, thickness and its long lines of terrace levels fringing these mountains about it. The upper portion of the terminal moraine from Morris Plains to Summit, has been modified by the action of water, and has assumed the form of a long and broad, level-topped bank dividing the valley, on a northwest and southeast line. The glacial drift contributed its materials to the formation of extensive beds of earth, sand, gravel and bowlders which are found in the valley north of the terminal moraine and probably much fine earth was carried southward and deposited in the deep basin south of it. The upper level, corresponding to that of the moraine in the Morris Plains, and the level from Morristown to Madison has a mean elevation above tide of three hundred and eighty-five feet. It is recognized in the flat-topped hills northeast of Boonton and south of Montville, in the beautiful terrace cut by the Boonton Branch railroad, north of Montville and on the eastern side of the Highlands at the west border of Pompton Plains. It has been traced around the mountain to Bloomingdale; the sand hills near the rubber works are near the same height, and they are, probably, part of the same formation. The high terrace near the Ponds Reformed Church and Oakland, in Bergen county, is also nearly as high and may belong to it. On the Second mountain, two miles southeast of Pompton Furnace and at Upper Preakness, has a mean elevation of three hundred and forty to three hundred and sixty feet. There are indistinctly defined levels at the same elevation at Cedar Grove, at Caldwell and at Centreville, in Essex county. These latter are also on the western slope of the second mountain. Terraces have been observed at the same height on the Hook mountain from ten to fifty feet below the crest line. No attempt has been made to trace out fully this high terrace. Careful examinations of the surface will discover many others, and, possibly, show a continuous level along these mountain sides. The thickness of the formation exceeds one hundred feet on the line of the terminal moraine. In the terraces which skirt the Highlands it is probably much less than one hundred feet. A very fine section, seventy-five feet high, can be seen on the line of the Boonton Branch railroad, a half mile northeast of Upper Montville. At the bottom of the cut the ledges of gneissic conglomerate are exposed finely polished and striated. The lower part of the bank is a stratified yellow sand and gravel; the upper part is gravelly. The gravel consists of red sandstone, gneissic rocks, quartz and Green Pond mountain conglomerate. Comparatively few cobble stones and small bowlders are found in the gravel. Very little limestone has been observed in it. It can be seen, however, at Upper Preakness near the Reformed Church, and on the line of the Pompton and Paterson road. At these localities the materials are more gravel and cobble stones and very large bowlders. Near Great Notch there is a long and deep section in the stratified drift.

From the number of hills of drift in the neighborhood of Hanover, Columbia, Whippany, Troy and Franklin, which are from two hundred and forty to two hundred and eighty feet high, it would seem as if there had been a terrace at about that height. The knolls cut by the Littleton and Whippany road are also of the same height. The sand and gravel hills along the Passaic, near Totowa, mark the site of the dam of drift which occasioned the formation of this terrace. The Pompton Plains is, perhaps, the most remarkable level in all this valley. As its name indicates, it is a plain, and is bounded on the north and west by the gneiss ridges of the Highlands, and on the east and south by the Packanack and Towakhow or Hook mountains. The same level stretches north of Pompton Furnace and Pompton village, up the Wynokie valley a long distance, and includes Furnace Pond within its bounds. Its mean elevation is two hundred feet, descending slightly southward, in which direction its drainage is effected. The Bog and Vly meadow at the southwest end is the wet alluvial part of the plain. The New York and Greenwood Lake railroad, running north and south, shows very plainly the gradation in the gravel and sand southward. Thus the cuttings from Pompton to Pequannock Station are in fine gravel and gravelly loam; thence to Mountain View the material is a reddish, sandy loam. At the southwest is the peat of the Bog and Vly meadows. There is no extent of the same level along the Passaic, although south of the Hook mountain there are some low hills, which are, on an average, one hundred and eighty feet high. The mean height of the alluvial tracts of Lee, Black, Troy, Horseneck and Great Piece meadows, which may be classed with it, is one hundred and seventy feet.

In explanation of their origin we may consider these levels or terraces as marking the successive heights at which the waters stood in this great valley after the retreat of the glacier had begun, during the Champlain epoch and continued through the Terrace epoch. The melting of the ice in the valley and on the Highlands north and west produced an enormous volume of water, which filled the great basin, forming a lake thirty miles long and eight miles wide. The top of the terminal moraine was levelled off and a part of its material was carried southward and silted on the bottom of the lake, where are now the great swamp and the Dead River flats. The gaps through the trap-rock ranges at Paterson and Little Falls were filled with drift by the glacier. The excavation of these drift-filled gaps began as it disappeared, and the outlet again followed the line of the old channel into the red sandstone country on the east. Two causes contributed to the lowering of the lake level. They were the diminished volume of water in the Champlain epoch after the great masses of ice had disappeared from the surrounding hills, and the cutting down of the drift dams along the outlet between Paterson and Little Falls. The former source of supply soon closed and the natural drainage of the water shed with the rainfall on its surface were the sole feeders. The upper terrace is most plainly marked on the surrounding hill and mountain sides. It was the broad pebbly shore of a lake into which poured torrents of water from the neighboring hills, carrying cobble stones and bowlders into it and depositing them so confusedly together as in places to resemble a glacial deposit. The accumulations of drift at Bernardsville and Basking Ridge may have come in that way. The lower level topped hills mark the more quiet waters as they subsided and shrunk into narrow limits. Pompton Plains and the flats along the Passaic and Whippany rivers mark their further contraction into irregular shaped ponds within the bounds of the old lake basin. The erosion through the drift at Little Falls was probably the gradual wear of the Terrace epoch until the hard trap-rock reef was reached. At that level the drainage stopped. The slow work of excavation through this barrier and the recession of the falls have been in progress since that time; and a gorge three hundred feet wide at the east, narrowing westward to the falls, and between thirty and forty feet deep, has been cut back about six hundred feet in the rock. As the falls have not yet materially changed since the earliest records of it, this recession must have required a long period. The further work of cutting through the barrier of trap-rock must be very slow, and hence the drainage of the old lake basin may be considered as practically at an end, unless furthered by the agency of man. We see to-day the undrained meadows and swamps occupying the sites of the later ponds. The process of filling them with sediments derived from surface wash of the surrounding hills is going on, and is destined to fill them eventually, unless the flow of the stream is accelerated by an alteration in the fall. It would be extremely interesting to trace out the borders of this ancient lake, and locate the streams which fed it, and note the islands of Hook mountain, Riker Hill, Horse Hill and others in it, and then follow its contracting outlines until it disappears and then were left the present wet meadow bottom. Its history is impressed upon the topographical features of the country so plainly that the enthusiastic and diligent student can, by the aid of good maps, restore it. And for such inquirers the little map of LAKE PASSAIC (*a glacial lake*), is here inserted. It is only a section of the State map, and its geographical associations will be better understood by a reference to that at the end of this Report.

WYNOKIE AND RINGWOOD VALLEYS.—The stratified drift in the valley of the Wynokie creek and in that of its tributary, the Ringwood, is the north extension of that of the Passaic valley, already described. The valley flat or drift, from the Pompton Reformed Church and Pompton Junction, for three miles northward, is narrow, being in places less than a quarter of a mile across. At Wynokie it widens to more than a mile, and the old Empire Furnace pond is in it. It is traversed longitudinally by sharp and narrow outcrops of gneiss, apparently the crests of ridges partially buried in this drift formation. The creek flows in a narrow bed about twenty feet below the valley level. Going northward there are several gravelly terraces on the foot of Bear mountain and west of the stream. The largest terrace is two hundred and ninety feet high; that of the Wynokie flat or level is two hundred and forty feet above mean tide. The terraces have disappeared from the valley of the Ringwood, near its junction with the Wynokie, but at Ringwood the drift is again recognized in the gravelly knolls, and the formation is near a half a mile wide, from the valley road on the east to the stream on its west border. The elevation at the residence of Hon. A. S. Hewitt, is three hundred and fifty feet, corresponding to the upper terrace on the eastern side of the Passaic valley. To the north there are isolated patches of drift in the bottom of the narrow valley, higher than the terrace at Ringwood. The few cuttings along the railroad through the Wynokie valley expose low sections of stratified sands, gravel, cobble stones, but no bowlders more than one foot in length. As no wells or excavations go through it, the maximum thickness is unknown. From the sharp, steeply sloping ridges in it, there is reason to believe that it is in places, deep. Whether the rock basin was the work of a glacier, or the result of an older geological agency, possibly connected with the uplift of the gneissic strata, is not certain. The terraces indicate the extension of the great Passaic lake of the Champlain epoch, to Ringwood and its successive chain of lakelets in the terrace epoch. The existing ponds are the diminutive representatives of the latter.

The hills of sand and gravel near the Bloomingdale rubber works, and the beautiful valley occupied by the farm of Martin J. Ryerson, east of the village, are also the stratified or modified drift. The railroad cutting at West Bloomingdale shows a thickness of forty feet of sand, and at top a deposit of coarse gravel and cobble stones. These two levels indicate the westward extension of an arm of the Passaic lake up the Pequannock valley as far as this point. The rapid fall of the Pequannock, and the volume of water furnished by its mountainous watershed, may have done much to obliterate traces of the lake levels in it, and to alter the surface since the waters disappeared.

ROCKAWAY VALLEY.—This valley has been referred to in the description of the terminal moraine, as it is bounded at the south end by the moraine, from which, at Franklin and Denville, it trends northeast to its northeast head, near Decker's Forge. It is eight miles long and about half a mile wide. The drainage is through Den and Beaver brooks and the Rockaway river. The height of the valley at the Rockaway valley school house is five hundred and twenty-seven feet; and at the Denville depot five hundred and twenty-three feet. The canal level of five hundred and seven feet is in it. The composition of this drift formation as observed in the cuttings along the Delaware, Lackawanna and Western railroad line are loam, sand, gravel and cobble stones, stratified in irregularly alternating layers. Its thickness is not known. And the rock under it is also unknown, though very probably gneiss. At the northeast end there is an indistinctly marked terrace on the western side of the valley, about fifty feet above it. No attempt has been made to trace its extension about the valley.

VALLEY OF HORSE POND BROOK.—The valley, thus designated, is separated from the Rockaway by the sharp, rocky Bald Hill. It also runs northeast and southwest and its length from Meriden to the moraine hill, near Rockaway, is near four miles; while its average breadth is from a half to three-quarters of a mile. At Beach Glen a side valley enters from Hibernia, which was formerly occupied by Horse Pond. The height of the valley above mean tide level is five hundred and forty-eight feet at Meriden, and five hundred and seventeen feet at Beach Glen. The Hibernia Mine railroad runs on its west border at the foot of the gneiss rock slopes. There are good, but shallow sections of the formation about the Horse Pond near Beach Glen, and on the point of the terrace between Beaver and Horse Pond brooks. The flats bordering the streams are a few feet only lower than the general level of the valley.

This valley and the Rockaway, east of it, appear to have been lakes connected along the depression of the Rockaway and shut in by the terminal moraine at the south. Bald Hill was a narrow and rocky peninsula separating them. The cutting down of the dam of drift at Powerville and Boonton in the Terrace epoch drained them.

VALLEYS OF WEST MILFORD, LONGWOOD AND BERKSHIRE.—The ong depression in the Highlands formed by the connected valleys from the New York line at Greenwood Lake to the terminal moraine at the southwest has in it much stratified or modified drift—not, however, as a continuous formation. The Middle Forge valley is properly a parallel branch from the Rockaway depression to the northeast. It extends from the glacial drift hills, which are crossed by the Dover and Sparta road, northeast to the Middle Forge Pond, about three miles. And it is from a quarter to a half mile wide. The surface is for the most part swampy. The height of the level at Middle Forge is seven hundred and fifteen feet. The materials are gneissic, granitic, sandstone and Green Pond mountain conglomerate gravel with layers of sand. The Green Pond brook drains it over a reef of bowlder drift near Mount Pleasant. The natural course of the drainage would seem to be southwest into the Rockaway near Baker's Mills. But the glacial deposits changed this to the southeast and formed a basin of several hundred acres, which are gradually filling with a swampy accumulation of wood, muck, &c.

The valley of West Milford includes that east of Bearfort mountain from Greenwood Lake southwest to the Pequannock river. The Kanouse mountain and ridges of the Highlands bound it on the east. Its breadth on this stream is nearly three miles; at West Milford it is scarcely half a mile. Greenwood Lake is six hundred and sixty-five feet above ocean level. The hills in it northeast of Newfoundland are two hundred feet higher, and the level at the latter place is seven hundred and sixty feet high. The ridges of the valley are covered by glacial drift. And this sheet is so thick north of Newfoundland as to cover all the strata and render the tracing of geological boundaries very difficult. The watershed of the valley, between the Pequannock and Greenwood Lake, near D. Cisco's, consists of a drift surface which is very uneven and which has on it many large bowlders of blue limestone, sandstone, conglomerate gneiss and of other rocks. Further north there are smooth ridges and round hills of sand and gravel, evidently a modified drift. The Long Pond meadows, probably alluvial, are on the western side of the valley. The drift at the southwest end of the Lake is a gravelly level about fifty feet above the surface of the water. There is more unsorted, glacial drift on the eastern side of the valley and about the outlet. The origin of the beautiful lake, in a long and deep valley, shut in on the southeast and northwest by high and exceedingly rough mountain ranges, is in all probability, glacial. A careful survey of the surface and further examination of the country on all sides is needed to enable any one to indicate the old lines of drainage and the shape of the rocky basin in which it lies.

In the vicinity of Newfoundland all the rock strata are buried under drift, excepting the ledges of Green Pond mountain. Eastward round drift knolls, about 50 feet above the valley, are crossed by the Charlotteburgh road. The level at J. P. Brown's hotel and at the depot stretches southward nearly a mile and abuts against the rocky side of the Green Pond mountain. The mean height is 760 to 770 feet. The road to Green Lake runs on it. There can be no doubt of the stratification of its drift material. Going west, up the Pequannock gravelly hills are seen on the south or right bank of the stream. And their sides cut into for gravel show vertical sections at least 75 feet high of sorted drift. Further southwest and half a mile northeast of Oak Ridge the sand and gravel drift has been extensively opened in a large pit. The order of arrangement here is generally sand at the bottom and gravel at the top of the bank. The latter is made up to a large extent of pebbles of slaty and gneissic rocks. Their average size ranges from one-quarter to one inch in length, and they are not well rounded. .

In the valley between Oak Ridge and the Green Pond mountain there is a great deal of drift, and the outcrops of fast rock are few and of small size. Thence to the southwest, all the way to the terminal moraine, the valley is characterized by the flat topped hills and terraces. The Newfoundland level of seven hundred and seventy feet can be traced along the Pequannock southeast of Oak Ridge, and thence gently rising to a summit of eight hundred feet about a mile south of that village—the water shed between the Pequannock and the Rockaway rivers. Mooseback lake lies in a basin in this terrace formation. The road from Milton to Russia runs over a level which is connected with that drained by the former of these rivers. At Milton the deepest wells (forty feet) do not go through the modified drift. Although the surface is very near a level sink holes are not uncommon in it. The valley from Petersburg to Berkshire is narrow, hemmed in by high and rocky ranges. The drift partly covers the slate strata, except on low, long outcrops, which range with the valley. The flat bordering the stream is from twenty to sixty feet lower than the general level of the drift hills and benches. It constitutes the whole of the valley bottom for nearly a mile south of Lower Longwood. Thence to Berkshire valley and into the limits of the terminal moraine there is a great deal of drift, and the average height of the hills and of the gravelly shelves bordering the sides of the valley is seven hundred and sixty feet, or sixty feet above the creek in it.*

The gravelly, terrace formation of the valley is half a mile wide on the line of the Sparta turnpike; and the same width is continued southward. These hills are smooth, often of ellipsoidal and circular section, and with their trend corresponding to that of the valley. The slopes are frequently very steep. Cuttings on the Longwood road, and also at Berkshire valley, expose strata of sand, gravel, cobble stones and a few small bowlders. The thickness, as shown by a well at F. W. Fichtor's place, is at least 60 feet. It is very likely more in the middle of the valley.

The uniform height of the terrace formation in this long and narrow valley, rising but 40 feet from the terminal moraine to the water shed, a distance of 11 miles, and then descending 30 feet in four miles, to Newfoundland, leads us to infer the existence of a long and comparatively shallow lake which formed behind the terminal moraine, and which was connected with the waters of the West Milford and Greenwood Lake basin. It was remarkable for its elevation and its steep, rocky mountain sides. And it was so narrow as to be fiord-like. Greenwood lake may be compared to it, although much shorter. The outlet was first at the southwest by the Rockaway and through the terminal moraine. The retreat of the glacier northward opened the Pequannock and permitted a part of the waters to escape eastward. The small pond holes and the Little Mooseback lake are the undrained part of the old lake. The deepening of the outlet stream has been in progress ever since, except where interfered with by man.

SUCCASUNNA PLAINS.—This beautiful plain, or valley, stretches southward from the terminal moraine to German valley on the southwest and to Chester Station on the east.† It is bounded on the west by the Schooley's mountain range, and on the east by Mine Hill and the Ironia and Chester hills. It is from five to eight

*The heights and the slopes of these remarkable flat topped hills are very plainly shown on a survey and map made in 1876 by M. Gregory and W. E. King, for the Geological Survey. It is on a scale of eight inches to a mile.

†The name is, however, usually restricted to that part of the valley from McCainsville south for a distance of three miles, and lying east of the sandstone ridges.

miles long, and two and a half miles wide. And it descends very gently from an elevation of 720 feet at the north to 680 feet at the extreme south—an average rate of five feet per mile. The nature of the superficial beds is finely exposed in the successive cuttings on the High Bridge Branch railroad from the moraine hillocks to Bartleyville; and on the Chester Branch railroad also. As stated on page 27, the material just south of the moraine is very coarse gravel and cobble stones. At McCainsville the cuts are in a coarse yellow sand. On the road to Succasunna Plains village the same gradation is observed. And it is shown also in an easterly direction on the road from Drakesville via McCainsville to Mine Hill. The eastern side is bordered by a wet meadow and the swamps along the Black river. The materials of the gravels and sands are almost wholly derived from gneissic rocks. The soil is easily tilled, but too loose to be sufficiently retentive. It is in marked contrast with the stony slopes and hill-tops about it. The absence of bowlders is particularly noticeable. The thickness of the stratified drift is not known, but from the steeply, sloping mountain sides it is inferred that it is much greater than any of the diggings yet made in the valley. Ridges of sandstone rise out of the plains' level north of McCainsville and west of the village of Succasunna Plains to a mean height of 100 feet above it. The northeastern end of the Fox Hill range divides it at the southwest and then descends beneath its surace. On the point of this ridge there is a mantle of glacial drift which rises 140 feet above the plains. Near the Barnes mine, east of the Black River valley the Chester road passes over a sandy evel of the same height. It is also to be noted that these heights are the same as those of the moraine hills between Drakesville and Port Oram. It may be that a lobe of the glacier at one time reached as far south as these points of drift, and that subsequently it retreated and remained for a long period where the terminal moraine is now found. These isolated drift bodies mark its upper limit also. The drainage of this valley, in pre-glacial times, appears to have been to the northeast, into the Rockaway river, and the water shed was somewhere near Chester and near Bartleyville on the west side of the valley. Throughout the glacial epoch it must have been turned southward and when the ice retreated the moraine formed a divide further north. The cobble stone and coarse gravel beds are evidences of the torrents of water which must have flowed southward from the melting ice, depositing the finer sediment where the Plains village stands. The rocks along the Black river, south of Chester Station, made a dam, and in the long pond behind it, silted the finest of the clay. The peaty accumulations of later periods have been gradually filling it up.

LUBBER'S RUN AND LOCKWOOD VALLEYS.—The valley so designated is properly the northeast extension of the Musconetcong valley from Waterloo and old Andover to its head, near Lion Pond about six miles from the former place. It is not over a third of a mile wide on an average. It is 640 feet and upwards in height above ocean level. A side valley comes in at Roseville from Wright's Pond and Punkhorn Creek. The drift in this valley is unmodified in thin patches on its rocky sides, and more or less modified in the form of gravelly flats between Roseville and Waterloo. Wright's Pond is in one of those gravelly levels, and is shut in by a drift bank stretching westerly across the valley from the Roseville mine hill. The gravel pits of the Sussex Railroad Company, near old Andover, are also in this drift formation, and the residences of Seymour R. Smith and Hon. Samuel Smith, at Waterloo, are on the same beautiful valley flat.

KITTATINNY VALLEY.—The modified drift of the lesser or subordinate valleys in the great Kittatinny valley is most remarkably shown in the depression and limestone belt, which stretches northeast from Andover to Monroe Corner in Sussex county. A part of it is known as German Flats. Its beauty, its diverse drainage, in three directions, and its natural lakes, combine to make it attractive. It is bounded on the east by the Pimple Hills and on the west by the slate ridge. It is ten miles long and a mile wide. The elevation on the terrace at Struble's Pond is 620 feet; and near Monroe Corner about 580 feet. At the northeast there is the chain of Kimble's, Lane's, Mud and White Ponds, emptying into the Wallkill. The drainage from German Flats is by the east branch of the Paulinskill. Near Pinkneyville, is Mulford Pond, having no outlet, then the chain of Hall's, Struble's and Hewitt Ponds, which are tributaries of the Pequest river. And these natural ponds are generally near the southeast border of the flat or valley. Sink holes and muck ponds also are on the same side. No bowlders are to be seen on the surface, but the few scattering ones may have been picked off in clearing. The few shallow road cuts show stratified layers of gravel with sand and earth. Blue limestone and slate abound in this drift. There are scattering pebbles of gneissic and more of quartzose rocks of the Kittatinny mountain, but no zinc ore has been observed. White limestone is rarely found. The level of this valley may be traceable southwest to the head of the Great Meadows and northeast to the terrace level of the old North Church. Further surveys are necessary to decide these points. It seems to have been a long lake whose waters were held back by the Townsbury moraine and which afterwards were drained southwest into the Pequest, and this chain of ponds and pond holes show that the old channel was on its southeastern side close to the Pimple Hills range.

PEQUEST VALLEY.—The gravelly levels along the head waters of the Pequest river and its tributaries were referred to in the description of the terminal moraine, as evidences of the northward extension of a great lake basin. The country south-southwest of Newton to Johnsonburgh, is characterized by the sharply contrasted features of very rocky knobs ("cobbles,") and ridges of blue limestone and the gravelly flat or very gently undulating plains. Wet meadows and swamps and natural ponds interrupt the continuity of the latter. Whenever cut into, the gravel, sand and earth are seen stratified. Slate makes up the greater part of the gravel, but there are no bowlders of any size though cobble stones are common. The road from Newton via Springdale to Johnsonburgh affords a good view of the striking features of this country. On the northern borders of the Great Meadows and bordering Trout Brook into Sussex county, there are low terraces of earth, sand and gravel ten to thirty feet above the flats along the streams. Tranquility Church stands on one of them. The road from Alamuche to Johnsonburgh cuts at two or three points a few feet into the beds of earth, gravel and cobble stones and few small bowlders. The several ponds north and east of Johnsonburgh are in basins partly in gravel and are about the same height—600 feet. All of them empty into Bear Creek, and so with the Pequest. The watershed between them and the head of Beaver Brook, on the west of Jenny Jump, is 595 feet high. The gravel is mostly blue limestone and slate. In places it has in it irregular shaped pockets or deposits of clay. But the fine loam of much of the surface of the meadows, as also the black peaty earth, are alluvial beds and later than the drift. The new channel dug through the meadows cuts through the muck, into sand, gravel and a greyish white loam or clayey sand further up the stream. Glacial drift forms the surface of the islands in the meadows. The elevation of this gravelly formation of the Pequest is at "Red Gate Farm" of Hon. Henry C. Kelsey, 610 feet. There is a very gentle descent southward to the Great Meadows level. It may be noted here that the Paulinskill Meadows, near Newton, are 570 feet high, which corresponds to that of the meadows southeast of Newton.

These surface features of the drift are very suggestive. There must have been a submergence of waters in the broad streams or connected lakes, which flowed in a southerly direction, making islands of rocky knobs and depositing gravels, sands and cobble stones in layers over extensive areas. The many wet meadows, pond holes and natural lakes are the remaining parts of these waters. The alluvial beds around the head of the Great Meadows represent the lake which in the Champlain and Terrace epoch covered that part of the valley, and which may have continued into the historic period. A survey of a large area of country must be made before all the shores of this old lake and its islands and other features can be made out.

In the valley of *Beaver Creek*, south of Hope, there are short terraces on the foot of Jenny Jump mountain and more extensive ones near Sparta and Belvidere. They are all connected with the retreat of the glacier as indicated in the description of the terminal moraine.

PAULINSKILL VALLEY.—Modified drift, consisting largely of slate gravel, mixed with pebbles of blue limestone, sandstone, conglomerate and other rocks derived from ledges to the north and west, forms low, rounded hills and gravelly flats in the valley of the Paulinskill from Branchville to the Delaware. The heights of these levels or terraces diminish as you go down the stream. At Augusta the elevation is 498 feet. At Swartswood, west of the kill, there is a stony flat of near that height. And Swartout's pond is a large natural lake, with much drift about it. Its elevation is approximately 480 feet. There is a level at Blairstown 360 feet high. Thence to Columbia there are gravelly terraces on both sides of the stream. At Portland, Pennsylvania, opposite Columbia, there is a fine section in a bluff along Jacobus creek, which had (1) at the top yellowish, sandy loam, with thin layers of pebbles and cobble stones, 20 feet; (2) bowlder drift containing many large bowlders of blue limestone and other rocks, 10 to 20 feet; (3) blue limestone.

The drift in this valley has not been examined in detail, and the notes on it are too scanty to enable us to give the extent and structure of the formation and indicate the origin and sources of its materials.

DELAWARE RIVER VALLEY.—Very much of the drift in this valley is stratified, as stated on a preceding page. It is seen in the levels along the Mill and the Little Flat brooks, and along both banks of the river in the form of terraces and flat topped and smooth hills of sand, gravel and cobble stones, with a few small bowlders. The banks, at intervals along the Mill brook from near Carpenter's Point to Montague, are about 80 feet above the stream at the northeast. But the finest terraces and the most characteristic drift knolls are along the Flat brook, from Centreville to Flatbrookville. They are 60 to 80 feet higher than the stream. The elevations above ocean level, according to barometric observations, are 485 feet at the Centreville Methodist Episcopal Church, and 460 feet at B. P. Van Syckle's, at Peters Valley—a mean height of 80 feet above the Delaware at Dingman's. The Milford and Newton road runs at the north border of the terrace east of Centreville, to the Big Flat brook. The Reformed Church at Peters Valley is on one of these terrace hills. The formation, where exposed in slides and road cuttings, is stratified, and is made up of materials from the rocks of the Delaware valley and the adjacent mountain ranges. South of Walpack Centre the two parallel valley roads run on this formation. Near Flatbrookville its breadth is not over 300 yards. These drift banks and hills show the size of the glacial river which poured through this valley into the Delaware. At the junction of the two Flat brooks it was more than a mile broad and at least 40 feet deep.

The modified drift bordering the Delaware forms terraces or gravelly and sandy shelves and flats from the hillsides down to the present flood plain. At Milford and at Dingman's Ferry there are two well marked terraces above the river flat, and the latter is no longer a *flood plain*, so that we may say that there are three terraces at these points. The strata of this river formation are horizontal or gently undulating layers of loam, sand, gravel and cobble stones. Bowlders are of small size and scarce. At Carpenter's Point the terrace is 440 feet high. Port Jervis is built on two of the terraces, that at station being 440 feet above mean tide level. Between the mouth of the Neversink river and Montague the belt of modified drift varies from a few rods to a half a mile in width. It covers some of the corniferous or cherty limestone ledges near Van Noy's, and on Mashipacong Island conceals almost all of the black (Marcellus) shale. At Montague, Hornbeck's mills are at its eastern border, and thence to the river it has a breadth of nearly a mile. Milford, on the opposite bank, is on a second terrace, about 60 feet above the river flat. On the same side, at Dingman's, the upper terrace is about 60 feet above that on which the Reformed Church stands. The lower terrace, or flat, is seen on the Jersey side, north of the ferry, in the beautiful farm lands bordering the river. At Walpack Bend the terrace is southwest of Flatbrookville. The Pahaquarry flats, in Warren county, and the narrow belt of level along the river thence to the Water Gap belong to this drift formation. In the Gap the upper terrace is 40 to 45 feet higher than the river flat on which the slate works are located. Across the river very beautiful terraces are seen abutting against the limestone ridge north of Marshall's creek and in the Cherry Créek valley west of Dutotsburg. South of the Gap there is a narrow strip of level to the Shawpocussing creek, where it widens and continues 100 to 300 yards wide, thence to Columbia. Its height at this place is 303 feet. Delaware Station is on the same level. Southward to Belvidere there are very narrow and lower flats. The southern limit of the glacier was somewhere here, and the moraine has given place to modified drift in a series of levels from Scott's mountain on the east to the high slate hills on the western bank of the river. Belvidere is on one which is nearly 50 feet above the river. A much broader one, extending to Oxford Church and Roxburgh is 110 feet above it. The gravel of these terraces resembles closely that of the present river bed. The lower level or flat is, however, rather more sandy. And it makes the greater part of the easily tilled, choice truck farm land of the valley.

TRANSPORTED GLACIAL DRIFT.

The drift along the Delaware river, south of the terminal moraine, consists of a series of terraces and flats, at varying elevations above the river. They rise step-like from the lowest, which is occasionally covered by water, and is known as the flood-plain, on each side to heights of 60 and more feet above it. Down the stream they lower, and the maximum elevation above the river is less than it is northward. The pebbles, cobble stones and bowlders are very smooth and well worn. Spherical and lenticular shapes abound. Scratched stones are very scarce in this river formation. Some of them look as if the striæ had been in part obliterated by the subsequent wear. The various rocks, which crop out in the Delaware valley, are represented in pebbles and bowlders. The greater part of the material has probably come from the glacial debris of moraines along the upper Delaware. A part of the materials and the less rounded and more angular fragments and blocks have come from the ledges washed by the river. They have been torn off and carried down the stream by the action of water or of water and floating ice. From the well-known transporting power of existing rivers, we can form some conception of that of the Delaware in the Glacial and Champlain epochs, when its volume was many times what it is now and its current more swift. A careful examination of many ledges, well situated to receive and retain glacial markings has failed to find any traces of a glacier. The rough and sharp ledges, the absence of *roches moutonnèes* and the general absence of flowing outlines so characteristic of a glaciated country, are wanting. Then, again, the drift is all modified or stratified. The stratification shows that the materials have been assorted by water. On the broad terrace plain south of Belvidere and west of Scott's mountain there are scattering bowlders of quartzites, grey sandstone and siliceous conglomerates. These are generally of small size, and it is noticeable that they are confined mainly to the terrace level, as they are not seen on the mountain slope on the east of it, above a height of 680 feet. South of Marble mountain the plain is from an eighth to a quarter of a mile wide, and it is 35 feet above the ordinary river. Its height above the ocean is about 200 feet. Thence to Riegelsville the terraces are not continuous and are narrow. The latter village is partly built on a sandy level which is forty feet above the river, and 166 feet above tide.

Two very pretty terraces are seen on the opposite side of the river, and the Riegelsville church is on the upper one of them. At Johnson's Ferry the plain is gravelly, and the wagon road runs at its eastern margin. Its greatest breadth is not over 300 yards. There is a lower plain at Holland, but little above the river. Milford stands at the head of a long terrace level which is continued beyond Frenchtown. Its height at Milford is 140 feet, and about 30 feet above the river. At Frenchtown it is 128 feet high, and about 20 feet above the stream. Its breadth averages between a quarter and a half a mile. Thence southward it narrows gradually until between Erwinna and Tumble it is pinched out by the bold highlands of the *Narrows*. This terrace at Point Pleasant is a very narrow fringe. Again, at Bulls Island, it widens to a half a mile, and there it is 97 feet high, and 25 feet above the river. From Stockton to Prallsville there is no terrace. It appears again near the Alexsocken creek, and at the cemetery it is 60 feet above the river. Lambertville occupies quite all of it, from the Goat hill northward for a mile. Its elevation is 75 to 80 feet, and about 30 feet above the stream. On the Pennsylvania side two terraces are seen near New Hope. South of Goat hill and north of Belle mountain the terrace is narrow. Between the latter and Bald Pate hill it is again narrow. Near Titusville it is seen, and the village is on it. Thence to Trenton there is a continuous strip, bounded most of the way on the east by a low sandstone bluff, and traversed by the railroad and the feeder. The lower level is in places, as at Greensburg, nearly half a mile wide, but it is a few feet only above the flood plain. The eastern limit of the terrace in Trenton, is near the Belvidere Delaware railroad, until it curves to the northeast and runs south of the Princeton turnpike, leaving the greatest part of the city on the terrace. Its height along the Pennsylvania railroad between Pond run and the Trenton railroad station is about 50 feet above mean tide. And this level is maintained through the city southward and southwest to the river bluff at Riverview cemetery. The stratification and the nature of the materials are very finely shown in the long and extensive cuttings and excavations along the railroad northeast of the station. The area here dug over is about one-third of a mile long and 200 feet wide, and its average depth 12 feet. The surface layer is a fine, yellowish, sandy loam. In it there are scattering pebbles. No bowlders are now found on the surface, but they were probably picked off many years ago. The sand and gravel are in alternate layers from an inch to a foot thick. The sand shows an ebb and flow structure. As regards size of materials, there are sharp-edged, angular blocks of a micaceous quartzite ranging up to six feet in length, round and smooth, well worn bowlders from four feet in length, downwards, and the cobble stone size, gravel and sand. Only two striated stones have been found among several thousands which have been examined. And on one of them the markings have been partly worn away, as if by subsequent attrition. The characteristic glacial polish is always wanting. Fully 95 per cent. of the bowlders are siliceous, including conglomerates and quartzose rocks of the Triassic beds, sandstones and conglomerates of the Potsdam, Hudson and Oneida epochs and a little chert, from the magnesian and corniferous limestones. The rocks of the Kittatinny mountain are particularly numerous. The remaining five per cent. are gneisses, granites, syenites, trap-rocks, magnesian limestone, calcareous conglomerates and fossiliferous rocks from the Upper Delaware valley. The cobble stones and gravel are largely quartz, but with a large admixture of red and dark colored shales and slaty rocks of the Triassic formation. Flattened spherical and lenticular shapes predominate. They resemble closely the gravels of the present river bed. A mastodon tusk, four feet long, was found in 1878 in the gravel of this pit, fourteen feet beneath the surface. [See *Annual Report of State Geologist for* 1878, *page* 15.] This formation was passed through at the State Prison in a well dug in 1878. It went through a thickness of fifty-two feet down to the gneiss rock. Another section of this terrace formation is the river bank in the southern part of the city, near Riverview cemetery. It is about fifty feet high. On account of the steepness of the bank the stone and surface materials are washed down and gradually incorporated with those in place lower on the bluff. Hence it is difficult to define accurately the limits of the several strata or the order of their arrangement. And in places the bank exhibits a stratification down the slope, as if the materials had been arranged by water flowing over it. So far as can be seen, the upper part of the bank—fifteen to twenty feet—is yellowish-white sand, with thin, pebbly layers. The lower part is a more clayey earth, with angular blocks and round stone. Some of them have come from the surface and worked down in the ordinary wear of the bluff. The largest of these round stones are trap-rock and gneiss. The smaller ones are of grey sandstone, siliceous conglomerate, trap-rock, gneiss and arenaceous slate from the Delaware valley. The smaller stones are smooth and apparently much worn. No glacial markings have been detected on any of them. The same rocks are represented in the gravel and cobble stones. There is a larger percentage of red shale and red sandstone.

In this bluff, and in the Pennsylvania railroad cut, near the railroad station, Dr. C. C. Abbott, of Trenton, has found stone implements which he considers to have been made by pre-historic man, and to mark conclusively the palæolithic age of the archæologists. His discoveries are published in the Peabody Museum Reports [Tenth Ann. Rep., pp. 30–44 and Eleventh Ann. Rep., pp. 225–257], and he has a work now in press giving still more complete descriptions and figures of the various articles he has found in these Trenton deposits.

The Trenton terrace, or level, extends northeast along the Assanpink creek, a distance of seven miles, to Lawrence. The Bear Swamp borders it on the east, and is of the same height. The Delaware and Raritan canal level of 57 feet runs to Kingston, 13 miles distant from Trenton. This terrace marks the southeast border of the gneiss outcrop, and here the river leaves the rocky bluffs through which it has worn its way down to this point. Terraces of the same height are to be seen on the Raritan at South Bound Brook, at Fieldville, at Raritan Landing and in New Brunswick, and between South Amboy and Morgan on Raritan Bay shore, along the Passaic river in Newark, in Bergen Cut, and at the Narrows in New York harbor. The location of these prove it to have been an extended sea border formation of the Champlain epoch. The land level was at least 60 feet lower than at present, and the Delaware reached the sea where Trenton now stands. [See Annual Report of State Geologist for 1878, pp. 22 and 23.] The river terraces along the Delaware northward belong, apparently, to the same epoch with the lower levels. An epoch when the flooded river which carried an immense quantity of loose materials was much broader than at present, and equally rapid. The sediments were deposited in the broader reaches and wherever the current was slack behind reefs and narrow gorges. No deposition was possible in the latter, on account of the rapidity of the torrent-like stream.

The highest levels are probably the oldest, and represented the river when it spread out broadly between its bluff banks. As the waters diminished in volume, and cut deeper channels in the drift bed, it was more and more contracted until the present flood plain was reached. We can easily conceive of the river bringing down on its floods, during the Glacial epoch, huge masses of floating ice, which would carry with them more or less of debris accumulated on the glacier front. These floating bergs would abrade, to some extent, the softer and more yielding rocks in their way, and still further add to the quantity of material to be moved forward by the stream. The grinding action of the hard, round stone, carried along by the swift current, would also tend to wear down the exposed ledges and add more material for transport by the waters. The action of these powerful agents of destruction continued throughout long periods of time must have been far greater than any of the existing river, and must have done much in cutting the deep, almost canon like valley of the river through the red sandstone formation. And these agents were increasingly active as the glacier retreated northward and contributed both its moraine accumulations and great volumes of water to the work. Owing to the narrowness of even the old channel and the rapidity of the current, the greater part of the finer sands and the clays did not reach their final resting place until they were deposited in the more quiet waters at the mouth of the river. Much of the gravel and cobble stones also were there laid down with the sands and earthy material. The floating ice of floods brought down mixed stone and earth, which, on melting, fell together without much assorting. The more angular bowlders, and the larger blocks of gneissic and quartzose rocks were most likely transported in this way.

Lower terraces along the Delaware river and bay and along the Atlantic coast, made of finer materials, show that the uplift during the Terrace epoch was not continuous. They mark the intervals when it was interrupted by halts and the level of the sea remained for a time the same, as referred to the land.

The surface of the country east of the Delaware valley and south of the terminal moraine lacks the striking drift features which belong to the country north of it. The inequalities of the surface, the confused mixture of materials and thick and wide-spread bodies of glacial drift are wanting. The absence of glaciated ledges and the disintegrated and earthy condition of the rock outcrops wherever denudation has not been great, testify to the absence of glacial action. But it is not an entirely *driftless* area. There are a few deposits which have somewhat the appearance of glacial drifts, and which may mark the southern ends of lobes or tongues of ice stretching beyond the general or frontal line of the glacier. It is, however, more probable that they are deposits of local floods, especially as in all of them there are traces of stratification.

Throughout the central part of the State small bowlders of hard rock, very smooth and round, are sparsely scattered over the surface. Stratified beds of earth, sand, gravel and small bowlders are found at very many localities. The latter are common on the lower grounds, and especially in the valleys of the larger streams. The bowlders are more widely distributed in the valleys and on the hills. Both of them appear to be deposits in water, transported by the currents of broad streams or carried on floating ice and dropped with less assorting. The southern limit of the coarser drift and cobbles is defined by the valleys of Lawrence's brook and the Assanpink creek. South of the line there are few bowlders, whereas north of it to the terminal moraine they are common. The greater part of this drift, including the smooth and well-worn quartzose bowlders and cobble stones and the stratified beds of yellow sand and gravel, appear more like that in the southern part of the State. And it is an older glacial, or possibly pre-glacial drift. But it is difficult to draw the line between it and the remaining part which came from the north and belongs to the modified glacial drift, except that much of it occupies a higher level. An incomplete series of observations upon the upper limits or distribution in height of the drift in this part of the State fixes the range between 350 and 500 feet in the Great Red Sandstone plain, and between 500 and 900 feet in the higher valleys and on the hillsides of the Highlands. A submergence to this extent would have allowed icebergs and icefields to drop scattering bowlders and gravels and would explain the position of these erratics. From the height of the gravels in Monmouth county it is evident that the submergence was at least 380 feet, if not much greater. And this seems to correspond with the drift line in the central part of the State and in the red sandstone district.

The stratified gravels and sand, and the less assorted drift masses, as also the scattered bowlders of the Highland valleys, and of the northern border of the red sandstone formation, belonging mostly to the modified glacial drift. The following notes of localities serve to illustrate these general statements:

Beginning at the northwest, no bowlders have been observed on the broad crest of Scotts mountain, and not above a line 680 feet high on its western side. At Oxford Furnace the excavations for limestone throw out from the surface earth, occasionally, a small bowlder of gneiss. Southeast of the village, in the Furnace Brook valley, gneiss and grey conglomerates are numerous on the surface. The gneiss may have come from higher outcrops on the hills about the head of the valley. To the northeast, near Stewarts Gap, and in this same Pequest valley, there are several remarkably flat-topped hills of sand and gravel, evidently deposited by glacial waters partly filling the valley. The relation of the terraces further down the Creek valley, and that near Stewarts Gap is yet to be made out.

Pohatcong valley, altogether south of the terminal moraine, has its drift in the shape of many scattering quartzose bowlders, and its thin patches or sheets of coarse gravel and cobble stones. They are especially noticable in that part of the valley north of Washington. The bowlders rarely exceed two feet in length. A very small proportion of the whole drift is chert.

The southwestern part of the Musconetcong valley is remarkable for its freedom from bowlders and gravelly drifts, excepting a local body of bowlder drift, closely resembling that of a glacier in Hunterdon county. It is seen in the Easton and Amboy railroad cut at the west end of the tunnel. Judging from the surface indications, it is scarcely larger than some of the flood deposits of the historic period.

South of Hackettstown there is, along the depression of the creek, on the eastern side of the valley, a thin gravel and cobble stone formation, which was probably a deposit by the waters from the glacier whose front was but two or three miles away to the north. On the high slate outcrop or ridge, in the middle of the valley, there are scattering bowlders of quartzite, conglomerate and red sandstone. Much of the loose stone on the surface of this valley, near the mountains bordering it, have come from ledges on them, and others are the broken outcrops of the underlying strata; as for example, the sandstone west of Bloomsbury and near Kennedy's mills, and the gneissic blocks near Uniontown, at the foot of Scotts mountain.

The table land, or plateau of Schooley's mountain, like that of Scott's mountain, is free from drift, except a narrow belt near the terminal moraine, on which the scattering bowlders of gneiss, blue limestone and grey sandstone and conglomerate are noteworthy. Further south these are confined to the ravines and the mountain sides. The absence on the summit is particularly striking on the road crossing from Hackettstown by the Mountain Houses to Flanders.

In German valley there appears to be more drift than in the western limestone valleys. About Naughtrightville and thence down the valley coarse gravel and small bowlders, principally gneiss, but with some sandstone, mixed with reddish, loamy earth, forms a thin sheet in patches disposed on the limestone. This covering is nowhere more than three to five feet thick. Many of the sandstones are very smooth, and have a jaspery looking exterior. Many of the larger stone have been picked off the fields and thrown along fences, so that the existing farmed surface is smooth. Both the gneiss and the sandstone may have come from outcrops in the valley. But it appears more probable that they were carried down the valley by water, as this valley was the outlet for the glacial stream. At High Bridge the Central railroad cuts into an unsorted bowlder drift a quarter of a mile west of the village. It consists of a yellow, gneissic earth, thickly studded with round and also some angular blocks of gneiss. No blue limestone or sandstone were found in it. The surface of the ground rises gradually, going north 150 yards to a steeper slope. The extent of the deposit is not great, as it does not appear in the road cuttings west or south. The thickness is 40 feet in the railroad cut. East of High Bridge, towards Annandale and Cokesburg, bowlders of sandstone and grey silicious conglomerate are found here and there on the surface. The largest observed did not exceed four feet in length. At Union Church or Vansyckle's, there is a drift plain which slopes southward. At Pattenburg a like drift sheet is crossed by the Easton and Amboy railroad. The cut shows it to be 10 feet thick and a quarter of a mile long. It is an unsorted mass of yellow, clayey earth, with both smooth and round bowlders and angular blocks of gneiss. No glacial markings could be detected on any of them, or on the red shale under the drift.

On the plateau of the red sandstone country west of Clinton and south of the Musconetcong mountain, a very few silicious conglomerates and quartzites have been observed, but no gneissic nor limestones. Much of the gravel and cobble stone of the surface earth near Clinton, Pattenburg and Milford, is the result of a disintegration of the conglomerate in place. In the vicinity of the South Branch there are some thin deposits of stratified drift. The structure and composition are to be seen in the Easton & Amboy railroad cut near Mefter's Mills. It consists of yellow clay earth, holding gravel and small bowlders, and is 6 feet thick, lying upon red shale. Its surface is at least 25 feet above the stream. The flat bordering the stream varies from 5 to 25 feet above it. And in places it is quite broad. The surface layer is a yellow loam. The drift of the Lamington river valley is similar to that of the South Branch. At Pottersville, in Somerset county, the east or left bank of the stream has unstratified drift at the top from 4 to 6 feet thick on blue limestone. And east of the stream there is a gravelly flat, forming the triangular point between the river on the west and a small brook on the east. Its height above the stream is 25 feet. There are many small bowlders and cobble stones in the surface earth. At Roxiticus, in Morris county, along the North Branch and along Burnet Brook further west, there are many quite large bowlders and some drift earth. The Mine Brook valley, another tributary to the North Branch, has drift in it. And at Bernardsville the railroad cut shows its thickness and composition.

These accumulations of drift in the red sandstone country at the southeastern base of the Highlands and along the tributaries of the Raritan appear to be of a more local character than the drift in the northern valleys of the State. They may be the deposits of the floods which came from the Highlands during the Glacial epoch, when the melting ice furnished great volumes of water and much loose material. Local causes may explain the unsorted drifts at Pattenburgh, High Bridge and Pottersville. Floods and torrents may have deposited these mingled masses of rock and bowlder earth.

Between Bernardsville and Basking Ridge there is a singular ridge of drift, which runs southeast to the Basking Ridge railroad station. It is three-eighths of a mile long, and a quarter of a mile wide, and is 100 feet high above the railroad, or 475 feet above mean tide level. Its outlines are uniform and its surface is smooth, consisting of a reddish, sandy loam mixed with gravel, cobble stones and scattering bowlders. These latter are chiefly crystalline rocks of the Highlands, but there are also many of Green Pond mountain conglomerate, and of red sandstone. They range from six inches to three feet in length. No indications of glacial action were observed on any of them. The cut in the southeastern face of another hill east of this ridge and north of the Madisonville road, shows the bowlder drift at the top five to eight feet thick, lying upon a yellow sand. Both of these hills look like mounds of glacial drift. But they may have come from the Highlands to the northwest. There is considerable drift on all the lower grounds in the vicinity of Basking Ridge, but none on the higher trap rock ridges. The ridge at the south of the village has an elevation of 424 feet; that of Second mountain, west of the village, is 520 feet. The great "Passaic Lake," already described, had the trap-rock range of Second mountain for its western and southern rim, and these drift bodies may have had their origin in some way connected with that sheet of water, although their summits are higher than its terrace levels. The higher parts of the Basking Ridge, of Long Hill and of the New Vernon ridge must have stood above its waters as rocky, narrow islands. The deep alluvial formations along Dead river and in the Great Swamp were the fine deposits on its bottom. The depth of the rock basin is great, a well on the farm of Hon. F. S. Lathrop, in the Great Swamp, having been bored 165 feet in sand, clayey sand and fine sediment, or to within 80 feet of the ocean level without finding rock. What could have scooped out so deep a basin is not plain. The valley between the First and Second mountains, from the limit of the terminal moraine southwest to Washingtonville, contains drift in the bottom and on the lower part of the First mountain slope, up to a mean height of 375 feet above tide. Scattering bowlders of trap-rock, gneiss and Green Pond mountain conglomerate are found in this thin, superficial drift formation.

One of the most marked surface features due to the drift is the long and narrow belt of sand bordering on the southeast, the First mountain from Scotch Plains to Bound Brook. It can be traced west of the Raritan river to Millstone. Its length, east of that stream, is ten miles, and its average breadth ten miles. Plainfield, Dunellen and Bound Brook are on it. The railroad cuttings show the surface layers. It descends from Scotch Plains, southwest, at the rate of 10 feet per mile. The sand at the northeast is coarser grained and of a darker red color than at the southwest, and is mixed with more gravel and some cobble stones. At Scotch Plains it is only two to three feet thick in some places. And generally, on the southern side, it seems to thin out, as can be seen in the railroad cuts from New Market to Bound Brook. Wells on Park avenue, Plainfield, went through 60 feet of loose materials before the rock was reached. Here the top is quite pebbly. About Dunellen it is more sandy. The explanation of this belt is at length evident, since the discovery of the terminal moraine, and since the survey of the surface has given the drainage lines. It is the dry bed of a broad stream which flowed from beneath the glacier at the foot of the First mountain, in a westerly course to the Raritan, near Bound Brook. The Millstone entered the Raritan nearly opposite. During the Champlain epoch this stream must have diminished greatly, as it was no longer fed by melting ice of the glacier. The submergence of the land 50 feet in this epoch, according to the terrace heights at Trenton, New Brunswick, and on Raritan bay shore, brought the tide level up the Raritan to its mouth, and for a time it must have mingled its waters with the tides of the river. Green brook is the existing representative of this ancient river.

North of Somerville, and on the southwestern face of the First mountain, there is a yellow, stratified sand and gravel formation, three to five feet thick; although at one point, near the Bound Brook road, it is 30 feet thick. Trap-rock, gneiss and sandstone bowlders lie on the surface and imbedded in the top strata. The sand is reddish-yellow at the top and yellow underneath, and alternates in irregular layers, with thin beds of gravel made up of small quartz pebbles. The height of this gravelly shelf is, in places, near 200 feet. Near Weston a similiar formation is cut on the line of the Delaware and Bound Brook railroad.

About New Brunswick, particularly in the southern part of the city, gravelly beds, generally in small patches and but a few feet thick, are common. Mixed with the gravel there are many small bowlders and cobble stones. Quartz is the prevailing mineral of this drift, although trap-rock, Green Pond mountain conglomerate, and gneiss are occasionally found. A few scratched bowlders have been observed. Nearly all of them are very smooth and are well rounded, as if they had undergone much attrition. The largest stone are seen near the Cranberry turnpike, two miles south of the city. A number of bowlders are grouped together at this locality, and the largest of them is 15 feet by 6 feet, and two feet out of the ground. Several others are nearly as large. They are coarse grained quarttzite. Their occurrence in a group suggests floating ice as the transporting agent.

Another drift locality is at Kingston, in Somerset county. A very good section of it, 50 feet high, is had in the bank east of the canal and north of the station. The materials are sand, gravel and cobble stones, with a few small bowlders, and are stratified. The red sandstone is at the bottom. Quartz of white and yellow shades and red sandstone predominate. Trap-rocks, reddish conglomerate and red shale fragments are also found. The shales and sandstones are more angular and less worn than the more silicious rocks. The maximum size of the bowlders is about three feet. No striæ or groovings, or other glacial markings, were seen on any of the bowlders or on the red sandstone ledges under the drift. Whence came this body of drift is not now evident. Quartzite, sandstone and trap-rock bowlders and cobble stones, and thin patches of yellow, quartzose gravel are quite common on the red sandstone country west of the Millstone and north of the Rocky Hill range. The scattering bowlders, one to three feet long are found on the Rocky Hill up to a height of 350 feet. They are like those at Kingston, very smooth and well rounded.

The Sand Hills between Dean's and Ten-Mile Run is a sandy ridge which trends easterly from the Ten-Mile Run trap-rock ridge to the straight turnpike. The slopes are smooth and quite steep. At the eastern end the sand is cemented into a brown sandstone. On the turnpike there is a cut about 40 feet deep. A yellowish clayey earth is at the top, then a beautifully stratified sand and gravel, largely of trap-rock material. The streaks of reddish sand contain a considerable percentage of red shale. The absence of bowlders in this drift is remarkable. Underneath the drift there is a white, sandy, laminated clay. The sand and gravel indicate the probable sources of this body of drift.

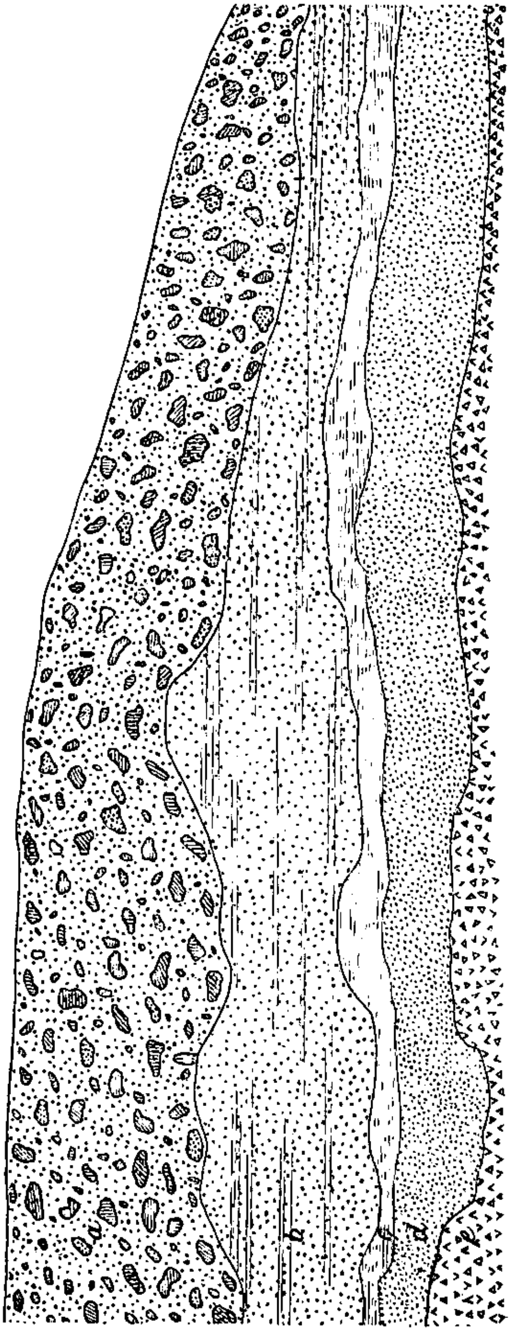
The drift north of Somerville, about New Brunswick and Kingston, and in general, the scattered bowlders, cobble stones and gravelly beds along the southern border of the red sandstone country belong to the older or pre-glacial formation, but the quartzose material is at these localities mingled with red shale, red sandstone and trap-rocks derived from outcrops near them. And in this particular they resemble the deposits of the modified glacial drift further north.

PRE-GLACIAL DRIFT.

The general characters of the drift in the southern part of the State were indicated in the preliminary statements respecting all the drift phenomena south of the terminal moraine. The retreat of the glacier furnished both material and a transporting agent for its wide-spread distribution. The southern limits of this later distribution by water extended to the waters of the ocean, and the bays and sounds opening into it. At the Narrows in New York harbor, along the southern shore of Staten Island, and at Perth Amboy, the glacier reached the ocean. The later drift, carried by the swollen streams at the close of the Glacial epoch, and during the Champlain epoch, reached tidal waters along the present Raritan river valley from Perth Amboy to Bound Brook, and on the western side of the State from Kingston to Trenton. There was a narrow sound in the Raritan and in the Millstone depression from New Brunswick to Kingston, and thence southwest along that of Stony Brook to the more open waters at the mouth of the old Delaware river. The southern half of the State was an island, bounded on the north by this tidal sound. Its shape was very irregular, and its dimensions considerably less than those of the existing Delaware and Atlantic outlines. The coast line was several miles further west, and Cape May, as also a large portion of Atlantic county, were beneath the ocean. On the western side there was a broad bay which extended north to the mouth of the Delaware, on the present site of Trenton.

The stratified sands and gravels of the southern part of the State are distinct from the modified drift already described. And they are older than the glacial drift of the terminal moraine and of the northern part of the State. The northern limit of these sands and gravels is, however, north of the old shore line and sound above indicated. And in places they are mixed with the modified drift which came from the north. The overlapping of the glacial drift and the subsequent mingling of the two stratified formations prevents as has already been stated, any accurate determination of its limits. In like manner on the coast line and along the shore of Delaware bay and in the valleys of the Delaware river, they have been modified by the mingling of foreign materials and have been redeposited with these, forming the sea border formation or terrace. In Middlesex county we find the terminal moraine lying upon the yellow sand and gravel. The line of demarcation is sharply defined. The description of the line of this moraine on pages 17 and 18, refers to the two formations. The accompanying wood cut, taken from the *Report on Clays*, 1878, *page* 120, is here inserted to illustrate their occurrence:

FIGURE No. 1.



The upper bed (*a*) is the Glacial Drift.
The succeeding bed (*b*) represents the Pre-Glacial Drift; the bed (*c*) represents a red clay; (*d*) a fire sand, and (*e*) the *feldspar* bed.
(*c*), (*d*) and (*e*) are members of the cretaceous formation.

The figure represents a vertical section at the Forbes farm *feldspar* bank, near Woodbridge, in Middlesex county. The plastic clay series are covered by these drift formations. On the Delaware river the older drift is covered by the later terrace or river formation. The best section is in DeCou's clay bank, about two miles southeast of Trenton. The upper or modified (river) gravel drift is here twelve feet thick; the lower gravel is seven feet thick, and lies upon the dark-colored, sandy clay of the plastic clay series. The two can be seen on the line of the Pennsylvania railroad in going from Princeton Junction to Trenton. The terrace gravels are not seen on the railroad east of Mirey run. On account of the earthy nature of nearly all the strata outcropping in this part of the State, it is not always possible to determine from the surface material the limits of this drift formation. Much of the sandy soil is the outcrop of the glass sand or other sand beds which belong in the older and regular geological series. The presence of gravel and cobble stones more or less interstratified with sands and sandy earths and clays is evidence of this formation. Stratification is characteristic of it almost at all exposures and outcrops. The layers and laminæ are very commonly horizontal, or only slightly descending. Sometimes they are wavy. Often they are short, one layer thinning out or giving way to different material, as sand replacing gravel, or clay in place of sand, and so forth. Gravel or pebbly layers very commonly alternate with sand, but in many places sands of different degrees of fineness or more or less mixed with earth, or of different shades of color, are seen in alternating beds. There is much variation in the thickness of these strata or beds, from the thinnest lines of sand to beds several feet thick. And these are irregularly stratified together in many cases. A very common occurrence is that of thin layers of gravel between thicker beds of sand, although solid beds of gravel without much sand or earth are by no means rare. In the sands or sandy clays oblique lamination or false bedding is very common; that is, lines of lamination are oblique to the plane of stratification or of bedding.

The composition as to nature of the materials varies greatly as already indicated. The greatly predominating components are sands, sandy clays and gravels. Hence the designation used in the "Report on Clays" was "yellow sand and gravel." The sands, as also the clays, are of varying grades in fineness—from sand *dust* to grains approximating to fine gravel. And generally the grains are somewhat rounded, as if much worn by attrition with one another. The gravel is almost wholly made up of smooth, yellowish white quartz pebbles. Subangular and rough fragments are not common in it. Irregular masses and fragments of cemented sand of indurated clay and nodular concretions of pyrite are common—abundant in many localities. The gravel, as to size of pebbles, varies of course. Throughout the central part of South Jersey the pebbles are on the average one-quarter to three-quarters of an inch in length. Much of it is about *chestnut size.* It appears to be rather coarser near the shore and southward, although in the clay district of Middlesex county it is coarse. The pebbles exceeding two inches in length are comparatively a small fraction of the whole mass. And those between two and four inches are still fewer, and in many localities very scarce. Spheroidal, (flattened) and ovoidal shapes are most common.

Quartz makes up a very large percentage of the whole material of this formation. It is most common as white, yellowish white, translucent grains and pebbles. Colorless and transparent pebbles are rare, although the clear variety is common in the form of sand grains. The other common varieties of quartz are chalcedonic, jaspery, cherty, amythystine and hornstone. Feldspars and hornblende are comparatively rare. And mica is generally wanting, except in some of the sands. The absence of this common mineral is suggestive, perhaps, as to the source of this drift. Gneiss is rarely found. Oxide of iron is often found, cementing sands and gravels and forming sandstones and conglomerates, the well-known *brown sandstone* of South Jersey. From their prevalent tints they are thus designated. But the "brown sandstone formation" of Prof. H. D. Rogers' survey must not be confounded with them, as that term included much other stone, especially that made by cementation of the red sand bed of the cretaceous age, besides the yellow sand overlying the middle marl bed. Generally the loose sands are of a yellowish color, due to a fraction of one per cent. of oxide of iron. Darker and brown shades are also common. A characteristic feature of these gravels is the presence of *fossiliferous* pebbles, or silicified fossils. Very generally they are not so round or well worn as the quartzose, but of irregular shapes. Many of them are too much worn and too indistinct to allow of their specific identification. These *fossiliferous* pebbles appear to be more abuudant in the gravels on the southeastern side of the State or Atlantic slope than on the western. At a few points they constitute about ten per cent. of the whole mass. A small collection picked up in the vicinity of Woodbridge and Amboy and submitted to Prof. R. P. Whitfield of the American Museum of Natural History, Central Park, New York, were reported on as follows: "The fossils in the various lots are nearly all from the Upper Helderberg limestone group. Those from Martin's dock contain three species of Favosites, several fragments of *cyathophylloid* corals, a *Michelina,* also allied to *Favosites, Atrypa reticularis, Strophodonta parva* and some other shells fragmentary, also several specimens of an undescribed *Stromatopora* (spongoid).

"Those from Everett and Fish's clay banks are mostly cherts and jaspers, and many, likely, from the Corniferous.

"The pebble with fish tooth is most likely Upper Helderberg. One other lot contained a curious pebble of sandstone composed of a white matrix and rounded quartz and on being broken open revealed a large fragment of *Orthis hipparionyx,* Vanuxem.

"Another lot reveals *Atrypa reticularis,* Spiriferae (species?) and several fragments of Devonian brachiopods and corals and an impression of the dorsal side of a Gyroceras, or Cyrtoceras, very like C. ——— Hall, from the Schoharie Grit.

"There is no evidence of anything in the lot of more recent age than the Hamilton, and that only on two fragments, the others being Upper Helderberg, Oriskany and perhaps some of the *Favosites* Lower Helderberg, possibly though not probably."

A large collection from localities in Monmouth, Ocean, Burlington, Atlantic, Cape May, Cumberland, Salem, Gloucester and Camden counties, was more recently examined by Prof. Whitfield. The fossils identified are nearly all of the Upper Helderberg epoch, and are like those from Woodbridge in their general characters. No division or generalizations according to localities was apparent.

This formation is not continuous throughout the southern part of the State, although it is found unconformably upon all the older strata of the cretaceous and tertiary ages. It is common on all the higher grounds, and forms the crests of the hills and ridges. The tops of many of the Mount Pleasant hills from Neversink Highlands westerly, Arney's Mount in Burlington county, and the hills of the southeastern and the southern parts of the State are made up largely of this formation of drift. It is cut into at so many points on the lines of the New Jersey Southern, the West Jersey, the

Camden and Atlantic and other railroads that it is not necessary to mention them individually. In the green sand marl belt it is wanting over quite large areas, and it appears in small patches, but generally forming the hill tops or making slight swells in the surface. Southeast of that belt it is not found uniformly throughout the country, but in belts. It would seem as if it had been originally much-more extensive, but the denudation of the surface and the drainage wash of the country has removed it from large areas, exposing in the marl belt the older strata of marls, sands and clays, thus making diversities in the soil which would not have been possible in the case of a uniform drift covering spread over all. The rich and fertile valleys of Monmouth county, and the broad and rich farms of Burlington county are some of these lowlands where denudation has so altered the face of the country, and whence the gravelly drift has been in great part removed. In the clay belt bordering the marl on the northwest, the denudation has been very great and wrought a great alteration in the surface. In fact the changes wrought in the surface of the southern part of the State by the drift, and by the subsequent wear, are not surpassed in extent and variety by those accomplished further north through the agency of glaciers. This wash of the sand from the hills in the southeastern part of the State has made the sandy tracks and belts bordering the streams, and has left the more extensive, clayey soils on the hills and higher grounds. So marked is this feature of the surface that the alternating belts of sandy and clay-gravel lands were indicated on a map of the State published in 1878, and were described in the annual report of the State Geologist for that year.

The thickness of this formation varies exceedingly from point to point. In the clay district of Middlesex county, where it has been penetrated in the *stripping* of clay beds, it ranges from four to forty feet. On the Mount Pleasant hills, in Monmouth, it is in places 40 feet thick, and possibly 70 feet in the highest of them. Further south, and in the southeastern part of the State, it may range from five to forty feet.

Some of the gravelly hills and ridges of South Jersey are not hills of denudation, but drift accumulations which were so deposited. The trend of these ridges is in general northeast and southwest, but in a few cases nearly north and south. Their elevation above the mean level of the surrounding country is in none of them over 100 feet.

The Forked river mountains in Ocean county, Stone Hill, southwest of Toms river in the same county, the ridges of the East Plains in Burlington county, Pine Mount in Cumberland county, and Turnip Hill in Salem, are examples of hills which trend in this direction. Pine Mount, near Greenwich, is a very remarkable ridge which stands out on a sandy plain and rises 70 feet above it, and 120 feet above the ocean. Its a very steeply sloping surface, and its narrow crest, only 50 feet wide, make it a prominent object of the landscape and a puzzle to geologists.

Associated with the gravel and sand and imbedded in it there are, at a small number of localities, bowlders of grey sandstone and quartzite. They appear singly or in groups. In Monmouth county only one has been observed, which was three feet long. The very few others were smaller, from a foot to two feet long. In Burlington and Camden counties they are scarce. A very few scattering ones have been observed on the East Plains. They appear to be more numerous on the Delaware bay side of the State. And two notable localities are here referred to at length. The first of them to be described is a belt of country, one mile wide, from Woodstown southwest to Mannington creek in Salem county. It is on the outcrop of the middle marl bed. The bowlders on it are white quartzite and white to yellowish white, coarse granular sandstone, resembling the Potsdam rocks of North Jersey and the primal sandstone of Pennsylvania. They range from cobble stone size to blocks four feet long and are *roundish* and very smooth. The exterior after exposure often assumes a jaspery appearance. In spots they are so numerous in the surface as to interfere with cultivation. Woodnutt Pettit, of Mannington, says that he has carted 50 loads off a single acre of his farm. They are known in the neighborhood as "bull heads." And they serve as fence blocks or supports for worm fences. They do not appear to the southwest, on Mannington Hill, nor to the northwest, near Penns Grove. In the absence of serpentine and gneiss characteristic of the ledges across the river in Pennsylvania and Delaware, it does not seem plausible to suppose that their origin was to the northwest. Another locality, still more remarkable for the size of the bowlders and their occurrence, is in the northwest part of Cape May county and about Dennisville. Only a few have been seen south of Dennis creek. But they occur from that stream northward to Cumberland county. They are referred to in the Geology of Cape May, 1857, pp. 25 and 26. These bowlders are generally quite irregular in form, and the edges are worn down, but not so as to round them. The exterior is smooth. No glacial markings have been observed. The largest of them, thus far, is on the street in North Dennisville. It was struck by the plow point in the field of ex-Senator Rice. When found it lay in the earth, inclined southward, at an angle of about forty degrees. Its original length was fourteen feet, and its other dimensions eleven by seventeen inches by thirteen to sixteen inches, or nearly square. Both ends were pointed, and the edges were sharp. Two sides were smooth, apparently water-worn. As a *bowlder*, this is by far the largest stone yet found in the southern part of the State. Another stone, near West creek, one and one half miles from Dennisville, is reported as rounded and seven feet in diameter. Of the smaller bowlders a very few are white, silicious conglomerates, resembling the Kittatinny mountain rock. Small ones of gneiss are rare. They are generally found close to the surface, so as to be struck by the point of the plow, and in that way are discovered. As stone are scarce, these are used in cellar walls and as fence blocks. These localities have both attracted the attention of careful observers, and the origin of the bowlders has been variously accounted for by those attempting to explain the question. There are difficulties in the way of all the theories proposed, but that they were transported by ice and not by water is most probable. When the land was submerged to the depth of at least sixty feet, in the Champlain epoch, the floods and ice coming down the Delaware could have carried them thus far and then dropped them.

The age of sand and gravel formation, or South Jersey drift, preceded that of the glacial drift, as already stated. It may be later tertiary. The source of the materials does not appear to have been to the northward as it lacks characteristic elements which could hardly be wanting in a drift coming from that quarter. The increasing number of fossiliferous pebbles to the southeast does not agree with such a theory. And the prevalence of Upper Helderberg and more recent forms of mollusks and the absence of Potsdam and Trenton fossils also indicate that the parent ledges were not at the north unless those of the upper Delaware valley and the more distant outcrops furnished the materials to the exclusion of all on the east of the Kittatinny mountain range. A possible hypothesis is that it was the wash from land to the southeast, and now buried beneath the ocean and took place in the later Tertiary Age. The flora of South Jersey and of Staten Island south of the glacial drift, is known to be distinctively American, whereas that on the glacial drift bordering this southern or older drift, is more allied to that of Europe.

Mr. N. L. Britton, of the Columbia College School of Mines, New York City has studied the characteristic plants on these formations and on Long Island and has found that thirty-four of the characteristic pine barren plants which grow in the southern part of Staten Island are not found on the glacial drift. On Long Island, in Suffolk county, he has found forty-six of these plants. "Not a single one of the above mentioned plants (see doc. cited) growing, as we have seen, just along the edge of the glacial drift is a native of Europe: that is they belong to a true American flora, which had its origin in the southern part of the continent. In contrast to which fact we have another one, equally prominent, and that is, that of the species growing in the material brought down by the ice sheet, about one-third are common to northern Europe and America, thus pointing to a common origin of each in the territory now occupied by the ice and snow of the Arctic regions." Bulletin of the Torrey Botanical Club, Vol. VII., No. 7, pp. 81, 83.

This pre-glacial drift formation was submerged on the Atlantic coast and along the Delaware river valley, south of Trenton, to a depth of fifty feet during the Champlain epoch. The rise of the land in the Terrace epoch laid bare and dry a more or less wide sea border formation. The terrace of that height, and the lower levels and flats on the Atlantic side of the State, including the sea beaches and the low-lying necks on the Delaware bay and along the lower Delaware river, are made up of the finer materials of this drift modified and redeposited in the Terrace epoch and in part in the Recent or Historic Period. The later terraces of the sea border have not been fully traced out, though recognized at many localities. They gradually diminish in height as we go southward, and in Atlantic and Cape May counties are not more than thirty feet above mean tide level. The alluvial necks of Cumberland and Salem counties belong to a lower terrace but a few feet above high tide. Topographical surveys, which are now in progress, will, it is hoped, enable us to define the limits of the several terraces. Their description, as also that of the more recent and alluvial formations in all parts of the State, including the wet meadows, the peat bogs, the tidal marshes, sea beaches and the various deposits of shell marl and infusorial earth must be left for subsequent reports. And this whole subject of the surface geology can only be completed when the State is carefully surveyed and accurate topographical maps are constructed to receive the data from geologists.

VI.

IRON ORES.

In the annual report for 1879, there was a short review of the iron-mining industry of the State, and statistics of production for the years 1873 to 1879 inclusive. The condition of the trade during the long business depression, with its stoppages of working mines, the absence of new developments, the reduction of wages and consequent loss of population, and the diminished aggregate production was given. The revival of business and its effects, as manifested in the demand for ores, the opening of new mines, the advance in wages and the influx of labor, was also stated. And the activity everywhere in the iron-mining districts, warranted the assertion that the production for this year (1880) would be equal to, if not in excess of that of 1873, when the maximum of 665,000 tons was attained.

The year opened with a brisk demand for ores of all grades, and at comparatively high rates. The extremely high price of iron appeared to justify these rates for ore. The large importation of foreign irons, consequent upon such a demand and so great a rise in prices, together with the greatly increased production of our home furnaces after a time, satisfied the demand, and then began the reaction which threatened to prostrate the iron trade to the low level reached during the preceding dull period. But the general prosperity of the country, the need everywhere for material to replace that worn out during the hard times, and the new enterprises, which confidence in the future inaugurated and sustained, kept up so large a demand that the furnaces were enabled to sell, although at reduced prices. The lessened importations also relieved very materially the market, and allowed the substitution of home products for those of foreign manufacture. The fall in the rates for iron made itself felt very soon in the iron mines, and prices were again brought down nearly to those ruling in the early part of 1879. With the reduction in ore rates wages were reduced. The reaction from this fall in the prices for ore and labor have been slight. But the demand for ores has continued steady and as a consequence our mines are generally in operation. The so called "boom" in the summer and autumn of last year started up nearly all the old mines and discovered many new ore localities. Work was resumed in many of these places without any previous careful inquiries as to their natural advantages for successful working. Ore was found and was mined without much regard to cost. And at many of the mines the preparations for producing ore were scarcely made when the fall in prices came. As a result, the mines which had advantages in location, in extent and size of the ore masses, in ease of working, and in the quality of their ores, continued to produce, although with less profits. Others, lacking these elements of success, suffered more or less, and many of them were again discontinued.

In the report of 1879, the product for that year was stated to be 488,028 tons, an increase of 78,000 tons over that of the year immediately preceding. From the accounts of those mining and transporting ores during the year 1880, we estimate the product of the New Jersey mines for the year to be 840,000 tons, an excess of 350,000 tons above the product of 1879, and of 175,000 tons above that of 1873. These figures show the extraordinary increase in the production of our mines, as well as their capacity for an increased yield whenever the demand is made upon them. The increased activity is seen in the number of mines which are now worked, or which have been in operation during some part of the year. The following list gives these mines, as also the lengths of their working periods.

Of those mines in the list which have not been worked at all, or for only limited periods, the past year, there are various causes to be assigned for their being idle. Some of them are owned by men without the capital requisite to carry them on when prices are low and sales are slack; others are so located as to require inconvenient or expensive hauling; some undoubtedly can only yield ore at a cost above the average selling prices; and others still are idle because they are worthless. But it is not any proper cause of discredit to a mine that it is not now worked. Many in the list, in other hands, will be steadily and profitably worked. And it should be thoroughly understood that to carry on the business of opening mines or extracting ore profitably, skill and experience must be joined to adequate capital. For the lack of these indispensables, very many cases of disappointment and financial distress occur every year.

Very nearly all of our large and well known mines have been worked steadily throughout the year, and their annual production has in nearly every one been largely increased. The great addition to the aggregate comes from them. Several mines and ore localities have been discovered or first opened during this year, and are described for the first time in this report. They indicate the energy and perseverance of those who are accustomed to prosecute such searches and their success may incite others to do likewise. In consequence of the short period during which high prices ruled these discoveries are not so numerous as they would have been if the high prices had continued through the year. But it is safe to say that they are quite equal to the discoveries of any previous year.

The number of mines working a part or all of the year is 136, counting the single mines *i. e.*, resolving the groups into their components. The total number in our list for the year is 350, so that 39 per cent. have been at work. The number at work at the close of the year as far as known is 81, or 23 per cent. of the whole number.

The present outlook for our mines is not like that of the close of 1879. It is not so flattering as to stimulate an unhealthy growth, but the demand for ore is steady and is such as to call for a large production, and is to be preferred to the abnormal stimulus of a *boom* in the iron trade.

This list with notes is a directory rather than a geological notice of them. The order of arrangement is the same as that of last year's report. The mines are grouped according to the four belts known as Ramapo, Passaic, Musconetcong and Pequest. And in these belts the order is from southwest to northeast. The township and county in which they are located are also given after each mine.

The mines which have been worked during any part of the year are indicated by the bold-faced type, while those which have been idle all the year are printed in the ordinary type of the report.

This list includes all the producing mines, and it is believed that nearly all the ore localities which have been opened, are in it. It is not possible to ascertain all the places where ore in small quantities has been found, when it is remembered that magnetite, or *iron ore* is one of the more common constituent minerals occurring in the Archæn rocks of our Highlands. In many cases the names of owners and of lessees have been given, and also the names of furnaces or parties who receive and smelt the ore.

It has not been possible to add geological notes as very little time has been given to field work. These are reserved for future reports in which it is hoped to describe the iron-ore bearing rocks in detail and to so systematize the whole that a practical application may be possible. These annually accumulating data are the means to the end in view; the exploration of its geological features in such a manner as to enable the miner to work more successfully and the prospector to search more intelligently for new mines and to guide capital, energy and skill into safe channels.

MAGNETIC IRON ORES.

RAMAPO BELT.

Bernardsville Mine..................Bernard township, Somerset Co.
Janes Mine..............................Bernard township, Somerset Co.
Connet Mine............................Mendham township, Morris Co.
Beers Mine..............................Hanover township, Morris Co.
Taylor Mine............................Montville township, Morris Co.
Cole Mine...............................Montville township, Morris Co.
KAHART MINE.................Pequannock township, Morris Co.

This mine was worked three or four weeks last spring and forty to fifty tons of ore raised.

Lanagan Mine.........................Pequannock township, Morris Co.
DeBOW MINE...................Pequannock township, Morris Co.

Some work in exploring was done here in early spring by Thos. D. Hoxsie, of Paterson, but the place was abandoned after the failure to find a workable extent of good ore.

Jackson, or Pompton Mine........Pequannock township, Morris Co.
Ryerson's DeBow Mine...........Pequannock township, Morris Co.
Beam Mine.............................Pompton township, Passaic Co.
BROWN MINE..................Pompton township, Passaic Co.

S. D. Brown, of Paterson, reopened this mine in February, 1880, and it has been worked up to the present time. Several hundred tons of the ore have been shipped to the Saucon Iron Co.'s furnace, at Hellertown, Pa.

Kanouse Mine.........................Pompton township, Passaic Co.
Butler Mine............................Pompton township, Passaic Co.

PASSAIC BELT.

Large's Mine ....Clinton township, Hunterdon Co.
ANNANDALE MINE.........High Bridge township, Hunterdon Co.

The Annandale Mine, on lands of David B. Sharp, one mile north of the Central Railroad of New Jersey, was worked during a part of the year by the Annandale Iron Company, and 500 tons of ore were taken out. The depth is about 30 feet, and the vein, as far as it has been opened, is 7 feet wide. The ore is said to be low in phosphorus and fairly rich. It has been used at the Coplay furnace, Pennsylvania.

TAYLOR MINE.................High Bridge township, Hunterdon Co.

The old High Bridge, or Taylor Mine, has been idle for some time, although a little ore was taken out by the superintendent, Llewellyn James.

SILVERTHORN, OR KANE MINE,
High Bridge township, Hunterdon Co.

S. K. Large & Co., worked here two months, and raised about 200 tons of ore, and they are again about to resume work there.

Emery Mine..........................High Bridge township, Hunterdon Co.
CREGAR MINE........ ....High Bridge township, Hunterdon Co.

Andrew Cregar, owner and operator. Between 200 and 300 tons of ore were mined here early in the year.

OLD FURNACE MINE......High Bridge township, Hunterdon Co.

This mine was re-opened in March by E. P. Merritt and F. H. Smith, of New York. The mine has reached a depth of 150 feet, and about 2000 tons of ore have been taken out. The ore is rich, but the vein is narrow.

Cokesburgh Mine....................Tewksbury township, Hunterdon Co.
BURRILL MINE...............Tewksbury township, Huuterdon Co.

This locality was opened two years ago, and a few tons of ore obtained.

Fisher, or Fox Hill Mine..........Tewksbury township, Hunterdon Co.
Sutton Mine..............................Tewksbury township, Hunterdon Co.
Pottersville Mine......................Tewksbury township, Hunterdon Co.
Bartles Mine............................Tewksbury township, Hunterdon Co.
Pottersville Northeast Mine......Chester township, Morris Co.
Rarick Mine............................Chester township, Morris Co.
LANGDON MINE..............Chester township, Morris Co.

This place is being developed by L. W. Langdon & Son, and is reported as very promising.

PITNEY MINE...................Chester township, Morris Co.

On lands of R. D. Pitney, one and a quarter miles from Hacklebarney, and in the valley of Black river. The mine has been worked by Cooper, Hewitt & Co., and a large part of the ore has been used in their Pequest furnace.

Budd & Woodhull Mine...... .....Chester township, Morris Co.
TOPPING MINE................Chester township, Morris Co.

The vein on this property was re-opened during the year, and worked four months by William J. Taylor & Co., of Chester. The ore went to the Chester furnace.

SAMSON MINE.................Chester township, Morris Co.

This mine was re-opened in January by Cooper, Hewitt & Co. It has been in operation throughout the year, and the ore has been used at Durham, Pa.

Hotel Property Mine..............Chester township, Morris Co.
Collis Mine..............................Chester township, Morris Co.
Creamer Mine...........................Chester township, Morris Co.
Swayze Mine............................Chester township, Morris Co.
COOPER MINE.................Chester township, Morris Co.

The Cooper Mine is named from the late Gen. Nathan Cooper, on whose estate it is opened. Work began here in December, 1879, and it has gone on vigorously since that time, under the superintendence of John B. Evans, of the Cooper Mining Company. A fuller description is given in the notice of new mines appended to this list.

SQUIRE'S MINE...............Chester township, Morris Co.

This name is given to a newly-opened mine about a quarter of a mile northeast of the Cooper Mine, and on the west side of the Dover road. It is near the Leake Mine.

HACKLEBARNEY MINE, Chester township, Morris Co.

The Chester Iron Company continues to develope this noted mine property, and the product for the year amounts to 20,000 tons (shipped).

Gulick Mine............................Chester township, Morris Co.
Creager Mine..........................Chester township, Morris Co.
Hedges Mine..........................Chester township, Morris Co.
Dickerson Farm Mine.............Chester township, Morris Co.
Creamer Mine........................Chester township, Morris Co.
De Camp Mine........................Chester township, Morris Co.
Leake Mine.............................Chester township, Morris Co.
Daniel Horton Mine................Chester township, Morris Co.
Barnes Mine...........................Chester township, Morris Co.
Henderson Mine............... ......Randolph township, Morris Co.
George, or Logan Mine............Randolph township, Morris Co.
David Horton Mine............ .....Randolph township, Morris Co.
DeHART MINE..................Randolph township, Morris Co.
LAWRENCE MINE..........Randolph township, Morris Co.

The DeHart and Lawrence Mines have been worked throughout the year by the Reading Iron Company. The ore is sent to Reading, Pa.

DALRYMPLE, or **CARBON MINE,**
Randolph township, Morris Co.

The Crane Iron Company has been operating this mine throughout the year. The ore is smelted at the company's furnaces, Catasauqua, Pa.

Trowbridge Mine ....Randolph township, Morris Co.
Solomon Dalrymple Mine .... Randolph township, Morris Co.
Cooper Mine..... ....Randolph township, Morris Co.
Munson's Mine........................Randolph township, Morris Co.
LEWIS MINE.....................Randolph township, Morris Co.

Some work done at re-opening by E. P. Merritt, of New York.

COMBS MINE....................Randolph township, Morris Co.

Worked by E. Canfield. The ore has been used at Scranton, Pa.

Van Doren Mine.....................Randolph township, Morris Co.
BRYANT MINE.................Randolph township, Morris Co.

This mine is owned by D. L. & A. Bryant. It has been in operation steadily during the past five years,* and the ore has been shipped to the Bethlehem Iron Company, Bethlehem, Pa. The total product of the mine is estimated at 20,000 tons.

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*Incorrectly reported in 1879 as idle.

Connor Fowland Mine..............Randolph township, Morris Co.
Charles King Mine..................Randolph township, Morris Co.
KING MINE........................Randolph township, Morris Co.

Owner, Dickerson-Suckasunny Mining Company; lessee, A. Pardee. It has been in operation more or less throughout the year. The ore was sent to furnaces on the Lehigh and to the Musconetcong Iron Works at Stanhope.

McFarland Mine..... ....Randolph township, Morris Co.
EVERS MINE.....................Randolph township, Morris Co.

The Saucon Iron Company has been working the Evers Mine throughout the year. The *veins* continue, as heretofore, narrow, but the ore is of excellent quality, although not very rich. The company's furnace at Hellertown, Pa., uses the ore.

BROTHERTON MINE........Randolph township, Morris Co.

This mine was in operation five months—up to June of the present year. Lessees, George & Pullman.

BYRAM MINE..................Randolph township, Morris Co.

The Andover Iron Company continues to work this mine.

MILLEN MINE.................Randolph township, Morris Co.

This mine has been worked by its owners, the executors of estate of Jas. C. Lord, and under the superintendence of Robert F. Oram. The ore has been used at Boonton and at Port Oram.

RANDALL HILL MINE....Randolph township, Morris Co.

Owned and worked by the Crane Iron Company.

Jackson Hill Mine..................Randolph township, Morris Co.
Canfield Phosphatic Mine.........Randolph township, Morris Co.
BLACK HILLS MINE.......Randolph township, Morris Co.

This mine of the Dickerson-Suckasunny Mining Company, is leased to A. Pardee. It has been worked more or less throughout the year. The ore has been used in the manufacture of Bessemer pig at the Secaucus Iron Works.

DICKERSON MINE..........Randolph township, Morris Co.

Dickerson-Suckasunny Mining Company. Lessee, A. Pardee. This mine continues to yield a large amount of rich ore. The aggregate product for the years 1868–1880 inclusive, exceeds 300,000 tons. The "Geology of New Jersey," published in 1868, put the estimated product up to that date at 500,000 tons, making a grand total of over three-quarters of a million tons of ore.

Canfield Mine..........................Randolph township, Morris Co.
BAKER MINE..................Randolph township, Morris Co.

The Lackawanna Iron and Coal Company owns and operates this Baker Mine.

IRONDALE MINE............Randolph township, Morris Co.

Of this group of mines the Sterling and Hurd have been working during the year. They are leased to the Thomas Iron Company. The New Jersey Iron Company is the owner.

ORCHARD MINE..............Randolph township, Morris Co.

Owner, estate of J. Cooper Lord. The mine has been worked throughout the year by the executors of the Lord estate.

Erb Mine................................Randolph township, Morris Co.
SCRUB OAK MINE........ ..Randolph township, Morris Co.

This mine was worked from February to June by its owner, Andover Iron Co. The vein is large, but the ore is lean.

Johnson Hill Mine...................Rockaway township, Morris Co.
HOFF MINE.......................Rockaway township, Morris Co.

The Chester Iron Company worked this mine about half of the year and shipped 6000 tons of ore. The vein at the bottom in the road shaft has greatly enlarged, and the ore is very solid and clean. The capacity of the mine for the ensuing year is estimated at 15,000 tons. The ore is reported to be especially adapted to soft foundry iron. A carefully selected sample from the bottom, lately sent to the Survey Laboratory, has been analyzed. The composition is :

Silica	11.70
Sesqui-oxide of iron	77.42
Lime	3.19
Magnesia	2.58
Alumina	2.04
Titanic acid	0.75
Phosphoric acid	3.10
	100.78
Metallic iron	54.19
Phosphorus	1.33
Sulphur	Traces.

Dolan Mine............................Rockaway township, Morris Co.

WASHINGTON FORGE MINE,
Rockaway township, Morris Co.

Since the last annual report the Carbon Iron Manufacturing Company has been working this mine.

A sample of ore from this mine was sent to the Geological Survey Laboratory by R. J. Brown, of Dover. It was analyzed. The analysis shows:

Metallic iron	61.84 per cent.
Phosphorus	0.633 per cent.
Sulphur	0.245 per cent.
Titanium	none.
Manganese	none.

MOUNT PLEASANT MINE,
Rockaway township, Morris Co.

This well-known mine has been steadily worked through the year by its owners, estate of J. Cooper Lord. The western extension of the vein on this property is opened near the Washington mine. It is known as the *West Mount Pleasant* mine. The vein is 16 feet wide, including a horse of rock 2 feet wide. The depth is 140 feet.

Baker Mine............................Rockaway township, Morris Co.

RICHARDS MINE.............Rockaway township, Morris Co.

Worked uninterruptedly by the Thomas Iron Company. Ore goes to Hokendauqua, Pennsylvania.

ALLEN MINE....................Rockaway township, Morris Co.

Owner, New Jersey Iron Company; lessee, Andover Iron Company.

TEABO MINE....................Rockaway township, Morris Co.

Worked throughout year by owners, Glendon Iron Company.

MOUNT HOPE MINE........Rockaway township, Morris Co.

The large and noted mines at Mount Hope are owned and worked by the Lackawanna Iron and Coal Company. They have been in operation all the year. The ore goes to furnaces in the Lehigh Valley, Pa. The aggregate product of these mines approximates to 1,000,000 tons.

Swedes Mine..........................Rockaway township, Morris Co.
Sigler Mine.............................Rockaway township, Morris Co.
White Meadow Mine...............Rockaway township, Morris Co.

Gibb Mine................................Rockaway township, Morris Co.
BEACH MINE.....................Rockaway township, Morris Co.

Re-opened in March, and worked by the Andover Iron Company. It is the property of the New Jersey Iron Mining Company.

HIBERNIA MINES...........Rockaway township, Morris Co.

There are three companies at work on this long and remarkably persistent ore bed, viz.: the Andover Iron Company, at the southwest; the Glendon Iron Company, in the middle; and the Bethlehem Iron Company, at the northeast. The mines have been worked vigorously all the year, and the aggregate output of the three companies is 150,000 tons.

BEACH GLEN MINE.........Rockaway township, Morris Co.

The Beach Glen is another of the mines owned by the estate of J. Cooper Lord. It has been in operation during the whole year.

COBB MINE........................Rockaway township, Morris Co.

The Cobb Mine is worked for the supply of the Splitrock forge.

SPLITROCK POND MINE..Rockaway township, Morris Co.

Wm. S. DeCamp worked this mine a part of the year.

Greenville Mine.......................Rockaway township, Morris Co.
GREEN POND MINE........Rockaway township, Morris Co.

The mining operations here have been carried on with activity throughout the year by Chas. E. Maxwell, Trustee for the Green Pond Iron Mining Company.

DAVENPORT MINE.........Rockaway township, Morris Co.

A new mine opened within the year by Cooper, Hewitt, & Co. [*See* notes of new mines appended to this list.]

HOWELL TRACT MINE...Rockaway township, Morris Co.

A little work was done here last spring by Wm. S. Decamp.

Kitchell Tract Mine...... ....Rockaway township, Morris Co.
CHARLOTTEBURGH MINE.
Rockaway township, Morris Co.

The old mine south of Charlotteburgh is again in operation and is now worked by Cooper, Hewitt & Co.

Botts Mine..............................Rockaway township, Morris Co.

ROCKAWAY VALLEY MINE,

Rockaway township, Morris Co.

Paul P. Todd, of New York, re-opened the DeCamp or Rockaway Valley Mine and raised five hundred tons of ore and then abandoned it. It is again idle.

Decker Mine............................Rockaway township, Morris Co.
Gould Mine.............................Rockaway township, Morris Co.
PIKE'S PEAK MINE.........Rockaway township, Morris Co.

M. J. Ryerson mined about 100 tons of ore during the year and it was worked into blooms in the forge at Bloomingdale. It is now idle.

An analysis of a sample of the ore sent by Mr. Ryerson to the survey laboratory gave:

Metallic Iron	63.45 per cent.
Phosphorus	traces.
Sulphur	2.03 per cent.
Titanic Acid	0.30 per cent.
Manganese	none.

Vreeland Mine........................West Milford township, Passaic Co.
✓Wynokie Mine........................Pompton township, Passaic Co.
Tellington Mine.. ....Pompton township, Passaic Co.
Rheinsmith Mine.....................Pompton township, Passaic Co.
✓Monks Mine...........................Pompton township, Passaic Co.
Board Mine.............................Pompton township, Passaic Co.
✓**RINGWOOD MINES**.........Pompton township, Passaic Co.

The Ringwood Mines are steadily worked by Cooper and Hewitt and continue to be productive, yielding annually about 20,000 tons of rich ore.

MUSCONETCONG BELT.

HAGER MINE...................Holland township, Hunterdon Co.

Until June of the present year the Hager Mine was worked by the Holland Mining Company. About 700 tons of ore were taken out and shipped to furnaces in Pennsylvania.

Duckworth Mine.....................Holland township, Hunterdon Co.
Bloom Mine...........................Holland township, Hunterdon Co.
Martin Mine...........................Alexandria township, Hunterdon Co.
WEST END MINE............Bethlehem township, Hunterdon Co.

The West End, or Turkey Hill Mines, owned and operated by the West End Iron Company have been at work all the year. The branch railroad, connecting the mines with the Lehigh Valley Railroad, greatly facilitates the shipment of ore. At last accounts the mines were producing about 1800 tons per month.

SWAYZE MINE................Bethlehem township, Hunterdon Co.

The West End Iron Company is now working this mine. It was re-opened late in 1879.

Alpaugh Mine.........................Bethlehem township, Hunterdon Co.
Wild Cat Mine.........................Bethlehem township, Hunterdon Co.
PETTY MINE.....................Bethlehem township, Hunterdon Co.

A new iron ore locality on lands of Mrs. E. Petty, which was opened in March, 1880, and worked a short time by David McCrea. [*See* Appendix.]

WRIGHT MINE.................Bethlehem township, Warren Co.

A new opening. [*See* Appendix to this list.]

CASE MINE........................Bethlehem township, Hunterdon Co.

Another new mine, opened in December, 1879, by David McCrea. It is on lands of Isaac B. Case, near Pattenburg.

Church, or Van Syckle's Mine...Bethlehem township, Hunterdon Co.
RODENBAUGH MINE......Bethlehem township, Hunterdon Co.

Worked one month by West End Iron Company.

ASBURY MINE..................Bethlehem township, Hunterdon Co.

This old mine was re-opened in 1879. It was worked by the West End Iron Company for a few weeks. It is again idle.

Miller Mine.............................Bethlehem township, Hunterdon Co.
MABERRY MINE... ....Bethlehem township, Hunterdon Co.

A new opening, made this year, on lands of Frederick Maberry, near the Miller Mine, and west of Glen Gardner. Work has been suspended for the present.

Banghart Mine.........................Lebanon township, Hunterdon Co.
EVELAND MINE..............Lebanon township, Hunterdon Co.

A new mine at Glen Gardner, Hunterdon county, which was worked by Lewis Barnes until April.

Terraberry Mine......................Lebanon township, Hunterdon Co.

ALVEY GRAY or SAND FLAT MINE,
Lebanon township, Hunterdon Co.

This mine has been worked by the Saucon Iron Company.

White Hall, East, Mine............Lebanon township, Hunterdon Co.
Castner Mine........................Lebanon township, Hunterdon Co.
MATTISON MINE.............Lebanon township, Hunterdon Co.

The Mattison farm, one mile southeast of Andersontown, was opened by Lewis Barnes, of Annandale, and some exploring work was done.

PIDCOCK MINE................Lebanon township, Hunterdon Co.

This old mine was started up last March by the owners, Theodore S. Pidcock & Co., and about 140 tons of ore were mined. It is sixty-five feet deep, and the vein is five to six feet wide.

Sharp's Mine.........................Washington township, Morris Co.
HANN MINE......................Washington township, Morris Co.

The Hann Mine was worked up to May 1st by William W. Marsh, of Schooley's Mountain. The work was mainly surface exploration, resulting in raising about 150 tons of rich ore.

Hunt Farm Mine...................Washington township, Morris Co.
STOUTENBURGH MINE...Washington township, Morris Co.

This mine was in operation during the first three months of the year, for the supply of the Hackettstown furnace.

Fisher Mine..........................Washington township, Morris Co.
Marsh Mine..........................Washington township, Morris Co.
Dickinson's Mine...................Washington township, Morris Co.
Hunt Mine.............................Washington township, Morris Co.
Lake Mine.............................Washington township, Morris Co.
NAUGHRIGHT MINE.......Washington township, Morris Co.

This property is held under a lease by D. Runkle & Co., of Pennsylvania. Very little work has been done further than to open a new vein 3½ feet wide.

Sharp Mine...........................Washington township, Morris Co.
Rarick Mine..........................Washington township, Morris Co.
Hopler Mine..........................Washington township, Morris Co.

[Note.—Considerable prospecting was done about Bartleyville in the spring. On the Sharp farm 25 or 30 tons of ore may have been taken out, but no developments of extent or importance were made.]

POOLE MINE.....................Washington township, Morris Co,

A new opening on lands of William Poole, near Drakestown.

Shouse Mine..........................Mount Olive township, Morris Co.
Cramer Mine...........................Mount Olive township, Morris Co.
APPLEGET MINE............Mount Olive township, Morris Co.
Smith Mine...............................Mount Olive township, Morris Co.
Lowrance Mine.........................Mount Olive township, Morris Co.
MOUNT OLIVE MINE......Mount Olive township, Morris Co.

The Mount Olive Mines were worked from January to June, 1880, by William E. George. On account of light demand for ore the mines have been idle during the latter part of the year.

Drake Mine...............................Mount Olive township, Morris Co.
Osborn Mine............................Mount Olive township, Morris Co.
Hilts Mine................................Roxbury township, Morris Co.
Baptist Church Mine................Roxbury township, Morris Co.
KING MINE........................Roxbury township, Morris Co.

Worked up to May 1st, 1880, by L. F. & W. E. King.

HIGH LEDGE MINE.........Roxbury township, Morris Co.

This mine stopped in May. [*See* notices of new mines.]

GOVE MINE.......................Roxbury township, Morris Co.

The Gove Mine has been going throughout the year. Francis M. Gove is working it. The ore is mostly shipped to Pennsylvania furnaces.

Davenport Mine.......................Jefferson township, Morris Co.
Noland's Mine..........................Jefferson township, Morris Co.
Hurdtown Apatite Mine...........Jefferson township, Morris Co.
HURD MINE.......................Jefferson township, Morris Co.

This remarkable ore body continues to be followed down and to yield as largely as ever. The Glendon Iron Company holds it.

Lower Weldon Mine.................Jefferson township, Morris Co.
WELDON MINE................Jefferson township, Morris Co.

The Weldon Mine was reopened last winter, and worked until it was found that the shoots began to *pinch* and to diverge from each other. The Weldon Mining Company, Mr. Wm. Allen Smith, superintendent, owns the mine.

DODGE MINE....................Jefferson township, Morris Co.

The Dodge Mine also is worked by the last named Company.

FORD MINE........................Jefferson township, Morris Co.

A. Pardee & Co. work this mine for the supply of their Musconetcong Iron Works, at Stanhope.

Scofield Mine..........................Jefferson township, Morris Co.

The Crane Iron Company is about to re-open the Scofield Mine.

Fraser Mine............................Jefferson township, Morris Co.
Duffee Mine............................Jefferson township, Morris Co.
Shongum Mine........................Jefferson township, Morris Co.
Cline Mine..............................Franklin township, Warren Co.
Smith Mine.............................Franklin township, Warren Co.
Dean Mine..............................Franklin township, Warren Co.
WILLEVER AND GODFREY MINE,
Greenwich township, Warren Co.

A new mine. [*See* list of new ore localities at end of these notes.]

Chapin and Lommasson Mine...Washington township, Warren Co.
Lanning Mine.........................Washington township, Warren Co.
OXFORD FURNACE MINE,
Washington township, Warren Co.

These mines have been going all the year. They are worked for the supply of the furnaces of the Oxford Iron Company.

CREAGER MINE..............Mansfield township, Warren Co.

Some work in way of re-opening and further exploration has been done here during the year by Wight and Goulding.

Mitchell Mine..........................Mansfield township, Warren Co.
Stephenson Mine.....................Mansfield township, Warren Co.
BALD PATE MINE............Mansfield township, Warren Co.

A few months' work was done here by H. J. Boardman. The place is again idle.

Shafer, or Welch Mine.............Mansfield township, Warren Co.
Egbert Church Mine................Mansfield township, Warren Co.

Searle Mine..............................Independence township, Warren Co.

BARKER, or BULGIN MINE,
Independence township, Warren Co.

[*See* Appendix to this list.]

Buck's Hill Mine.....................Independence township, Warren Co.

DAY MINE.........................Independence township, Warren Co.

[*See* Appendix to this list.]

Frace Mine..............................Allamuchy township, Warren Co.
Young Mine............................Allamuchy township, Warren Co.
Pyle Mine...............................Allamuchy township, Warren Co.
Oxford Mine............................Allamuchy township, Warren Co.
Bryant Mine...........................Allamuchy township, Warren Co.
Excelsior Mine........................Allamuchy township, Warren Co.
Eureka Mine...........................Allamuchy township, Warren Co.
Tunison Mine..........................Allamuchy township, Warren Co.

WINTERMUTE MINE.......Allamuchy township, Warren Co.

A newly-opened locality. [See appended notes.]

Haggerty Mine........................Allamuchy township, Warren Co.
Brookfield, or Waterloo Mine....Allamuchy township, Warren Co.
French's Mine.........................Byram township, Sussex Co.
Smith, or Cascade Mine...... .....Byram township, Sussex Co.
Allis Mine..............................Byram township, Sussex Co.

HUDE, or STANHOPE MINE,
Byram township, Sussex Co.

This mine has been worked more or less throughout the year by John M. Barnes, of Ironia. The greater part of the ore has been used at Stanhope.

WRIGHT, or BUDD MINE,
Byram township, Sussex Co.

Smith & Rusling, of New York, have a lease of this property, and they have been mining during the greater part of the year.

Silver Mine..............................Byram township, Sussex Co.
Haggerty Mine........................Byram township, Sussex Co.
Lawrence Mine........................Byram township, Sussex Co.

LAWLESS MINE..............Byram township, Sussex Co.

[*See* notices of new mines.]

Gaffney Mine..........................Byram township, Sussex Co.
SICKLES MINE..................Sparta township, Sussex Co.

The Sickles Mine was reopened in December, 1879. The Blooming Ridge Mining Company has been raising ore from it during the current year, and shipping it to the furnaces at Stanhope and Secaucus.

Goble Mine..............................Sparta township, Sussex Co.
Boss Mine...............................Sparta township, Sussex Co.
Sherman Mine.........................Sparta township, Sussex Co.
Bunker Mine ....Sparta township, Sussex Co.
OGDEN MINES...................Sparta township, Sussex Co.

Three parties have been working at the Ogden Mines; the Davenport Mine of the Sussex Iron Company, worked for Atkins Brothers, of Pottsville, Pa.; the Roberts Mine by the same parties; the Pardee Ogden Mine worked for the supply of the Stanhope furnaces; and the old Ogden, or Lehigh Mine, of the Coplay Iron Company by its owners.

Greer Mine..............................Hardyston township, Sussex Co.
Hopewell Mine.......................Hardyston township, Sussex Co.
CANISTEAR MINE...........Vernon township, Sussex Co.

The Franklin Iron Company, owners of this mine, worked it for several months until the demand for ore became slack, when work was suspended.

Tracey and Crane Mine...........Vernon township, Sussex Co.
Henderson Mine.......................Vernon township, Sussex Co.
WILLIAMS MINE.............Vernon township, Sussex Co.

This mine has been going a part of the year.

Rutherfurd Mine.....................Vernon township, Sussex Co.
Hunt Mine..............................Vernon township, Sussex Co.
WAWAYANDA MINE......Vernon township, Sussex Co.

The Thomas Iron Company began mining ore here but stopped after running a very short time.

GREEN MINE....................Vernon township, Sussex Co.

The Green Mine, also, was reopened and in operation for a few weeks. It is owned by the Thomas Iron Company.

WELLING MINE..............Vernon township, Sussex Co.

M. F. Ten Eyck, of Warwick, N. Y., operated here for one or two months and raised about 400 tons of ore. It is still on the bank.

Kimble Mine..........................West Milford township, Passaic Co.
Budd & Hunt Mine..................West Milford township, Passaic Co.
Scranton & Rutherford Mine.....West Milford township, Passaic Co.
Jennings & Rutherford Mine.....West Milford township, Passaic Co.
Clinton Tract Mine... ....West Milford township, Passaic Co.
Wallace Mine..........................West Milford township, Passaic Co.
Centennial Mine......................West Milford township, Passaic Co.

The Squier's, or Centennial Mine, on the Rutherford tract, was worked by E. H. Wright, of Warwick, N. Y., a part of the year. The ore was sent to Elmira and Greenwood furnaces, N. Y., and to Hokendauqua, Pa. It is again idle.

PEQUEST BELT.

SCHULER MINE..............Oxford township, Warren Co.

The good character of the Schuler ore led to the re-opening of the mine by Cooper, Hewitt & Co., but after drifting northeast and southwest, and sinking four shafts further east, no workable extent of ore was found. About 100 tons was mined.

ROSEBERRY MINE..........Oxford township, Warren county.

Since the last annual report this mine has been re opened and about 200 tons of ore mined by Peter Fry. The Durham furnace received the ore.

Barton Mine................. ....Oxford township, Warren Co.
Shoemaker Mine.......................Oxford township, Warren Co.
REDELL MINE.................Oxford township, Warren Co.

Worked a short time in the spring by Joseph Wharton.

Little Mine ....Oxford township, Warren Co.
Raub Mine.............................Oxford township, Warren Co.
PEQUEST MINE..............Oxford township, Warren Co.

Owned by Cooper, Hewitt & Co. Worked about five months for supply of Pequest furnace.

Hoit Mine..............................Oxford township, Warren Co.
Smith Mine.............................Oxford township, Warren Co.
Deats Mine.............................Oxford township, Warren Co.
HENDERSHOT, or HOAGLAND,
Oxford township, Warren Co.

A new ore locality, on what is known as the "Hendershot farm," and near the Free Union Church, two miles southwest of Danville, which was opened last March. [See appended notes.]

KISHPAUGH MINE..........Hope township, Warren Co.

Owner, Crane Iron Company. It continues as productive and as promising as ever. About 80,000 tons of ore have been taken out of it by its present owners, and the ore used in their furnaces at Catasauqua, Pennsylvania.

Inschow Mine..........................Hope township, Warren Co.
Stiff Mine..............................Hope township, Warren Co.
Potter Mine............................Independence township, Warren Co.
Stinson Mine..........................Independence township, Warren Co.
Garrison Mine........................Independence township, Warren Co.
DAVIS MINE....................Independence township, Warren Co.

This property is now leased, and ore is being taken from it.

Albertson Mine.......................Independence township, Warren Co.
Shaw Mine..............................Independence township, Warren Co.
Howell Mine...........................Independence township, Warren Co.
Carroll Mine..........................Independence township, Warren Co.
Cummins Mine.......................Independence township, Warren Co.
SCHAEFFER MINE..........Independence township, Warren Co.

Worked by E. Bulgin, of Danville.

GRAY MINE.....................Independence township, Warren Co.

Much work has been done on both the Schaeffer and Gray farms by E. Bulgin, of Danville. [See appendix to the list.]

Maring Mine..........................Allamuchy township, Warren Co.
Hibler Mine...........................Allamuchy township, Warren Co.
LIVESEY'S TUNNEL MINE,
Allamuchy township, Warren Co.

This tunnel is being driven in at the foot of Allamuchy mountain and on the Rutherford tract, to intercept veins of iron ore which are opened on top of the mountain. It is in over 200 feet. The openings on the mountain show a vein twelve feet wide, dipping between regular walls towards the southeast, and carrying fairly good ore, but sulphurous.

Glendon Mine..........................Green township, Sussex Co.
McKEAN MINE ....Byram township, Sussex Co.

Clarkson Bird and Son have a lease of this property, and have been working it more or less during the year.

Byerly Mine............................Byram township, Sussex Co.
ROSEVILLE MINE...........Byram township, Sussex Co.

The old Roseville Mine was reopened by its owners, the Andover Iron Company, in February, 1880. The ore is used at Phillipsburg, in the furnaces of the company.

Andover Mine........................Andover township, Sussex Co.
SULPHUR HILL MINE.....Andover township, Sussex Co.

The Sulphur Hill, or northeast part of the Andover Mine has been in operation throughout the year. Wm. J. Taylor & Co., are lessees. Andover Iron Company are owners. A large amount of ore has been taken out of it and the greater part of it has gone to the furnace at Chester, although several thousand tons have been shipped to furnaces in Pennsylvania.

TAR HILL MINE ....Andover township, Sussex Co.

The Crane Iron Company is cutting a tunnel into the side hill preparatory to mining here.

Longcore Mine.......................Andover township, Sussex Co.
STIRLING HILL MINE.....Sparta township, Sussex Co.

The Manganese Iron Company continues to work this interesting ore body. A small amount of zinc ore is also mined here.

HILL MINE ....Hardyston township, Sussex Co.
FURNACE, or PIKE'S PEAK MINE,
Hardyston township, Sussex Co.

These mines are owned and worked by the Franklin Iron Company. They yield a steady product of excellent ore.

Green's Mine..........................Vernon township, Sussex Co.
Bird Mine..............................Vernon township, Sussex Co.

HEMATITE IRON ORES.

RADLEY MINE.................Lebanon township, Hunterdon Co.

About 70 tons of ore have been shipped from this locality during the year.

NOLF MINE.....................Holland township, Hunterdon Co.

The developments at this locality have disappointed the expectations of prospectors, and the place is abandoned. Several shafts have been sunk, and a thin vein of good ore has been opened on the Nolf and on the adjoining Eates property, but it is too narrow for profitable working.

MARBLE MOUNTAIN MINE,
Lopatcong township, Warren Co.

The mine on Marble Mountain was re-opened in the summer by Henry Fulmer, of Easton, Pennsylvania. The ore, as uncovered in a space 60x16 feet, is said to be rich and of good quality. A considerable amount has been taken out, and is on the bank. For lack of machinery work was stopped in early autumn.

Titman Mine..........................Oxford township, Warren Co.
Ayers Mine..........................Allamuchy township, Warren Co.
Simpson Mine........................Vernon township, Sussex Co.
Cedar Hill Mine.....................Vernon township, Sussex Co.
Cooley Mine.........................West Milford township, Passaic Co.
Bird Mine.............................Union township, Hunterdon Co.
NEIGHBOUR MINE..........Washington township, Morris Co.

The hematite mine on the farm of Sylvester Neighbour, two miles northeast of Califon, was worked a part of the year, and the ore was used at Chester, but it proved too troublesome on account of the zinc in it. Its disuse at the furnace led to the suspension of further work at the mine.

A sample of the ore was sent to the Survey Laboratory by Isaac Hummer, of High Bridge. It was examined for lead and zinc, and found to contain, of

Metallic lead	3.74 per cent.
Metallic zinc	10.00 per cent.

The lead exists as sulphide, or galena; the zinc is combined as zinc sulphide, or sphalerite and zinc carbonate or smithsonite.

DUFFORD MINE..............Washington township, Morris Co.

This place was worked in 1879, and a little while the present year, by the Port Oram Furnace Company, and a large amount of ore was taken out.

WEAN MINE.....................Bethlehem township, Hunterdon Co.

A little ore and ochre have been taken out during the year by the owner, John P. Wean.

Silver Hill Mine.......................Greenwich township, Warren Co.
Woolverton Mine.....................Bethlehem township, Hunterdon Co.
Hazard Mine...........................Bethlehem township, Hunterdon Co.
BROWN MINE..................Mansfield township, Warren Co.
SHIELDS MINE................Mansfield township, Warren Co.
THOMAS MINE...............Mansfield township, Warren Co.

The Brown, Shields and Thomas mines, are the several names given to the openings in the hematite ore body on the lands of the late Thomas Shields, and near Beattyestown, Warren county.

The *Brown Mine* is worked by Joseph Wharton, for the supply of his furnace at Hackettstown. It was opened in April, 1880.

The *Shields Mine* has been in operation uninterruptedly through the year. The Musconetcong Iron Works at Stanhope, are the lessees, and use the ore.

The Thomas Mine, formerly worked by the Thomas Iron Company, is now leased by Joseph Wharton. It has been in operation a part of the year. The ore was carted to the Hackettstown furnace.

RAPP MINE.......................Greenwich township, Warren Co.

The Rapp, Carpenter and Riegel Mines are openings on one ore body or deposit. [For fuller notes, see Appendix to this list.]

CARPENTER MINE..........Greenwich township, Warren Co.
RIEGEL MINE..................Greenwich township, Warren Co.
WM. HAMLEN MINE.......Lopatcong township, Warren Co.

The mine known as the *Hamlen Mine*, on Wm. Hamlen's farm, has been working since June. Ochre is associated with the hematite.

HENRY HAMLEN MINE..Lopatcong township, Warren Co.

A new mine opened in June.

Thatcher mine........................Franklin township, Warren Co.
NEW VILLAGE, or CLINE MINE,
Franklin township, Warren Co.

The Andover Iron Company explored this property, sinking ten or more shafts, and took out 700 tons of ore. It was in small pockets. It is again idle.

Broadway Mine.......................Franklin township, Warren Co.
Shiloh Mine...........................Hope township, Warren Co.
SWAYZE, or OSMUN MINE,
Hope township, Warren Co.

A. J. Swayze reports the production of the Osmun Mine, for the year, to be between 500 and 600 tons. The ore is shipped from Blairstown.

Van Kirk Mine.......................Sparta township, Sussex Co.
Scott Mine.............................Hardyston township, Sussex Co.
Edsall Mine...........................Hardyston township, Sussex Co.
Pochuck Mine........................Vernon township, Sussex Co.

NOTES OF NEW MINES AND IRON ORE LOCALITIES.

The following notes have been gathered through personal visits and examinations and by means of correspondence with those in position to report upon their respective localities. They relate to the mines opened during the year and to others which have been recently opened, but which have not been noticed hitherto in the annual reports of the Geological Survey. The list is not presented as complete to date, but it is believed that all the *mines* and all the more important ore discoveries are embraced in it:

COOPER MINE.................Chester township, Morris Co.

This mine was opened in December, 1879, on the property of the late Gen. Nathan A. Cooper, about one mile northeast of the village of Chester, and is operated by the Cooper Iron Mining Company, lessees.

The lease covers an area of 1600 feet on the course of the vein, and a width of 300 feet.

Beginning at the southwest extremity of the property the attraction varies from 60° to 90°. Positive for a distance of 900 feet along the course of the vein, varying in width from 50 to 100 feet. It then changes to negative, and remains so for about 200 feet, when the needle again shows positive attraction, varying from 30° to 90°, and continues to within a short distance of the boundary on the northeast.

To determine the extent of the deposit, trial pits have been sunk at intervals of 100 feet. After passing through from eight to ten feet of earth ore was struck in each shaft.

In character it is a soft granular, very much decomposed, and of a reddish color. The width of the vein varies from 15 to 30 feet, and the ore is of a very fine quality. Owing to the bad character of the hanging wall, which is very soft and crumbly, it was found necessary to strip the covering of earth on the vein for a width of 100 feet, thus exposing the outcrop for a distance of 700 feet.

In January an incline was begun in the centre of the deposit, and at right angles to the strike, the angle of dip is about 45° to the southeast.

At the present writing, December 1st, 1880, the slope is down about 90 feet, the whole distance being in red ore with the exception of the last 16 feet. Here blue ore was first struck on the foot wall.

The blue ore is rich granular, and contains a little sulphur, about one per cent.

The hanging wall at the bottom of the slope still continues soft and crumbly, and is a decomposed feldspathic rock, with mica, and is discolored with oxide of iron, necessitating close timbering.

The foot wall is much harder, and consists of a stratified hornblende with thin layers of feldspar and mica.

The first shipment of ore from this mine was made on the 14th of December, 1879, and since that time 12,000 tons of ore have been sent away.*

DAVENPORT MINE..........Rockaway township, Morris Co.

This new mine is on the eastern foot of Copperas mountain, southwest of the Green Pond Mine, and three miles from Charlotteburg. The course of

*Communicated by John D. Evans, superintendent, of Chester.

the *vein* is southwest, and the dip is about forty degrees to the southeast. It was worked in open cuts, close by the side of the Green Lake and Hibernia road and during the first half of the year. The walls are regular, and the ore cleaves free from them. At the northeast opening the vein was found twelve feet wide. At the southwest it includes a horse of rock. The ore contains sulphur, but otherwise, is of excellent quality. It is used by the owners, Cooper, Hewitt & Co.

On the Musconetcong mountain, and in Hunterdon county, there has been much prospecting and exploring in search of the southwestern extension of the Turkey Hill veins. B. F. Fackenthal, superintendent of Durham Iron Works, Riegelsville, Pa., reports an opening on *Peter Hart's* lands, 800 feet northeast of his house, on a belt of attraction (of ninety degrees) 150 feet long. A shaft was sunk to a depth of fifty-two feet, in a very hard gneiss rock, but no ore was found, nor was there any attraction below twenty feet from the surface. *Mellick Smith* farm, one mile northeast of the Hager Mine. Here a shaft fifty feet deep, located on an attraction of thirty degrees, found float ore only. *Herbert Sinclair*, one mile northeast of Spring Mills, an attraction of twenty-five degrees, was tested by a shaft forty feet deep, but only a thin leader of rich ore was found.

PETTY MINE....................Bethlehem township, Hunterdon Co.

This name is given to a new opening in Hunterdon county, about one mile south of Bloomsbury, and on the property of Mrs. Elizabeth Petty. It was opened by David McCrea, in March last, and up to June first, about forty tons of ore had been raised from it, when it stopped to have machinery put in for pumping and hoisting.

WRIGHT OPENING..........Bethlehem township, Hunterdon Co.

A single shaft, thirty-five feet deep, was sunk on Wm. Wright's farm, one and a half miles southwest of Turkey Hill. The rock and ore are said to correspond with those of the Turkey Hill Mines. Only ten or twelve tons of ore have been raised.

CASE MINE......................Bethlehem township, Hunterdon Co.

The Case Mine is a new opening on lands of Isaac B. Case, about a mile southwest of Pattenburg, and in Bethlehem township, Hunterdon county. The first work was done in December, 1879, and it was continued for three months by the lessee, David McCrea, of Bloomsbury. Only about twenty-five tons of ore was obtained, when the work was suspended on account of lack of machinery.

MABERRY MINE..............Lebanon township, Hunterdon Co.

The Maberry Mine is at Glen Gardner. It was opened and worked a part of the year by Halsey J. Boardman. About 300 tons of ore have been mined.

EVELAND MINE..............Lebanon township, Hunterdon Co,

This place, also at Glen Gardner, was worked by Lewis Barnes, of Annandale, until April. The *vein* was struck in three openings about fifty feet apart, and was found five to seven feet wide. The product amounted to 200 tons. Work is to be resumed in January.

ALVAH GRAY MINE.......Lebanon township, Hunterdon Co.

This mine has not been noticed in previous annual reports. Its development is comparatively recent. The Saucon Iron Company has been working it during the year. Mr. Fackenthall, Superintendent, at Hellertown, Pa., says: "We struck several fine bunches of ore going west from the main shaft, which promised well, but did not hold out. The character of the ore has changed from a good ore, practically free from sulphur, to one rich in in sulphur. We have mined between 3000 and 4000 tons, which will yield about fifty two per cent. of metallic iron. We mined the greater part of the ore at a depth of about sixty feet. There are some indications of ore on the foot wall side, but we have not tested it."

MATTISON OPENING......Lebanon township, Hunterdon Co.

This locality is one mile southeast of Andersontown. It is held under lease by Lewis Barnes. The line of attraction runs northeast and southwest. The vein, five feet wide, has been struck in several places at a depth of about twenty feet. Very little work has been done, except in way of exploration.

HIGH LEDGE MINE.........Roxbury township, Morris Co.

The High Ledge Mine is on the property of Thomas L. King, a half mile west of Drakesville, in Morris county. Mine No. 1 has been sunk to a depth of between fifty and sixty feet. The ore appears to be in a shoot which pitches towards the northeast, and which ranges from six to twenty feet in width. The ore is of a dark blue color, is coarsely granular, and contains from one to three per cent. of sulphur. The metallic iron is said to range as high as 65 per cent.

Mine No. 2 is 200 yards northwest of No. 1. It is about thirty feet deep. The *vein* here is six feet wide. The ore is very much like that of No. 1.

KING MINE, or Mine No. 3, is on the same property, and half a mile west of the High Ledge Mine. The shoot structure of the ore mass is noticed here also. The mine is fifty feet deep. The ore body measures six to twelve feet in width. The ore of this opening is of light blue color, fine granular, and mixed with whitish feldspar. It is reported to contain no sulphur and very little phosphorus. Several hundred tons of the ore of this mine have been shipped.

APPLEGET OPENINGS......Mount Olive township, Morris Co.

These openings were made the present season by Youngblood and Appleget. They are on the farm of Henry M. Appleget, one and a half miles east of Hackettstown. Several hundred tons of lean ore were taken out of a broad open cut and left on the bank. No regular walls were found, and the operations had not, at last accounts, discovered a continuous vein, although the line of attraction, of about ten degrees, is traceable towards the northeast from the open cut. Over the ore taken out there was a bed of loose quartzose and micaceous *sand*, or disintegrated rock.

WILLEVER AND GODFREY MINE,
Greenwich township, Warren Co.

This ore locality is new, having been discovered during the year. It is on lands of Henry Carter, near Stewartsville, in Greenwich township, Warren county, and is worked by Messrs. Willever & Godfrey. A shaft forty-eight feet deep opens the *vein*—nine feet in width. About 500 tons of ore have been mined, and nine car loads of it sent to the Saucon Iron Company at Hellertown and the Keystone furnace, Pennsylvania.

BARKER, or BULGIN MINE,
Independence township, Warren Co.

A new mine, opened in the autumn of 1880, on the land of C. Barker, about one-half mile south of Vienna, in Warren county, and about a quarter of a mile west of the road from Vienna to Hackettstown. It is owned by Bulgin and Swayze. The mass of ore which has been uncovered is twelve feet broad, and its dip thirty-eight degrees to the northeast. The attraction is very strong for a considerable distance up the hill towards the southeast, but is cut by a northeast and southwest fault, at the northwest edge of the opening. The ore has been exposed in an opening about twenty-five feet deep, and extending from northwest to southeast, about twenty feet. This has exposed a face of very rich magnetic iron ore. The ore is fine grained, uniformly dark colored, and almost free from rock. No sulphur was detected in the sample analysed, and a mere trace of pyrite was seen in one fragment of ore. The opening is high up on the side hill, so that mining can be done with little expense for either pumping or hoisting, and so far in mining several hundred tons of ore, there has been no water found, and no occasion for hoisting apparatus. An analysis of the ore has been made from a specimen carefully sampled from the whole. The following is the result:

Magnetic oxide of iron	85.56 per cent.
Titanic acid	1.45 per cent.
Sulphur	0.00 per cent.
Phosphorus	trace.
Manganese	0.00 per cent.
Insoluble	9.00 per cent.
Metallic iron	61.96 per cent.

There is another opening some 300 feet northeast from the last, in which good ore has been found, and a strong attraction is observed about it. Similar attractions have been observed southwest of the principal mine. The attractions are different in lines of direction from those usually found, but whether this is due to a peculiar strike of the rock, or to some other cause, can only be determined as the work is prosecuted more extensively. The present exposure of ore is very fine, and gives promise of a rich and valuable mine.

DAY MINE..................... Independence township, Warren Co.

This name is given to an opening made in the summer of 1880, by the late A. R. Day, on his farm, one mile northwest of Hackettstown, and on the left of the road from that town to Petersburgh. A shaft was sunk on the ore for fifteen or more feet, and a drift run to the northeast for ten feet or so. No work was going on when the mine was visited. A pile of perhaps twenty tons of ore was lying on the bank.

The ore is peculiar in appearance, being made up of crystalline masses of dark colored magnetite, imbedded in white crystalline feldspar. The feldspar appears to make up the bulk of the mass, and the patches of dark colored magnetite which vary from a quarter of an inch to an inch or more in diameter, set in a paste of white rock, give the whole a remarkable and characteristic appearance. A sample of the ore averaged at the pile showed the following composition:

Magnetic iron ore	70.26 per cent.
Manganese oxide	.45 per cent.
Titanic acid	5.00 per cent.
Phosphoric acid	0.19 per cent.
Sulphuric acid	trace.
Metallic iron	50.88 per cent.

This variety of ore has been found in a number of openings on the southeast slope of the mountains along the northwest side of the Musconetcong valley, between Hackettstown and Waterloo. The veins of ore have not been very large, and its apparent leanness has been rather discouraging to miners. The ore will undoubtedly make iron of a fine quality. It would find its best use where some process was in profitable operation for working ore that had been separated from its rock and left in a pulverized form, as in the common Catalan forge. The rock, however, is fusible at a blast furnace heat, and this ore, in proper mixture with others of different composition, may be advantageously worked without separating the rock. The titanium in it will probably make it a little more expensive to work than ores which are free from that substance.

WINTERMUTE'S OPENING,
Allamuchy township, Warren Co.

A vein of ore has been opened lately on the farm of George Wintermute, one mile southwest of Thomas Haggerty's mine, and about two miles south of Allamuchy, in Warren county. The ore is reported to be like that of Haggerty's.

LAWLESS OPENING......Byram township, Sussex Co.

A vein of ore three to four feet wide was opened on lands of John Lawless, near Byram Cove, on the west shore of lake Hopatcong. The vein dips to southeast between well-defined walls. The ore is sulphurous, and contains, according to an analysis made for the Durham Furnace Company, some titanium, but is low in phosphorus. Only a small amount of ore has been mined. It was shipped on the canal from Brooklyn.

HOAGLAND MINE.. ....Hope township, Warren Co.

The new mine known by this name is on the "Hendershot Farm," three-eighths of a mile west of the Kishpaugh Mine, and in Hope township, Warren county.

A single shaft, 50 feet deep, has been sunk on the *vein*, which is from two to five feet wide. Several hundred tons of the ore have been raised. The ore is said to contain some manganese and very little phosphorus.

A new mine was opened by Bulgin Brothers in the summer of 1880 on the lands of Moses Gray and James Shafer. It is in Warren county, Allamuchy township, on the southeast slope of the mountain, which lies northwest of Bacon's run, a little northeast of the Warrenville road. It has been sunk only a few feet, scarcely enough to find any walls to the vein of ore. It was located by the magnetic indications.

The ore is fine grained, and some of it gives a red streak, though it is mostly magnetite. An average sample from forty or fifty fragments prepared by Hon. C. H. Albertson, has been analyzed, with the following result:

Magnetic oxide of iron	87.21 per cent.
Oxide of manganese	0.00 per cent.
Phosphoric acid	0.025 per cent.
Sulphur	0.05 per cent.
Titanium	0.00 per cent.
Alumina	2.68 per cent.
Insoluble matter (silica 9.95 per cent.)	10.45 per cent.
	100.415 per cent.

It contains 63.15 per cent. of metallic iron and 0.011 per cent. of phosphorus.

GERMAN VALLEY..........Washington township, Morris Co.

The Neighbor and Dufford localities in this valley were worked a part of the year, (see pages 119–120). Explorations made last winter and spring, in the same neighborhood, on farms of Messrs. Trimmer by Isaac Hummer, of High Bridge, discovered under a drift five to eight feet thick, deposits of brown hematite on blue limestone, and wide spread on these farms. These discoveries, together with previous ones, indicate a very general occurrence of this ore in the valley. The older openings are on the Fox Hill side of the valley, but these latest made are at the foot of Schooleys mountain.

RAPP MINE.......................Greenwich township, Warren Co.

Three mines of hematite ore are worked near Carpentersville, southeast of the Pohatcong creek, and near the foot of the mountain. That of Andrew Rapp is at the southwest, and is an eighth of a mile from the Belvidere Delaware railroad. The ore has been worked to a depth of 204 feet, and the vein is from one to ten feet wide. About 3000 tons of ore were raised during the year and sent to Durham, Pennsylvania. It is reported to run forty-two per cent.' of metallic iron.

CARPENTER MINE..........

The openings on William Carpenter's lands are not new, having been worked years ago. The following data respecting the place, together with the ore on the adjoining properties, are from B. F. Fackenthal, superintendent, Durham Iron Works, Pennsylvania: "On property of William Carpenter, we have two openings, 100 and 115 feet deep. Unlike most hematite bodies this appears to be formed like a magnetic iron ore vein. The walls are quite regular. The ore *pitches* forty-five degrees south. The north wall is limestone, and the southern a grey rock, separated by five feet of clay. The ore body will average five feet wide, and extends below water level, which has not been worked. We have worked 500 feet on the *vein* and have 600 feet yet to work on the property. It extends through Isaac

T. Riegel's farm, where they have an opening, and then through Andrew Rapp's farm, where they have two openings with the same formation. It crosses the river to Pennsylvania, where larger deposits are found. Extent on Wm. Carpenter's farm, say 1100 feet; Isaac T. Riegel's, 600 feet; Andrew Rapp's, say 1000 feet.

SLACK FARM..................Franklin township, Warren Co.

Hematite was discovered last winter on the farm of Mrs. J. H. Slack, near the Bloomsbury and Asbury road, and one and one-half miles from West End. Several test pits were sunk, and ore was found in all of them. In one of them it was struck six to eight feet below the surface, and extended to bottom—28 feet. Limestone beds are on both sides of this deposit. The locality has not been further developed.

HENRY HAMLEN FARM..Lopatcong township, Warren Co.

The Crane Iron Company began working this locality in the summer, but nothing further has been learned about it.

ROSEBERRY MINE..........Oxford township, Warren Co.

Hematite has been worked on Joseph Roseberry's farm, in the Valley of Buckhorn Creek, two miles southeast of Belvidere. About a dozen shafts or trial pits were dug by the Andover Iron Company, as reported by Joseph C. Kent, superintendent, of Phillipsburg; and about 500 tons of ore taken out. The locality is interesting geologically, as it is a very narrow valley or depression, shut in by steep gneissic mountains, and the ore appears in a series of pockets running northeast and southwest, which are bounded on the west by clay-slate, and on the upper, or Scotts mountain side, by the same rock, which abuts against the gneiss of the mountain. On the lower side, in the valley, there is blue limestone. The ore appeared to *dip* at an angle of 30° towards the southeast. It was found in the pits eight to sixty feet beneath the surface.

GULICK MINE...........East Brunswick township, Middlesex Co.

This mine is half way between Milltown and Dunham's Corners, on land of Edwin Gulick. The ore occurs in a nearly horizontal bed about three feet thick, and overlaid by soil and clayey earth of depth varying from 1 to 7 feet. The ore is found extending under many acres, so that a large supply may be obtained from the bed. A sample prepared by Mr. Gulick, by taking fragments from forty different lumps of the ore, and making what he judges to be an average of the mine, was analyzed :

Sesquioxide of iron	71.36 per cent.
Oxide of manganese	0.70 per cent.
Phosphoric acid	0.27 per cent.
Magnesia	0.15 per cent.
Lime	trace.
Silicic acid	8.90 per cent.
Titanic acid	0 00 per cent.
Alumina	2.27 per cent.
Sulphuric acid	0.00 per cent.
Water	15.95 per cent.
	99.60 per cent.

It contains 49.95 per cent. of metallic iron, and 0.12 per cent of phosphorus.

VII.

FIRE-CLAYS.

REFRACTORINESS, TESTS AND CLASSIFICATION.

In the Report on the Clay Deposits of Woodbridge, South Amboy and other places in New Jersey, published in 1878, a large number of analyses of native and foreign clays was given, and the refractory properties of these clays, as indicated by their chemical composition, were discussed. [*See* Report on Clays, pp. 289–304.] The need of practical fire tests to supplement these chemical examinations was felt at the time, but it was not then possible to undertake them. Trials made at the Newark Steel Works were reported, but they were not so decisive as to warrant publication. Last April the re-examination of the clays was begun and carried forward to results which appear to be eminently proper and desirable to present in this annual report. Inasmuch as very high temperatures were required in order to detect differences in such refractory material as fire-clay, in any fire tests the first requisite was a furnace in which the highest possible temperature could be obtained. For this purpose experiments were made with two well-known forms, viz., the Sefstrom and the Deville blast furnaces. A Sefstrom furnace was imported from Berlin, and one of the Deville pattern was made for the Geological Survey, at W. E. Kelly's National Iron Works in New Brunswick. The latter consists of three pieces, viz., the cast-iron blast reservoir, a perforated, movable cast-iron plate, as its cover, and separating the reservoir from the cylindrical furnace. The whole is supported on a tripod of three vertically-placed legs. The blast reservoir is concave-shaped, and eight inches in diameter, with a pipe-connection on one side for the entrance of the blast. The circular plate covering this reservoir has forty openings, one-quarter inch in diameter, bored through it in concentric circles from one and one-sixteenth to three inches from a central opening. These serve as vertical tuyeres through which the blast is forced upwards into the furnace proper, and this perforated plate becomes the furnace bottom. The furnace cylinder is of sheet iron, lined with fire-brick. It is fixed vertically upon the blast reservoir and plate. Its internal dimensions are ten and one-half inches by eight inches. A sheet-iron cone, tapering into an ordinary stove pipe, serves to carry away the products of combustion.

The Sefstrom furnace consists of two cylinders, an outer of sheet iron and an inner one of sheet iron lined with fire-clay. The space between the two cylinders serves as a reservoir for the blast, which enters horizontally at the base of the exterior cylinder, and is forced into the furnace through eight horizontal tuyeres, equidistant and at about one-third way up from the base of the inner cylinder. This inner or fire cylinder is four inches high and four inches in diameter. The radical difference between these two furnaces is that in the Deville the blast is forced upwards through the fire, whereas in the Sefstrom the tuyeres make it converge horizontally to a focus in the centre of the furnace.

The blast in each case was supplied by a No. 1 hand Root blower, which delivered one-third cubic foot of air per revolution. Charcoal, coke and anthracite coal (pea size) were tried, but the coal was found to give the most intense and the most uniform heat. A little charcoal was used to start the fire, and the fuel was weighed in every trial. To hold the test specimens and protect against the fluxing tendency of any impurities in the coal or the coal ashes, circular, graphite, or black-lead plates, with cylindrical cavities bored in them, and covered by similar plates of the same material, were employed. The plates were from three-quarters of an inch to one inch thick, and from one and one-eighth inches to four inches in diameter, according as they were used in the smaller Sefstrom or the larger Deville furnace. The largest plates had each fifteen of these receptacles, and they were three-eighths of an inch deep and five-sixteenths of an inch in diameter. They were bored equidistant in a circle. The smaller plates had twelve, six and four receptacles, according to size, and also arranged in circles. In them the bored cavities were five-sixteenths of an inch deep and three-sixteenths of an inch in diameter. This circular arrangement was chosen that the exposure might be the same—that the plates might fit closely together and be kept so in the fire. The plates were ground true, and they were fitted together by a dowel of black lead. By this arrangement the specimens to be tested were protected, and were subjected to the action of the heat alone.

The clays which have been tested are representatives of their respective localities, and many of them are identical with the samples whose analyses appear in the Report on Clays, 1878. The fire tests can, therefore, be compared with the results of chemical analysis, a matter of great importance in the study of *refractoriness* and composition. The samples for testing were reduced to powder in an agate mortar, moistened with distilled water, and then cast in steel moulds, in the form of triangular prisms of two sizes, one of one-quarter inch in length and nine-thirty-seconds of an inch on a side, the smaller, one-quarter inch long and six-thirty-seconds of an inch on a side. The air-dried, sharp-edged and sharp-angled prisms were placed on end, and in a vertical position in the receptacles, resting on their three lower corners on the concave-shaped bottoms of the same. In this way there was the least possible contact with the mass of the black-lead enclosure.

The first series of tests was made in the Deville furnace, and fifteen specimens were exposed at a trial in a four-inch plate. The second series was made in the Sefstrom furnace, each plate holding twelve specimens or prisms. The third series, made in the same furnace as the second, had plates one and one-quarter inches in diameter, and each carrying six receptacles. A few of the more refractory clays were tested, four at a time, in one and one-eighth inch plates. In each series the conditions of all the trials were alike in the weight and kind of fuel used, the volume and pressure of blast, the length of the heat, and the dimensions of plates and test prisms. Thus in the first series of tests in the Deville furnace, there were fifteen separate prisms one-fourth inch long and nine thirty-seconds inch on a side, each in its receptacle, and twelve pounds of pea coal as fuel, one-quarter of which was under and three-quarters on the top of the plate. The volume of the blast was thirty-six revolutions of the blower per minute, equal to twelve cubic feet, and the length of the blast or heat was thirty minutes. In the second series, using the smaller Sefstrom furnace, twelve test prisms of smaller size were disposed in a plate two inches in diameter. The fuel consisted of two and one-half pounds of coal.

The blast volume was ($24x\frac{1}{3}$) eight cubic feet per minute, and the period thirty minutes. The third and fourth series employed smaller plates, but the weight of fuel, volume of blast and time of blowing remained as in the second series. The matters of fuel, rate of blowing, and time, were all determined by careful preliminary experiments, to be the best, and to give the most satisfactory results. The tests in all cases (reported) were made with fresh, unburned prisms, and by varying the order in each successive fire the plates were not duplicated, although the clays were tested from two to four times in each series. Those which fused in the first series were not tried in the second or third, but the more refractory went through these, so that in some cases as many as ten tests were made of the same clay.

A few tests were made in plates or receptacles of anhydrous alumina. Pure alumina hydrate was calcined and then pressed in moulds. The plates were one and one-half inches in diameter. The covers and dowels were also made of the same material. The Sefstrom furnace was employed, and the conditions of fuel, blast and length of heat, were the same as in the third series of tests, using graphite plates. The alumina plates were found to resist the heat and the fluxing action of the coal ash much better than those made of black lead. Platinum was tested in this series also. And it is to be noted that in the black lead plates in each of the series, this metal was fused to a globular mass; but the globule was found to be brittle. The carbon of the plate had evidently produced a change analagous to that of carbon in cast iron. In the alumina plates the platinum was fused, but it remained malleable and apparently unaltered. On the contrary, the clays appeared to be more easily fused in the alumina plates, as all which were tested in this way melted down to more or less rounded masses. And only the more refractory clays were thus tried. Further trials are desirable to determine the behavior of other clays in alumina plates, and to explain the varying phenomena of fusion. As the tests made in black lead receptacles correspond more closely to the conditions of practice, and as there is a marked and well defined gradation in the degree of refractoriness in the tests so made, the results are here presented and used as the basis of classification.

No measurements of the intensity of the heat, or pyrometric effects, were obtained, other than the fusing point of platinum. In the black lead plates it fused at the lowest temperature in the first series of tests. The temperature of the subsequent series was much higher, as was attested by the fusion of the clays in the latter; whereas, in the former they remained unaffected. Quartz, or rock crystal, was rounded on the edges in the first series and fused to globular mass in the latter. The partial vitrification of the black lead plates on the exterior, and their complete fusion in some of the fires of the fourth series, was evidence of the intensity of heat. The blue color, or *blaguliihhitze* of the Germans, was another striking indication of the intensity. But the behavior of the platinum in the alumina plate shows that its *fusing point* marked the limit attained in the third and fourth series of tests. The apparent fusion in the first series was due to a change wrought by carbon from the black lead plates.

One hundred and twenty-three clays, *kaolins*, *feldspars* and fire-sands, from about one hundred localities, have been tested. Of this number of specimens, there were from:

Raritan potters' clay bed	10 numbers.
Raritan fire-clay bed	3 numbers.
Woodbridge fire-clay bed	12 numbers.
Feldspar bed	2 numbers.
Kaolin bed	2 numbers.
South Amboy fire clay bed	10 numbers.
Fire-sand bed	1 number.
West Jersey clays	8 numbers.
Delaware and Maryland clays	2 numbers.
Pennsylvania clays	6 numbers.
Indiana and Illinois clays	6 numbers.
Missouri clays	5 numbers.
British clays	26 numbers.
French clays	19 numbers.
Belgian clays	6 numbers.
German clays	3 numbers.
Miscellaneous clays	2 numbers.
Total	123 numbers.

These numbers represent the most noted and best fire clays of our own country and of Europe. Their behavior in the fire, as shown in the appearance of the prisms, is given in the following list, with notes. The order of arrangement is, first, New Jersey clays, then those of other states of the Union, and then British, French, Belgian and German clays. According to their degree of resistance to more or less heat, as shown by sharp edges and angles, or by fusion on the edges, so as to round them, or by complete fusion, these clays have been arranged in seven groups or classes. But it must not be supposed that these classes are at all sharply defined or separated from one another. They grade into one another by insensible gradations, and the arrangement is an arbitrary one, which is employed to show more readily differences in their degrees of resistance, or in *refractoriness.**

The names of owners and localities, as given in the Report on Clays, published in 1878, are retained for convenience of reference to the descriptions of localities and analyses given in that report. A number of changes in ownership are known to have taken place since its publication. They can be identified from the descriptions of localities as there given.

CLASSIFICATION.

CLASS I.

Island Farm *clay*.
H. Cutter's *fire-clay*.
A. Hall & Son's *No.* 1 *fire-clay*.

CLASS II.

W. N. Weidener's *clay*, Martin's Dock. I.—II. (?)
Isaac Webster's *clay*, Ten Mile Run. I.—II. (?)
Crossman Clay Co.'s *No.* 1 *fire-clay*. I.—II. (?)
H. Cutter's *ware-clay*.
C. A. Campbell's *white fire-clay*.
Sayre & Fisher's *No.* 1 *fire-clay*.
Whitehead Brothers' *blue fire-clay*.
Brick Estate, *No.* 1 *fire-clay*.
E. F. & J. M. Roberts' *selected clay*.
George Such's *washed clay*, (1879). I.—II. (?)
Hawes' *flint clay*, Johnstown, Pennsylvania. Report on Clays, No. 12.
Pope county, Illinois, *clay*, Report on Clays, No. 17.

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* It should be stated that this classification is no disparagement to any clay, except in so far as it shows that it may not be capable of resisting the most intense heat. In many uses the *highest degree of refractoriness* is not essential. And in some instances this degree of resistance may not be found associated with other necessary and valuable properties.

Evens Mines (*crude*) *clay*, Howard co., Mo. Report on Clays, No. 25. I.—II. (?)
Evens Mines (*calcined*) *clay*, Howard co., Mo. Rep. on Clays, No. 26. I.—II. (?)
Bollene *clay*, Terre Noire Co., France. Report on Clays, No. 77.
Lezanne *clay*, Schneider & Co., France. Report on Clays, No. 71.

CLASS III.

George Such's *buff-colored clay*.
Anna, Illinois, *clay*. Report on Clays, No. 21.
Garnkirk *No. 2 fire-clay*. Report on Clays, No. 54.
Sorée (*fine*) *clay*. Report on Clays, No. 87.

CLASS IV.

NEW JERSEY CLAYS.

David Flood's *spotted clay*.
H. Cutter's *black clay*.
Brick Estate, No. 2 *fire-clay*.

CLAYS FROM OTHER STATES.

Hokessin, Delaware, *washed kaolin clay*. Report on Clays, No. 1.
Mount Savage *fire-clay*. Report on Clays, No. 2.
Mineral Point, (near Johnstown,) Pennsylvania. Report on Clays, No. 14.

BRITISH CLAYS.

Garnkirk *No. 1 fire-clay*. Report on Clays, No. 53.
Redruth, Cornwall, *china clay*. Report on Clays, No. 55.

FRENCH CLAYS.

Mussidan *clay*. Report on Clays, No. 68.
Bollene *clay*. Report on Clays, No. 69.

BELGIAN CLAYS.

Strud *slate clay*. Report on Clays, No. 83.

CLASS V.

NEW JERSEY CLAYS.

Charles M. Dally's *clay*.
W. H. Berry's *retort clay*.
Whitehead Brothers' *red clay*.
George Such's *washed clay*.
E. F. & J. M. Roberts' *fire-clay*.

CLAYS FROM OTHER STATES.

Sandy Ridge, Centre county, Pennsylvania. Report on Clays, No. 7.
Lawrence county, Indiana, *porcelain clay*. Report on Clays, No. 16.
Utica *clay*, La Salle county, Illinois. Report on Clays, No. 19.
Cheltenham, Missouri, *crude clay*. Report on Clays, No. 22.
Cheltenham, Missouri, *calcined clay*. Report on Clays, No. 23.
Cheltenham, Missouri, *washed clay*. Report on Clays, No. 24.

BRITISH CLAYS.

West Durham *clay*, England. Report on Clays, No. 32.
South Benwell Colliery, Newcastle-on-Tyne. Report on Clays, No. 33.
Kingwinsford, North Dudley. Report on Clays, No. 34.
South Brancepath Colliery, Durham. Report on Clays, No. 35.
Wortley, near Leeds, (Ingham). Report on Clays, No. 36.
Wortley, near Leeds, (Cliff). Report on Clays, No. 37.
Glenboig Star *fire clay*. Report on Clays, No. 39.
Sharrott, Halifax, *crucible fire-clay*. Report on Clays, No. 45.
Wragg, Sheffield, *crucible fire-clay*. Report on Clays, No. 48.
Burton-on-Trent, Derbyshire, (25 yards down). Report on Clays, No. 49.
Burton-on-Trent, Derbyshire, (50 yards down). Report on Clays, No. 50.
Farnley, Leeds, *crucible fire-clay*. Report on Clays, No. 51.
Horwichtown, Lancashire, *crucible fire-clay*. Report on Clays, No. 52.
Blaydon Burn Colliery, near Newcastle-on-Tyne. Report on Clays, No. 56.

FRENCH, BELGIAN AND GERMAN CLAYS.

St. Egreve *clay*. Report on Clays, No. 59.
Macon *clay*. Report on Clays, No. 63.
Macon *clay*, (*lean clay*). Report on Clays, No. 64.
Bollene *clay*. Report on Clays, No. 65.
Courpiere *No.* 1 *clay*. Report on Clays, No. 66.
Courpiere *No.* 2 *clay*. Report on Clays, No. 67.
Decize *clay*. Report on Clays, No. 70.
Gravoine *clay*. Report on Clays, No. 73.
Strud (*pale*) *clay*. Report on Clays, No. 83.
Nannines *No.* 1 *clay*. Report on Clays, No. 86.
Frankenthal. Report on Clays, 89.

CLASS VI.

NEW JERSEY CLAYS.

Wm. B. Dixon's *clay*.
B. Ellison's *clay*. (Pit 100 yards north of sandfield.)
Edgar Brothers' *No.* 1 *feldspar*.
Forbes farm *No.* 1 *feldspar*.
A Reeves' *fire-clay*, Fish House.

BRITISH CLAYS.

Stourbridge (*strong*) *clay*, Mobberly & Bayley. Report on Clays No. 41.
Stourbridge (*mild*) *clay*, Mobberly & Bayley. Report on Clays No. 42.
Stourbridge *No.* 3 *clay*, Harper & Moore. Report on Clays No. 29.
Stourbridge *No.* 2, (King Brothers.) Report on Clays No. 31.
Throckley Colliery, Newcastle. Report on Clays No. 38.
Glenboig *gannister*. Report on Clays No. 40.

FRENCH AND BELGIAN CLAYS.

Voiron *white sand*, France. Report on Clays No. 61.
Voiron *white clay*, France. Report on Clays No. 62.
Macon *clay*, (Terre Noire Co.) Report on Clays No. 75.
Macon *prepared*, (Terre Noire Co.) Report on Clays No. 76.
Voreppe *clay*, (Terre Noire Co.) Report on Clays No. 78.
Nannines *No.* 2 *clay*. Report on Clays No. 85.

CLASS VII.

NEW JERSEY CLAYS.

Dr. A. D. Newell's *clay*, New Brunswick, (22 feet down.)
Dr. A. D. Newell's *clay*, (bottom of boring.)
Wm. H. Berry's *sewer-pipe clay*.
Loughridge & Powers' *extra-sandy clay*.
Isaac Inslee's *retort clay*.
Crossman Clay Co. *No.* 2 *fire-clay*.
Sayre & Fisher's *front-brick clay*.
W. Allen's *clay*, South Amboy.
Dr. C. C. Abbott's *sagger clay*.
Joshua Eayre's *clay*, Florence.
J. D. Hylton's *clay*, Pensauken Creek.
James Conrad's *clay*, Tansborough.
White Oak Bottom *clay*.
Jona. G. Nugent's *clay*, Tuckerton.
Elmer Earl's *clay*, Cumberland County.
I. Mulford's *clay*, two miles south of Millville.

CLAYS FROM OTHER STATES.

Mapleton, Huntingdon County, Pennsylvania. Report on Clays No. 9.
Hawes' *dark fire-clay*, Johnstown, Pennsylvania. Report on Clays No. 13.
Winchester, Illinois. Report on Clays No. 18.
Wilmington, Wilmington County, Illinois. Report on Clays No. 20.

BRITISH CLAYS.

Stourbridge *No.* 1, Messrs. Harper & Moore. Report on Clays No. 27.
Stourbridge *No.* 2, Messrs. Harper & Moore. Report on Clays No. 28.
Stourbridge *No.* 1, (King Brothers & Stourbridge). Report on Clays No. 30.

FRENCH, BELGIAN AND GERMAN CLAYS.

Varielle *clay*. Report on Clays No. 79.
Coblentz *clay*. Report on Clays No. 90.
Sorée *No.* 3 *clay*. Report on Clays No. 88.

NOTES OF FIRE TESTS.

An examination of the notes of fire tests will enable the reader to understand the basis for this classification, and will show how the classes grade into one another. The behavior in the fire is given, and the refractoriness is indicated by sharp edges and corners and retaining shape; the rounding of edges and blistering show lower degrees of refractoriness; complete fusion expresses less resisting property. Whenever a result was indecisive, or there was a failure, the same is expressed by a blank following the fraction. The number of the plate, or trial, is indicated by the numerator of the fraction; the position of the specimen in the plate, by the denominator of said fraction. Roman numerals mark the series, thus, I. $\frac{7}{8}$ ——; represents the 8th receptacle or place in the 7th plate, or trial of the first series; and the blank shows that the result was not decisive.

RARITAN POTTERS CLAY BED.

Chas. M. Dally, south of Bonhamtown.

I.* $\frac{10}{13}$ blistered; $\frac{11}{11}$ ——; $\frac{12}{8}$ little blistered.
II. $\frac{2}{7}$† ——; $\frac{3}{7}$ ——; $\frac{15}{1}$ fused to bottom; $\frac{18}{1}$ fused.

W. N. Weidener, Martin's Dock.

II. $\frac{12}{8}$ sharp; $\frac{14}{8}$ sharp; $\frac{10}{12}$ sharp, $\frac{23}{2}$ sharp.
III. $\frac{2}{6}$ blistered slightly; $\frac{3}{6}$ blistered and rounded on edges; $\frac{11}{3}$ slightly blistered; $\frac{12}{3}$ sharp.

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* I. Deville furnace; II. Sefstrom furnace, plates 2 inches in diameter; III. Sefstrom furnace, plates $1\frac{1}{4}$-$1\frac{1}{2}$ in diameter.

† Plates 12, 14, and 1 to 7 inclusive, of II. and III. Series, and 24 and 28, not so hot as 8, 9, 10, 11 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, &c.

Island Farm clay.

I. $\frac{3}{8}$ sharp; $\frac{6}{8}$ ——; $\frac{15}{2}$ sharp; $\frac{10}{9}$ sharp.
II. $\frac{9}{7}$ sharp; $\frac{10}{11}$ sharp; $\frac{29}{8}$ sharp.
III. $\frac{5}{4}$ sharp; $\frac{6}{4}$ sharp; $\frac{7}{4}$ sharp; $\frac{8}{4}$ fused to side of cavity.

Dr. A. D. Newell, New Brunswick (22 feet down).

I. $\frac{18}{6}$ fused.

From same, bottom of boring.

I. $\frac{18}{18}$ fused.

Isaac Webster's Ten Mile Run.

D. 203 sharp; D. 204–5 slightly rounded, *blistered* on edges.
I. $\frac{18}{16}$ blistered slightly.
II. $\frac{1}{8}$ ——; $\frac{19}{12}$ sharp, $\frac{21}{1}$ fused (?); $\frac{12}{1}$ sharp; $\frac{22}{11}$ sharp; $\frac{28}{16}$ sharp.
III. $\frac{9}{8}$ little blistered; $\frac{10}{3}$ fused.

RARITAN FIRE-CLAY BED.

Wm. B. Dixon, Woodbridge.

Crucible (D) fused on edges; D. 203 blistered; D. 204–5 fused on edges.
I. $\frac{16}{1}$ badly checked, blistered.
II. $\frac{2}{1}$ ——; $\frac{3}{1}$ ——; $\frac{11}{2}$ out of shape; $\frac{12}{2}$ fused; $\frac{22}{1}$ blistered, but sharp on edges.

B. Ellison (6 feet deep, pit 100 yards north of sand field).

I. $\frac{10}{14}$ fused at bottom and blistered; $\frac{11}{12}$ ——; $\frac{12}{9}$ fused on edges at bottom; $\frac{10}{8}$ badly blistered.

WOODBRIDGE FIRE-CLAY BED.

W. H. Berry's retort clay.

Crucible (D) fused on edges.
II. $\frac{15}{2}$ gone; $\frac{17}{2}$ gone; $\frac{18}{2}$ fused on side; $\frac{20}{9}$ fused at bottom; $\frac{21}{9}$ badly blistered.

W. H. Berry's sewer-pipe clay.

D. 203 fused.
I. $\frac{1}{15}$ fused; $\frac{2}{15}$ fused; $\frac{14}{7}$ fused.

David Flood's spotted clay.

I. $\frac{10}{13}$ blistered a little; $\frac{11}{13}$ ——; $\frac{12}{10}$ sharp; $\frac{10}{2}$ sharp.
II. $\frac{1}{3}$ ——; $\frac{2}{3}$ ——; $\frac{3}{3}$ ——; $\frac{13}{12}$ sharp, blistered; $\frac{20}{2}$ fused at bottom.

Loughridge & Power's extra sandy clay.

Crucible (D) fused.
I. $\frac{3}{4}$ fused; $\frac{6}{4}$ ——; $\frac{13}{6}$ ——; $\frac{15}{8}$ fused.

A. Hall & Son, No. 1 fire-clay.

I. $\frac{1}{11}$ sharp; $\frac{2}{11}$ sharp; $\frac{17}{9}$ ——.
II. $\frac{7}{4}$ sharp; $\frac{10}{8}$ sharp; $\frac{23}{8}$ failure; $\frac{24}{6}$ sharp; $\frac{27}{1}$ sharp.
III. $\frac{2}{1}$ sharp; $\frac{3}{1}$ sharp.

Isaac Inslee's retort clay.

I. $\frac{1}{9}$ fused; $\frac{2}{9}$ fused; $\frac{13}{2}$ sharp; $\frac{14}{5}$ fused;

H. Cutter's fire-clay.

I. $\frac{1}{10}$ sharp; $\frac{2}{10}$ sharp; $\frac{17}{8}$ ——.
II. $\frac{2}{2}$ ——; $\frac{8}{2}$ ——; $\frac{15}{3}$ failure; $\frac{18}{10}$ failure; $\frac{12}{2}$ failure; $\frac{22}{7}$ failure, $\frac{24}{7}$ sharp; $\frac{28}{1}$ sharp.
III. $\frac{1}{1}$ *fused;* $\frac{4}{1}$ sharp; $\frac{11}{1}$ blistered very little; $\frac{12}{1}$ sharp.

H. Cutter's ware-clay.

II. $\frac{5}{1}$ sharp; $\frac{8}{2}$ sharp; $\frac{15}{8}$ sharp; $\frac{19}{9}$ sharp.
III. $\frac{2}{4}$ fused on edges; $\frac{3}{4}$ fused on edges.

H. Cutter's black clay.

II. $\frac{20}{4}$ fused; $\frac{22}{8}$ failure; $\frac{24}{9}$ sharp, blistered; $\frac{26}{12}$ fused to oblong mass; $\frac{27}{8}$ sharp.
III. $\frac{1}{3}$ fused; $\frac{4}{3}$ fused; $\frac{9}{4}$ fused on edges; $\frac{10}{4}$ rounded on edges.

Crossman Clay and Manufacturing Company, No. 1 fire-clay.

Crucible (D) sharp.
I. $\frac{1}{12}$ sharp; $\frac{2}{12}$ sharp; $\frac{13}{8}$ sharp; $\frac{14}{8}$ sharp; $\frac{17}{10}$ ——.
II. $\frac{9}{3}$ sharp; $\frac{10}{9}$ sharp; $\frac{27}{2}$ sharp.
III. $\frac{5}{1}$ sharp (?); $\frac{6}{1}$ sharp, $\frac{7}{1}$ blistered, little attacked; $\frac{8}{1}$ slightly blistered.

Chas. A. Campbell & Co., white fire-clay.

I. $\frac{10}{12}$ sharp; $\frac{11}{10}$ sharp; $\frac{12}{7}$ sharp.
II. $\frac{4}{5}$ sharp; $\frac{16}{1}$ sharp; $\frac{17}{1}$ gone; $\frac{19}{11}$ sharp.
III. $\frac{3}{5}$ blistered, but sharp; $\frac{8}{5}$ fused to side of cavity; $\frac{11}{2}$ very little blistered; $\frac{12}{2}$ sharp.

Crossman Clay and Manufacturing Company, No. 2 fire-clay.

Crucible (D) fused.

Forbes feldspar, No. 1.

Crucible (D) glazed; D. 203 sharp; D. 204–5 rounded on bottom.

I. $\frac{18}{14}$ quartz fused; $\frac{10}{3}$ quartz grains fused.

Edgar Bros., No. 1 feldspar.

I. $\frac{1}{13}$ sharp; $\frac{2}{13}$ sharp; $\frac{13}{4}$ glazed; 15 (inner circle) quartz fused; $\frac{10}{4}$ quartz grains fused; $\frac{17}{11}$ quartz grains fused.

II. $\frac{11}{12}$ ——; $\frac{12}{12}$ fused.

SOUTH AMBOY FIRE-CLAY BED.

Sayre & Fisher, fire-clay.

I. $\frac{3}{1}$ sharp; $\frac{6}{1}$ ——; $\frac{14}{8}$ sharp; $\frac{17}{12}$ ——.

II. $\frac{9}{6}$ sharp; $\frac{10}{16}$ sharp; $\frac{27}{3}$ sharp.

III. $\frac{5}{2}$ slightly rounded on edges; $\frac{6}{2}$ ——; $\frac{8}{2}$ slightly rounded on edges.

Whitehead Brothers, red clay.

I. $\frac{16}{1}$ blistered and swollen.

II. $\frac{20}{1}$ fused; $\frac{21}{7}$ fused on bottom; $\frac{27}{12}$ fused.

Brick estate, No. 1 fire-clay.

II. $\frac{13}{6}$ sharp; $\frac{14}{6}$ sharp; $\frac{28}{12}$ sharp.

III. $\frac{9}{1}$ rounded on edges; $\frac{10}{1}$ fused to cylindrical mass.

Brick estate, No. 2 fire-clay.

II. $\frac{20}{6}$ ——; $\frac{21}{12}$ fused (?); $\frac{23}{6}$ sharp, but blistered; $\frac{25}{16}$ sharp, but out of shape.

George Such, washed clay.

I. $\frac{3}{3}$ sharp; $\frac{6}{3}$ ——; $\frac{17}{14}$ ——.

II. $\frac{4}{7}$ sharp; $\frac{16}{2}$ fused on bottom; $\frac{17}{3}$ ——; $\frac{18}{3}$ fused on bottom; $\frac{19}{1}$ fused on bottom.

George Such, clay washed (1879).

D. 203 sharp.

I. $\frac{10}{6}$ sharp; $\frac{11}{4}$ ——; $\frac{12}{1}$ sharp.

III. $\frac{7}{5}$ sharp; $\frac{9}{5}$ sharp; $\frac{11}{5}$ fused on bottom; $\frac{12}{5}$ little blistered.

Whitehead Brothers, blue fire-clay.

II. $\frac{20}{7}$ sharp; $\frac{23}{11}$ failure; $\frac{24}{5}$ sharp.

III. $\frac{2}{2}$ badly blistered; $\frac{3}{2}$ blistered slightly.

E. F. & J. M. Roberts, fire-clay.

D. 203 sharp; D. 204–5 sharp.
I. $\frac{8}{5}$ sharp; $\frac{9}{5}$ ——; $\frac{13}{1}$ sharp.
II. $\frac{16}{3}$ fused to side of cavity; $\frac{17}{7}$ gone; $\frac{18}{7}$ shape lost; $\frac{20}{8}$ fused to side.
III. $\frac{8}{3}$ fused and gone; $\frac{9}{3}$ fused on edges; $\frac{12}{8}$ sharp edges.

E. F. & J. M. Roberts, extra, or selected clay.

D. 203 sharp; D. 204–5 sharp.
II. $\frac{2}{4}$ sharp; $\frac{16}{4}$ gone; $\frac{17}{11}$ gone; $\frac{18}{11}$ gone; $\frac{19}{7}$ sharp; $\frac{22}{9}$ failure; $\frac{24}{10}$ *sharp*.
III. $\frac{8}{3}$ fused; $\frac{9}{3}$ fused on edges; $\frac{15}{8}$ sharp.

FIRE-SANDS.

M. Compton's fire-sand.

I. $\frac{8}{2}$ solidified; $\frac{9}{2}$ ——; $\frac{13}{5}$ agglomerated; $\frac{17}{13}$ ——.

Fire-sand from A. Hall & Son.

MISCELLANEOUS CLAYS FROM NEW JERSEY.

Sayre & Fisher, front-brick clay.

I. $\frac{1}{14}$ fused; $\frac{2}{14}$ fused.

Wm. Allen's clay, South Amboy.

I. $\frac{8}{7}$ fused; $\frac{9}{7}$ ——; $\frac{11}{7}$ ——; $\frac{14}{9}$ glazed.

Dr. Abbott's clay, Trenton.

D. 203 fused.

Joshua Eayre clay, Florence.

I. $\frac{8}{14}$ fused; $\frac{9}{14}$ fused to globular mass; $\frac{11}{2}$ ——.

Hylton's clay, Pensauken creek.

D. 203 fused; D. 204–5 fused.

A. Reeve's clay, Fish House.

D. 203 fused on edges.
I. $\frac{10}{7}$ blistered and rounded on bottom; $\frac{11}{5}$ ——; $\frac{12}{2}$ blistered and fused on edges.

Conrad's clay, Gloucester county.

I. $\frac{11}{14}$ fused; $\frac{12}{11}$ fused, shape nearly gone; $\frac{14}{13}$ fused.

White Oak Bottom clay.

I. $\frac{11}{15}$ badly blistered, fused; $\frac{12}{15}$ fused, out of shape; $\frac{13}{8}$ fused.

Jona. G. Nugent's clay, Tuckerton.

I. $\frac{12}{13}$ fused; $\frac{18}{15}$ fused on edges.

Elmer Earl's clay, Cumberland county.

I. $\frac{12}{14}$ fused; $\frac{14}{14}$ fused.

Isaac Mulford's clay, two miles south of Millville.

I. $\frac{12}{15}$ fused.

MISCELLANEOUS CLAYS FROM DELAWARE AND MARYLAND.

Trucks & Parker, washed kaolin clay.

I. $\frac{5}{7}$ sharp; $\frac{8}{7}$ sharp; $\frac{14}{15}$ sharp.
II. $\frac{4}{3}$ ——; $\frac{22}{2}$ sharp, but blistered; $\frac{23}{3}$ fused on edges; $\frac{26}{4}$ sharp, but blistered; $\frac{27}{10}$ little blistered.

Mount Savage fire-clay.

I. $\frac{3}{15}$ sharp; $\frac{6}{15}$ ——.
II. $\frac{2}{6}$ ——; $\frac{8}{6}$ ——; $\frac{11}{3}$ fused at bottom, very rough; $\frac{12}{3}$ sharp; $\frac{21}{5}$ fused at bottom; $\frac{22}{7}$ sharp, not much attacked.

MISCELLANEOUS CLAYS FROM PENNSYLVANIA.

Sandy Ridge, Centre county clay. Report on Clays, No. 7.

I. $\frac{10}{11}$ sharp; $\frac{11}{9}$ sharp; $\frac{12}{6}$ sharp.
II. $\frac{4}{5}$ out of shape; $\frac{15}{4}$ fused (?); $\frac{17}{4}$ very rough: $\frac{24}{11}$ fused at bottom; $\frac{26}{9}$ fused.

Woodland fire-clay, Clearfield county. Report on Clays, No. 8.

I. $\frac{10}{10}$ sharp; $\frac{11}{8}$ sharp; $\frac{12}{5}$ sharp; $\frac{16}{5}$ sharp.
II. $\frac{1}{5}$ ——; $\frac{2}{5}$ ——; $\frac{3}{5}$ ——; $\frac{13}{10}$ very rough; $\frac{14}{10}$ fused (?) but rough; $\frac{23}{10}$ failure; $\frac{24}{3}$ little blistered.

Mapleton, Huntingdon county. Report on Clays, No. 9.

I. $\frac{4}{9}$ fused; $\frac{7}{9}$ fused; $\frac{10}{3}$ fused on edges; $\frac{15}{9}$ fused.

Hawes' flint clay, Johnstown. Report on Clays, No. 12.

I. $\frac{5}{12}$ sharp (?); $\frac{8}{12}$ sharp.
II. $\frac{7}{6}$ sharp; $\frac{8}{6}$ sharp; $\frac{20}{10}$ sharp, little blistered; $\frac{25}{7}$ fused at top; $\frac{29}{12}$ badly blistered.
III. $\frac{6}{3}$ sharp, but blistered; $\frac{8}{3}$ ——; $\frac{7}{3}$ badly blistered and fused on edges: $\frac{8}{3}$ fused fast to cavity.

Hawes' dark fire-clay, Johnstown. Report on Clays, No. 13.

I. $\frac{10}{8}$ fused; $\frac{11}{6}$ fused and partly rounded; $\frac{12}{8}$ fused.

Mineral Point clay, near Johnstown. Report on Clays, No. 14.

I. $\frac{10}{9}$ sharp; $\frac{11}{7}$ sharp; $\frac{12}{4}$ sharp.
II. $\frac{15}{8}$ fused; $\frac{17}{5}$ ——; $\frac{18}{5}$ fused at bottom; $\frac{19}{8}$ sharp, but rough; $\frac{22}{8}$ sharp, blistered a little.

MISCELLANEOUS CLAYS FROM INDIANA AND ILLINOIS.

Porcelain clay, Lawrence county, Ind. Report on Clays, No. 16.

I. $\frac{8}{8}$ sharp; $\frac{6}{9}$ ——; $\frac{17}{15}$ ——.
II. $\frac{16}{6}$ gone; $\frac{17}{8}$ gone; $\frac{18}{8}$ fused, almost shapeless; $\frac{19}{8}$ fused; $\frac{24}{4}$ sharp.

Pope county, Ill. Report on Clays, No. 17.

I. $\frac{4}{6}$ sharp; $\frac{7}{6}$ sharp; $\frac{15}{6}$ ($\frac{4}{6}$ re-heated) sharp.
II. $\frac{5}{9}$ sharp; $\frac{15}{9}$ gone; $\frac{17}{9}$ gone; $\frac{18}{9}$ rounded on edges; $\frac{20}{11}$ sharp.
III. $\frac{6}{5}$ badly blistered on edges and fused; $\frac{6}{5}$ ——; $\frac{8}{5}$ fused to cylindrical mass.

Winchester, Ill. Report on Clays, No. 18.

I. $\frac{3}{10}$ fused; $\frac{6}{10}$ ——; $\frac{10}{2}$ fused.

Utica clay, La Salle county, Ill. Report on Clays, No. 19.

I. $\frac{4}{5}$ blistered; $\frac{7}{5}$ blistered; $\frac{10}{5}$ slightly blistered; $\frac{16}{5}$ ($\frac{4}{5}$ reheated) blistered; $\frac{10}{8}$ blistered.
II. $\frac{5}{5}$ sharp; $\frac{7}{2}$ ——; $\frac{18}{11}$ fused; $\frac{18}{10}$ fused.

Wilmington, Will county, Ill. Report on Clays, No. 20.

I. $\frac{4}{2}$ fused; $\frac{7}{2}$ fused.

Anna clay, Union county, Ill. Report on Clays, No. 21.

I. $\frac{8}{12}$ sharp; $\frac{6}{12}$ ——; $\frac{14}{11}$ sharp.
II. $\frac{4}{11}$ gone; $\frac{5}{3}$ sharp; $\frac{16}{6}$ gone; $\frac{18}{4}$ gone; $\frac{19}{4}$ gone; $\frac{20}{12}$ sharp; $\frac{20}{9}$ sharp; $\frac{21}{8}$ fused.
III. $\frac{4}{3}$ fused; $\frac{4}{2}$ fused on edges.

MISCELLANEOUS CLAYS FROM MISSOURI.

Cheltenham (crude) clay. Report on Clays, No. 22.

I. $\frac{8}{11}$ sharp; $\frac{6}{11}$ ——; $\frac{14}{10}$ sharp.
II. $\frac{8}{8}$ very rough; $\frac{10}{1}$ about fusing; $\frac{21}{4}$ fused.

Cheltenham (calcined) clay. Report on Clays, No. 23.

I. $\frac{4}{4}$ blistered; $\frac{7}{4}$ blistered; $\frac{15}{4}$ ($\frac{4}{4}$ reheated) out of shape; $\frac{16}{7}$ agglomerated.

II. $\frac{4}{1}$ fused; $\frac{21}{1}$ fused (?); $\frac{24}{1}$ fused.

Cheltenham (washed) clay. Report on Clays, No. 24.

I. $\frac{4}{3}$ sharp; $\frac{7}{3}$ sharp; $\frac{15}{3}$ sharp.

III. $\frac{4}{12}$ gone; $\frac{8}{1}$ fused; $\frac{11}{7}$ fused; $\frac{12}{7}$ gone.

Evens' Mines, (crude). Report on Clays, No. 25.

I. $\frac{3}{13}$ sharp; $\frac{6}{13}$ ——.

II. $\frac{21}{2}$ sharp; $\frac{23}{1}$ fused; $\frac{25}{3}$ sharp; $\frac{27}{4}$ sharp.

III. $\frac{5}{3}$ badly blistered and rounded; $\frac{6}{3}$ blistered somewhat; $\frac{7}{3}$ blistered somewhat; $\frac{8}{3}$ blistered slightly.

Evens' Mines, (calcined). Report on Clays, No. 26.

I. $\frac{14}{12}$ sharp.

II. $\frac{8}{3}$ fused on one edge; $\frac{9}{10}$ sharp, but blistered; $\frac{10}{3}$ sharp, but blistered.

III. $\frac{7}{2}$ badly blistered; $\frac{11}{4}$ fused on edges; $\frac{12}{4}$ sharp.

MISCELLANEOUS BRITISH CLAYS.

Stourbridge, No. 1, Harper & Moore. Report on Clays, No. 27.

D. 203 fused; D. 204–5 fused.

I. $\frac{13}{9}$ ——.

Stourbridge, No. 2, Harper & Moore. Report on Clays, No. 28.

D. 203 fused; D. 204–5 fused on edges.

I. $\frac{13}{16}$ ——.

Stourbridge, No. 3, Harper & Moore. Report on Clays, No. 29.

D. 204–5 fused.

I. $\frac{8}{6}$ blistered.

Stourbridge, No. 1, strong. Report on Clays, No. 30.

D. 204–5 fused.

I. $\frac{8}{3}$ slightly blistered.

Stourbridge, No. 2, mild. Report on Clays, 31.

D. 204–5 fused on edges.

I. $\frac{9}{7}$ blistered.

West Durham clay. Report on Clays, No. 32.

I. $\frac{9}{14}$ badly blistered.

II. $\frac{7}{12}$ fused; $\frac{8}{12}$ fused.

South Benwell Colliery, Newcastle-on-Tyne. Report on Clays, No. 33.

D. 204–5 sharp. I. $\frac{9}{3}$ sharp.

II. $\frac{11}{6}$ fused; $\frac{12}{5}$ fused.

Kingwinsford, North Dudley. Report on Clays, No. 34.

I. $\frac{9}{11}$ blistered and out of shape; $\frac{13}{12}$ (——).

II. $\frac{7}{9}$ fused; $\frac{8}{9}$ fused.

South Brancepath, Durham. Report on Clays, No. 35.

I. $\frac{9}{13}$ blistered and out of shape.

II. $\frac{7}{11}$ sharp; $\frac{8}{11}$ fused; $\frac{9}{9}$ fused; $\frac{10}{4}$ fused.

Wortley, near Leeds, Ingham. Report on Clays, No. 36.

I. $\frac{9}{9}$ blistered; $\frac{13}{13}$ ——, $\frac{15}{1}$ blistered.

II. $\frac{7}{10}$ sharp, little blistered; $\frac{8}{10}$ fused; $\frac{22}{4}$ fused.

Wortley, Cliff. Report on Clays, No. 37.

II. $\frac{7}{7}$ fused; $\frac{8}{7}$ fused.

Throckley, Newcastle. Report on Clays, No. 38.

I. $\frac{9}{10}$ fused on edges; $\frac{13}{11}$ ——; $\frac{16}{12}$ fused.

II. $\frac{7}{8}$ fused; $\frac{8}{8}$ fused.

Glenboig Star, fire-clay. Report on Clays, No. 39.

D. 204–5 rounded on bottom.

I. $\frac{9}{8}$ sharp.

II. $\frac{11}{4}$ fused; $\frac{12}{4}$ fused; $\frac{23}{4}$ fused at bottom; $\frac{25}{1}$ fused.

Glenboig Star, gannister. Report on Clays, No. 40.

D. 204–5 fused.

I. $\frac{9}{1}$ agglomerated.

Stourbridge, strong, Mobberley & Bayley. Report on Clays, No. 41.

D. 204–5 fused.

I. $\frac{9}{4}$ blistered and swollen.

Stourbridge, mild. Report on Clays, No. 42.

D. 204–5 fused.

I. $\frac{9}{8}$ blistered and swollen.

Sharrot, Halifax, crucible fire-clay. Report on Clays, No. 45.

I. $\frac{1}{1}$ sharp; $\frac{2}{1}$ sharp; $\frac{14}{1}$ sharp; $\frac{17}{1}$ sharp.

II. $\frac{2}{8}$ ——; $\frac{3}{8}$ ——; $\frac{15}{11}$ fused, shape nearly gone; $\frac{18}{16}$ fused, shape nearly gone; $\frac{21}{8}$ fused.

Thos. Wragg, crucible fire-clay, Sheffield. Report on Clays, No. 48.

I. $\frac{1}{3}$ slightly swollen; $\frac{2}{3}$ incipient fusion; $\frac{11}{3}$ ——; $\frac{14}{4}$ sharp; $\frac{17}{3}$ ——.
II. $\frac{2}{10}$ badly blistered; $\frac{3}{10}$ ——; $\frac{15}{12}$ fused, but sharp; fused.

Burton-on-Trent, Derbyshire, (25 yards deep). Report on Clays, No. 49.

I. $\frac{1}{4}$ slightly swollen; $\frac{2}{4}$ slightly swollen; $\frac{14}{2}$ sharp; $\frac{17}{4}$ ——.
II. $\frac{2}{11}$ fused; $\frac{3}{11}$ very rough; $\frac{21}{9}$ fused.

Burton-on-Trent, Derbyshire, (50 yards deep). Report on Clays, No. 50.

I. $\frac{1}{5}$ slightly swollen; $\frac{2}{5}$ slightly swollen; $\frac{14}{3}$ sharp; $\frac{17}{5}$ ——.
II. $\frac{4}{8}$ ——; $\frac{7}{1}$ ——; $\frac{8}{4}$ fused, but rough; $\frac{9}{11}$ fused at bottom; $\frac{10}{2}$ fused on side; $\frac{21}{10}$ fused so as to be almost shapeless.

Farnley, Leeds, crucible fire-clay. Report on Clays, No. 51.

I. $\frac{1}{8}$ sharp; $\frac{2}{8}$ sharp; $\frac{16}{11}$ fused.
II. $\frac{9}{3}$ ——; $\frac{10}{7}$ fused; $\frac{22}{6}$ gone; $\frac{25}{9}$ fused.

Horwichtown, Lancashire, crucible fire-clay. Report on Clays, No. 52.

I. $\frac{1}{2}$ sharp; $\frac{2}{2}$ sharp; $\frac{17}{2}$ blistered, edges sharp.
II. $\frac{2}{6}$ ——; $\frac{11}{8}$ gone; $\frac{13}{8}$ fused; $\frac{24}{12}$ fused.

Garnkirk, No. 1, fire-clay. Report on Clays, No. 53.

D. 203 sharp; D. 204–5 sharp, little blistered.
II. $\frac{11}{10}$ gone; $\frac{12}{10}$ sharp, but blistered; $\frac{19}{5}$ fused; $\frac{24}{8}$ sharp, little blistered; $\frac{26}{6}$ blistered at top; $\frac{28}{5}$ little blistered.

Garnkirk, No. 2. Report on Clays, No. 54.

D. 203 sharp; D. 104–5 sharp, little blistered.
II. $\frac{11}{11}$ gone; $\frac{12}{11}$ rough and blistered; $\frac{16}{11}$ fused on one side; $\frac{19}{6}$ rounded on bottom; $\frac{22}{5}$ sharp; $\frac{28}{11}$ sharp.
III. $\frac{9}{6}$ fused fast (out of shape); $\frac{10}{6}$ fused.

Redruth, Cornwall, "china clay." Report on Clays, No. 55.

I. $\frac{1}{7}$ sharp; $\frac{2}{7}$ sharp; $\frac{6}{13}$ sharp; $\frac{17}{7}$ quartz fused.
II. $\frac{9}{2}$ fused at bottom; $\frac{10}{6}$ blistered at bottom; $\frac{21}{11}$ fused; $\frac{29}{8}$ (loose powder).
III. $\frac{1}{4}$ fused; $\frac{2}{4}$ fused.

Blaydon Burn, near Newcastle-on-Tyne. Report on Clays, No. 56.

I. $\frac{1}{6}$ slightly swollen; $\frac{2}{6}$ little swollen; $\frac{17}{6}$ ——.
II. $\frac{4}{6}$ gone; $\frac{9}{11}$ fused at bottom; $\frac{10}{5}$ fused to side of cavity.

FRENCH CLAYS.

St. Egreve. Report on Clays, No. 59.

I. $\frac{4}{10}$ sharp; $\frac{5}{10}$ sharp (?); $\frac{7}{10}$ sharp (?); $\frac{8}{10}$ sharp; $\frac{16}{10}$ ($\frac{4}{10}$ re-heated) fused.

II. $\frac{5}{7}$ fused.

St. Egreve fire-sand. Report on Clays, No. 60.

Voiron white sand. Report on Clays, No. 61.

I. $\frac{5}{5}$ fused on edges; $\frac{8}{5}$ glazed; $\frac{16}{14}$ fused.

II. $\frac{8}{9}$ fused.

Voiron clay. Report on Clays, No. 62.

I. $\frac{5}{7}$ blistered and edges rounded; $\frac{8}{7}$ glazed.

II. $\frac{6}{11}$ fused.

Macon clay. Report on Clays, No. 63.

I. $\frac{5}{9}$ sharp (?); $\frac{8}{9}$ sharp.

II. $\frac{12}{6}$ fused; $\frac{26}{2}$ ——; $\frac{27}{5}$ fused.

Macon clay, (lean). Report on Clays, No. 64.

I. $\frac{4}{15}$ sharp; $\frac{7}{15}$ sharp; $\frac{15}{15}$ ($\frac{4}{15}$ reheated) result as before.

II. $\frac{8}{6}$ ——; $\frac{16}{9}$ fused; $\frac{20}{11}$ fused; $\frac{29}{8}$ fused.

Bollene clay. Report on Clays, No. 65.

I. $\frac{5}{11}$ sharp (?); $\frac{8}{11}$ sharp.

II. $\frac{7}{5}$ little blistered; $\frac{8}{5}$ blistered, but sharp edges; $\frac{26}{3}$ fused.

Courpiere No. 1. Report on Clays, No. 66.

I. $\frac{5}{2}$ sharp; $\frac{8}{2}$ sharp.

II. $\frac{11}{6}$ gone; $\frac{14}{12}$ fused; $\frac{16}{7}$ fused (?), (gone); $\frac{18}{6}$ fused (?), (gone); $\frac{20}{8}$ fused (?), (gone); $\frac{23}{10}$ fused, (failure); $\frac{24}{7}$ sharp, blistered; $\frac{20}{11}$ fused on bottom.

Courpiere No. 2. Report on Clays, No. 67.

I. $\frac{5}{3}$ sharp; $\frac{8}{3}$ sharp.

II. $\frac{11}{9}$ gone; $\frac{12}{9}$ fused; $\frac{19}{12}$ fused.

Mussidan clay. Report on Clays, No. 68.

I. $\frac{5}{5}$ sharp; $\frac{8}{8}$ sharp.

II. $\frac{6}{12}$ partly fused; $\frac{7}{3}$ sharp; $\frac{22}{12}$ sharp; $\frac{20}{4}$ fused at bottom.

Bollene clay, Schneider et Cie. Report on Clays, No. 69.

I. $\frac{4}{13}$ sharp; $\frac{7}{13}$ sharp; $\frac{15}{13}$ ($\frac{4}{13}$ re-heated) and same result.
II. $\frac{14}{11}$ fused; $\frac{16}{8}$ fused; $\frac{25}{8}$ fused; $\frac{26}{8}$ rounded on bottom.

Decize clay. Report on Clays, No. 70.

I. $\frac{4}{12}$ slightly blistered; $\frac{7}{12}$ slightly blistered; $\frac{15}{12}$ ($\frac{4}{12}$ re-heated) same result as before.
II. $\frac{5}{8}$ blistered; $\frac{15}{8}$ fused; $\frac{17}{8}$ fused.

Lezanne clay. Report on Clays, No. 71.

I. $\frac{5}{6}$ sharp; $\frac{8}{6}$ sharp.
II. $\frac{6}{10}$ ——; $\frac{7}{4}$ ——; $\frac{15}{7}$ sharp; $\frac{18}{12}$ gone; $\frac{23}{5}$ sharp.
III. $\frac{5}{2}$ sharp; $\frac{10}{2}$ fused on edges.

Gravoine clay. Report on Clays, No. 73.

I. $\frac{5}{4}$ sharp; $\frac{8}{4}$ sharp.
II. $\frac{6}{8}$ ——; $\frac{15}{10}$ fused; $\frac{17}{10}$ fused.

Macon clay, (Terre Noire). Report on Clays, No. 75.

I. $\frac{4}{7}$ blistered, edges rounded; $\frac{7}{7}$ blistered and rounded edges; $\frac{15}{7}$ ($\frac{4}{7}$ reheated) result as before; $\frac{16}{8}$ rounded on edges.
II. $\frac{25}{8}$ fused; $\frac{26}{10}$ fused.

Macon clay, prepared, (Terre Noire). Report on Clays, No. 76.

I. $\frac{4}{14}$ slightly blistered; $\frac{7}{14}$ slightly blistered; $\frac{15}{14}$ ($\frac{4}{14}$ reheated) fused on edges.
II. $\frac{5}{6}$ blistered and rounded on bottom; $\frac{6}{5}$ blistered; $\frac{23}{9}$ gone; $\frac{21}{4}$ fused.

Voreppe clay. Report on Clays, No. 78.

I. $\frac{4}{11}$ fused on edges and bottom; $\frac{7}{11}$ fused on edges; $\frac{14}{11}$ ($\frac{4}{11}$ reheated) result as before.

Varielle clay. Report on Clays, No. 79.

I. $\frac{4}{8}$ fused; $\frac{7}{8}$ fused.
II. $\frac{4}{2}$ fused.

Bollene clay, (Terre Noire). Report on Clays, No. 77.

II. $\frac{27}{7}$ in angular fragments; $\frac{28}{3}$ blistered.
III. $\frac{1}{6}$ ——; $\frac{4}{6}$ blistered and rounded; $\frac{12}{7}$ badly blistered.

BELGIAN CLAYS.

Strud pale. Report on Clay, No. 83.

I. $\frac{18}{2}$ sharp.
II. $\frac{13}{2}$ fused; $\frac{14}{2}$ fused.

Strud slate. Report on Clays, No. 84.

II. $\frac{13}{5}$ fused (?); $\frac{14}{5}$ blistered; $\frac{23}{12}$ ——; $\frac{25}{5}$ angular fragments; $\frac{26}{9}$ little rounded.

Nanninnes, No. 2. Report on Clays, No. 85.

I. $\frac{16}{4}$ fused on edges; $\frac{18}{11}$ fused fast.
II. $\frac{13}{5}$ fused; $\frac{14}{5}$ fused.

Nanninnes, No. 1. Report on Clays, No. 86.

I. $\frac{18}{3}$ blistered and checked; $\frac{18}{10}$ blistered and checked.
II. $\frac{13}{4}$ fused; $\frac{14}{4}$ fused; $\frac{23}{7}$ fused.

Sorée fire-clay. Report on Clays, No. 87.

II. $\frac{13}{6}$ sharp; $\frac{14}{6}$ sharp; $\frac{25}{1}$ ——; $\frac{26}{12}$ fused; $\frac{27}{9}$ sharp; $\frac{28}{2}$ sharp, little blistered.
III. $\frac{1}{5}$ fused; $\frac{4}{5}$ fused.

Sorée, No. 3. Report on Clays, No. 88.

I. $\frac{18}{5}$ fused; $\frac{18}{12}$ fused.
II. $\frac{13}{7}$ fused; $\frac{14}{7}$ fused.

GERMAN CLAYS.

Frankenthal. Report on Clays, No. 89.

II. $\frac{13}{1}$ fused; $\frac{14}{1}$ sharp; $\frac{26}{1}$ fused (?); $\frac{28}{10}$ badly blistered.

Coblentz, (A. K. Hay). Report on Clays, No. 90.

I. $\frac{3}{5}$ fused; $\frac{8}{8}$ ——; $\frac{10}{1}$ fused on edges; $\frac{13}{7}$ fused.

Coblentz clay.

II. $\frac{20}{8}$ gone; $\frac{25}{2}$ fused; $\frac{26}{7}$ fused.

MISCELLANEOUS.

Geo. Such's buff-clay.

II. $\frac{20}{11}$ fused to irregular mass; $\frac{26}{5}$ sharp, but blistered; $\frac{27}{8}$ sharp, but blistered.
III. $\frac{10}{5}$ fused; $\frac{11}{6}$ badly blistered and rounded; $\frac{12}{6}$ ——.

Kaolin, Merritt's pits, Perth Amboy.

I. $\frac{18}{13}$ glazed, but sharp on edges.

Kaolin, Ellis' pits, Staten Island.

I. $\frac{18}{7}$ and $\frac{18}{14}$ glazed, but sharp.

VIII.

SOILS.

A few soils have been analysed this year, and we present herewith a tabular statement showing the composition of the different classes of soils in the State. There is much difference of opinion in regard to the value of soil analyses, some thinking that an analysis will enable the farmer to know just what fertilizers to apply in order to make their soils produce good crops; others look upon it as altogether useless. It has not done as much for agriculture as in the earlier days of chemical science was expected. But there are some advantages to be derived from soil analyses which should not be overlooked, and while not claiming for it all that its early advocates did, we still think it profitable to have the composition of soils understood, as it must always form the basis for any sound calculations for improvement.

The agriculture of the State is improving rapidly. More fertilizers are applied, larger crops are grown. More products requiring quick and convenient marketing are cultivated, the markets are watched, and everything is done to draw the largest and most profitable returns from the soil. At the basis of all this improvement the soil must lie, and the variety which is shown in the table of analyses below will help us to understand the great variety in the farm practice of the State.

The following table shows the different classes of soils of the State. The composition of these soils is put down as near to accuracy as the number of samples yet analysed allow. By having a greater number of samples selected and analysed, there may be some slight changes needed in the figures, but they will not vary materially from these here given.

The classification is based on the character of the rocks underlying the soil, and from which those soils have evidently been made.

Granitic Soils are found in the northern part of the State, overlying rocks of granite, gneiss, hornblende and others of the azoic series.

Limestone Soils are found only in the northwestern part of the State, and overlie the magnesian limestones.

Slate Soils occur wherever there are slaty rocks of the Hudson river series. They are only found in the northern part of the State; ordinarily they are near to the limestones.

Red Sandstone Soils cover the belt of country which extends across the middle of the State from the Hudson to the Delaware.

Trap Soils are those which are formed from the disintegration of the trap-rocks. They are found on those ridges which are so characteristic of the red sandstone formation.

Clay and Sand Soils are those which are in a belt crossing the State from Amboy to Bordentown, and which lie just south of the last-named belt.

Marl Soils are those in the region where marl is dug. They occupy a wide belt of country stretching across the State from northeast to southwest.

Oak Land and Pine Lands are two kinds which make up most of the surface of south and southeast New Jersey. They are found in limited districts near each other, and are recognized by the trees which grow on them.

Alluvial Soils are those low-lying rich uplands which border the ocean and Delaware bay.

These soils each have their peculiarities and adaptations. In looking at their constituents it will be noticed that those from 1 to 5 have more than six per cent. of alumina, while those from 6 to 10 have less than three per cent. of that substance. One per cent. of alumina represents two and a half per cent. of clay, so that the soils of the first half must contain at least fifteen per cent. of clay, while those of the last half contain at most six and a half per cent. of clay, and some are down to one per cent. The first would be called clayey soils, while the last are sandy. The difference in them is apparent in growth of vegetation. The first are naturally adapted to the growth of the narrow-leaved grasses, and to produce meadow and pasture lands, while the latter are not. They are as decidedly, though not as conspicuously, marked in some other vegetable products. The presence of oxide of iron is also characteristic of good soils, and it is observed everywhere that any poor soil which is high colored with oxide of iron is susceptible of profitable enrichment and cultivation. The three substances, potash, lime and phosphoric acid, which are the exhaustible and valuable constituents of soils, are in such quantity in 1, 2, 3, 7, that moderate crops can be grown on them without manure, by practicing a judicious rotation, though they are much benefited by the application of fertilizers. Some of the others were very productive at first, but were soon exhausted, and some of the others have so little of these elements that they have never produced a good crop until they have been enriched by some fertilizers.

The soils 1, 2, 3, may be taken as examples of soils rich in mineral matters, and only needing skillful rotation of crops, and production of nitrogen from growing of clover and feeding of stock, to keep up their fertility for an indefinite period. Soils 7 are equally rich in these elements, but deficient in alumina, so that they are more difficult to keep supplied with organic matter, and more liable to be worn out, while in the hands of skillful managers they are the most profitable to cultivate of any in the State. The organic matter, which gives color to the soil, and is in some way essential to its fertility, it will be seen, is in all of them that can be cultivated. Nitrogen is one of the constituents of the organic matter, and is found in all fertile soils; those to produce good crops of wheat needing from ten to twelve per cent. of that element. Some crops grow with a less percentage of nitrogen in the soil, and do well.

But the full benefit of these analyses can only come to the intelligent, practical farmer, who understands the necessity for good drainage and thorough tillage, and that the full value of the elements of fertility in the soil can fairly act upon the growing plants, only when these conditions have been complied with:

ANALYSES OF SOILS (AVERAGES).

Number.	CLASSES OF SOILS.	Number of Specimens Analyzed.	Water (Moisture).	Sand (Insoluble in Acid).	Alumina.	Oxide of Iron.	Magnesia.	Potash.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Carbonic Acid.	Organic Matter.	Total.	Nitrogen.
1	Granitic	5	1.877	73.962	10.038	6.212	0 597	0.148	0.175	0.146	0.006	0.060	0.055	6.753	100.029	0.112
2	Limestone	11	1.714	78.219	7.013	4.484	0.650	0 319	0.385	0.179	0.022	....	0.198	5.959	99.142	0 136
3	Slate	5	1.216	77.380	9.152	4.943	1.491	0.481	0.222	0 205	0.008	....	0 052	6.015	101.165	0.136
4	Red Sandstone	8	2 422	80.012	6.082	4.111	0.749	0.244	0.152	0.082	0.022	....	0.034	5.977	99.889	0 124
5	Trap	6	3.830	65.734	12.096	10 063	0.772	0.145	0.247	0.091	0.012	0.011	0.020	7.034	99.965	0 050
6	Cay and Sand	2	0 733	90.830	2.136	2.456	0.183	0.223	0.101	0.099			0 028	3 226	100.015	0.109
7	Marl	9	1.152	88.439	1.831	4.454	0.174	0.274	0.162	0.182	....	....	0.031	3.432	100.151	0.098
8	Oak Land	13	0.721	92.141	2.699	1.680	0.161	0.059	0.018	0.037	0.020	....	0.015	2.433	99.974	0.042
9	Pine Land	6	0.208	98.417	.371	0.352	0 015	0.015	0.009	0.021	0.008	0.002	....	0.508	99.920	0.015
10	Alluvial	2	1.200	88.720	2 010	1.470	0.038	0.170	0.420	0.107	0.050	....	....	5.020	99.205	0.168

In the reports for 1878 and 1879 there were published tables which showed the amount of the different fertilizing materials in an acre of the soil six inches deep, and the amount of mineral matter taken off from an acre by each of our leading crops. Also something of the sources from which these supplies could be most cheaply obtained. Reference may be made to either of these reports for the tables mentioned.

IX.

DRAINAGE.

Of the large tracts of wet lands and those liable to overflow in times of freshet, which the Geological Survey has been petitioned to provide for draining, only one is completed. That is the Great Meadows, on the Pequest, in Warren county, and mostly in the townships of Independence and Allamuchy. These meadows occupy a valley some seven and a half miles long and one and a half miles wide, and cover an area of about 5500 acres. They occupy a place that was originally a lake. It was first formed by a dam of glacial drift which was deposited across the whole valley, where Danville and Vienna now are. In the course of time this lake has been completely filled up by the accumulation of sediment, the deposition of vegetable matter and the growth of peat bogs. The Pequest found its way through this meadow in a crooked, narrow and shallow channel, and in every heavy rain it overflowed its banks, and the whole space was covered with a flood of water which ran off with extreme slowness, and left the land in such a swampy condition that it could not be safely crossed by men or domestic animals, and much of it was never used except for getting timber from the wooded portions while frozen in winter. Many expensive and ineffectual attempts have been made to drain the meadows, but they failed from expending all their labor in the meadows, instead of upon the outlet, which was the first essential to effecting a proper drainage.

The plan presented by the managers of the Geological Survey in answer to the petition of the land owners, was, by order of the Supreme Court, put in the hands of commissioners in the year 1872, to be by them carried out. The channel of the stream was to be made wide enough to carry all the water of the stream, and to be lowered fully five feet. This work was completed two years ago, and is eminently successful. The water is kept within the banks of the stream, and the swamps are drained and dry enough for cultivation. The land is taxed for the expenses of the drainage, and in adjusting the assessments there has been much delay and expensive litigation, and land owners have not pushed forward the improvement of the drained swamps as fast as their best interests demand. But enough has been done to show that its agricultural benefits are all that were anticipated. Some excellent fields of corn have been grown the past season by Mr. Buckley and others at Long Bridge, and by Mr. Abers, near Danville. Mr. Abers' ground was formerly under water much of the time. It was cleared and plowed for the first time this year, but no manure was put on it. The crop was an extraordinarily heavy one; a little uneven in its growth; the yield varying in different parts from 50 to over 100 bushels of shelled corn to the acre. Mr. William Vreeland and Mr. Patrick Welch, at Danville, have had very fine crops of hay and grass on fields of peat which they have cleared and used this year for the first time. Notwithstanding the extreme drought of the early summer, Mr. Vreeland had more than 30 tons of first quality hay from 15 acres of this soil, and since the mowing has had from 14 to 26 head of cattle grazing on it, and they have had enough good pasture all the season. These fields are as productive as the fens of England and the dyked lands of Holland, and are worth three or four times as much as the same area in the farmed fields on the surrounding uplands. The meadows, when they are properly cleared and improved, will form the most beautiful and productive tract of farm land in northern New Jersey.

The sanitary benefits of this drainage are, if possible, more marked than the agricultural. Formerly fever and ague, and other malarial diseases were very prevalent, in some seasons attacking almost every person. Now, when the drainage is completed, sickness is comparatively rare, and this year, which has been marked by the general prevalence of malarial disorders, there have been very few cases of such sickness anywhere about the Great Meadows; certainly not more than on the neighboring mountains. In the report for 1877, letters from Dr. Wm. I. Roe, of Vienna, Drs. E. T. Blackwell and J. S. Cook, of Hackettstown, and Dr. N. M. Hartpence, of Oxford, were published. They all spoke strongly in regard to the peculiar prevalence of intermittent and miasmatic diseases in the vicinity of the Great Meadows. The same gentlemen have been consulted again this year. Dr. Wm. I. Roe, has been succeeded in practice at Vienna by his son, Dr. J. I. Roe. He, after mentioning the general prevalence everywhere of malarial disease during the last autumn, says: "That one of the benefits resulting from the drainage of the Great Meadows has been a diminished prevalence of miasmatic diseases in the surrounding country, I think, is certainly the case." Dr. Hartpence has had no practice about the Great Meadows recently, but adds: "I will say that the drainage of the meadows at this place, by Mr. S. T. Scranton, has entirely driven out intermittent fevers, yet we have no less of remittent or other malarial troubles." Dr. Cook has not had occasion to learn of the health about the Great Meadows this year, neither has Dr. Blackwell.

The commissioners and their engineer, who have faithfully carried out their object under great discouragements, have built for themselves a monument more lasting than one of granite. It is much to be desired that other tracts of land in the State, subject to overflow, may be made useful and salubrious in like manner.

X.

WATER SUPPLY AND WELLS.

The question of water supply continues to be of great interest. There are more inquiries at the office of the Survey for information on this subject than any other whatever, and a great many samples of water have been sent into the laboratory for analysis; and to determine whether the water is fit to drink. We have given attention to such inquiries, as far as possible, though it is not easy, in many cases, to give positive answers. The analysis of drinking waters has exercised the ingenuity and skill of chemists for many years past, but they have not succeeded in bringing their methods to a satisfactory form. The really poisonous or disease producing elements in water seem at present to be as intangible as the virus of small-pox, or the poison of sumac. It is easy to find and weigh the mineral substances dissolved in water, and to tell their properties and effects. It is not specially difficult to determine the presence of organic matter in water; but this is not enough to furnish any indication as to whether the water is wholesome or not. In all of southern New Jersey the water which comes from swamps, particularly cedar swamps, is almost as brown as vinegar, from the organic matter it has dissolved out from the swamp earth, and yet such water is everywhere chosen as specially wholesome and agreeable. And in many of our streams where the water is rather sluggish, there is in summer a growth of vegetation which charges the water with organic matter. Such waters when analysed show a large quantity of albuminoids, which by some chemists have been pronounced dangerous, and yet such waters are used for the supply of towns and cities and no harm is known to attend their use. The injurious effects of drinking-water come from decaying or diseased animal matters which get into them. Waters may be filthy or disgusting to an extraordinary degree and yet not be poisonous. But where the sewage from towns, the drainage from sinks and cesspools, and the thousand contaminating substances which may drain into the waters of streams or wells in settled countries, there is always danger. The best examination of such water is partly chemical, partly microscopical and partly historical. If water is obtained from any source from which there is a possibility of its being contaminated with sewage or with drainage from cesspools, vaults or other sources of impurity, it may fairly be suspected. If on examination with a microscope it shows floating particles of organized matter it may well be feared.

If it comes from places not near the sea, and yet contains salt, it shows that sewage and animal matters must have filtered into it, and if on further examination it proves to contain albuminoid ammonia and nitrates, it must be pronounced unsafe to drink. To the timid, it may with confidence be said, that any water containing these germs of poison or disease may be rendered harmless by boiling, and it will in many cases tend to comfort, if no water is drunk unless it has been boiled.

Water from deep wells is usually free from any organic matters, and if not too hard, is quite safe to drink. But in many cases it contains too much mineral matter. The water collected in wooded, mountainous countries, or from grass and pasture land is also ordinarily pure and wholesome. Spring water is generally considered to be the type of purity, and in wild districts it undoubtedly is so, but in cultivated lands the water of springs sometimes becomes impure. Rain water collected from roofs in the country is generally pure and wholesome, but in towns it is liable to be contaminated with smoke, street dust, and the various impurities that are thrown into the air from factories, chemical works, &c. The water from shallow wells is always liable to be made impure by the surface water filtering through the ground.

There has been a desire to obtain supplies of water from artesian wells, and there are many who would willingly incur the expense of boring such wells if there was a reasonable prospect of getting good water in sufficient quantity. But thus far the results have not been very encouraging. Some of them have been failures, others have yielded water of bad quality, while others have proved satisfactory and valuable. In the Geological Report of 1879, an account was given of the principal artesian wells in the State. The deep wells bored in the red sandstone at Newark were described last year, and an analysis was made of the water in the well at Lister Brothers' works. This well is about 600 feet deep, and the water in it, yielded, at the end of 1879, about 152 grains of solid matter to the gallon. After pumping it for a year we have examined it again, and find that it now holds in solution 135 grains of solid matter to the gallon, so that it may reasonably be concluded that the water is becoming softer.

The bored well at the Passaic rolling mill, Paterson, was 1400 feet deep when our report was published last year. It was sunk about six feet in earth, all the rest was red sandstone and shale down to 1120 feet, where a layer of quicksand was met, which caused much trouble. There was some water found in the well at various depths down to the quicksand. It rose in the bore to within seventeen feet of the surface. Of this water in the well no examination was made at that time, but when the boring was down about 1700 feet, some of it was drawn up and tested. It was found to contain 340 grains of solid matter to the gallon, and most of this was sulphate of lime, so that it was quite unfit for drinking or for making steam. From the trials since made it is presumed that the water examined came from the layer of quicksand, which is 1120 feet down.

No attempt was made to pump the water from it at that time as it was hoped to find a supply that would rise above the surface and make a flowing well.

In order to shut off the quicksand the well was tubed down to 1120 feet. This effectually shut it out, and the water also, and the rock was found to be entirely without water from that down to 2050 feet. From 2020 to 2050 feet the red rock was more granular and worked up into sand by the action of the boring tools. Water that was strongly saline was met at 2050 feet, and the usual red shale and red sandstone continued on fifty feet further, at which depth the boring was stopped. The salt water rose in the well to within thirty feet of the surface. No attempt was made to learn how much the well would yield by pumping.

The analysis of this salt water was as follows, per gallon: Of

Chloride of sodium	408.46 grains.
Chloride of potassium	5.54 grains.
Chloride of calcium	278.32 grains.
Chloride of magnesium	109.44 grains.
Sulphate of lime	120.70 grains.
Chlorides of iron, alumina, &c	7.00 grains.
Traces of bromine and iodine	....
Total weight of solid matter per gallon	929.46 grains.

This is not more than one-half as salt as sea water, and the chlorides of potassium, calcium and magnesium are in much larger quantity than they are in the water of the ocean.

The following is a tabular account of the specimens sent from the Paterson well, with the depths at which they were taken, in feet, and the dates at which they were received.

Number.	DEPTH.	DATE.	DESCRIPTION OF MATERIAL.
1	65 feet	....	Red sandstone, fine.
2	110 feet	September 19, 1879	Red sandstone, coarse.
3	182 feet	September 19, 1879	Red sandstone, and a little shale.
4	400 feet	September 19, 1879	Red sandstone, shaly.
5	401 feet	September 19, 1879	Shale.
6	430 feet	September 19, 1879	Red sandstone, fine grained.
7	540 feet	October 9, 1879	Sandy shale, soft.
8	540 feet	October 9, 1879	Soft shale.
9	565 feet	October 9, 1879	Soft shale.
10	565 feet	October 9, 1879	Soft shale.
11	585 feet	October 9, 1879	Soft shale.
12	600 feet	October 9, 1879	Hard sandstone.
13	605 feet	October 11, 1879	Soft shale.
14	609 feet	October 11, 1879	Soft shale.
15	613 feet	October 11, 1879	Soft shale.
16	1,170 feet	November 9, 1879	Selenite, 2x1x1-16th in.
17	1,180 feet	December 5, 1879	Fine quick-sand, reddish.
18	1,180 feet	December 5, 1879	Fine quick-sand, reddish.
19	1,180 feet	December 5, 1879	Pyrites.
20	1,370 feet	February 13, 1880	Sandy rock, under quick-sand.
21	1,400 feet	February 13, 1880	Dark red sandstone.
22	1,400 feet	February 13, 1880	Light red sandstone.
23	1,415 feet	February 16, 1880	Dark red sandstone.
24	1,415 feet	February 16, 1880	Light red sandstone.
25	1,415 feet	February 16, 1880	Fragments of red sandstone.
26	1,540 feet	March 4, 1880	Red sandstone, and a pebble of kaolin.
27	1,700 feet	March 30, 1880	Light red sandstone.
28	1,830 feet	June 9, 1880	Light red sandstone.
29	1,830 feet	June 9, 1880	Light red sandstone.
30	1,830 feet	June 9, 1880	Light red stone.
31	2,000 feet	August 25, 1880	Red shale.
32	2,020 feet / 2,050 feet	August 25, 1880	Light red sandstone.
33	2,100 feet	November, 1880	Shaly sandstone.

At this depth the attempt to bore through the red sandstone was abandoned, the water being altogether unfit for ordinary use, and the character and amount of the saline impurities giving little hope of success by going deeper. The question as to the thickness of the red sandstone has not been settled, though it is shown to be more than 2100 feet thick at Paterson. And the questions suggested by finding the salt water must also remain unanswered for the present, though the fact that the rock salt of England, and of some of the other salt mines in Europe is found in rocks of the same age as this, raises the question whether it may not also be found here.

About the end of December the tubing was drawn out of the well and the bore was stopped by a seed-bag below 900 feet. The water now rises to within seventeen feet of the top. By putting down a pump forty feet into the well it has been made to yield 100 gallons of water a minute for five hours, without lowering the surface materially. This water has been analysed, and found to be slightly alkaline, agreeable to the taste, and to contain 13.54 grains of mineral matter to the gallon, and this mostly carbonates of lime and magnesia.

The analysis showed in a gallon or (58318 grains):

2.15 grains of magnesia,
3.71 grains of lime,
1.15 grains of soda, with very little potash,
1.08 grains of chlorine,
.55 grains of sulphuric acid,
Not weighed, carbonic acid.

It may be assumed that these constituents are combined and exist in the water as:

4.51 grains of carbonate of magnesia,
5.95 grains of carbonate of lime,
1.78 grains of common salt,
.37 grains of carbonate of soda,
.93 grains of sulphate of lime.

13.54

These constituents are not such as to make the water unwholesome for drinking or for household uses, and they will probably deposit in boilers as a sandy or muddy sediment, and the water can be used for supplying steam-boilers without danger or inconvenience.

The well was begun with an eight-inch bore, and was cased with a six-inch tube down to 1120 feet, and the bore from that down to 2100 feet was four and one-half inches. It is now proposed to ream the bore for the 900 feet, so as to make it sufficiently large before permanently arranging the apparatus for pumping.

The artesian well at Jamesburg was down 285 feet at the date of last year's report. This well is in earth, and had been sunk through various strata of clay and sand, meeting some water, but not enough in quantity nor good enough in quality to satisfy the needs of the school. An eight-inch tube had been used. This year a six-inch tube has been driven down to a depth of 481 feet, passing through strata of sand and clay, as follows, from information furnished by Mr. Eastman, superintendent of the school, and by Mr. H. F. Walling, of New York, who bored the last part of the well, in 1880:

SECTION OF JAMESBURG WELL.

THICKNESS.		DESCRIPTION OF MATERIAL.	DEPTH.	
Feet.	Inches.		Feet.	Inches.
9	.....	Yellow sand	9	.....
4	.....	Yellow sand and gravel (from 12 to 13 feet, water)	13	.....
30	.....	Black clay, containing very little sand—moist	43	.....
8	6	Dark sand, somewhat colored with green, containing a little clay. Rather dry. (From 46 to 47 feet, some whitish clay, rocks, lumps, and thin layers)	51	6
.....	6	Sand rock	52	.....
12	.....	Dark and greenish sand, containing a little clay, and of a marl nature. Rather dry and crumbly	64	.....
1	6	Black clay	65	6
4	6	Dark and greenish sand, containing some clay, rock and thin sand crusts. Rather dry	70	.....
.....	6	Sandstone	70	6
5	.....	Black clay	75	6
4	6	Black clay, with some sand and a little stone in it	80	.....
12	6	Black clay, containing very thin layers of white sand	92	6
1	.....	Hard, dry, whitish clay	93	6
15	.....	Black clay, with thin layers of white sand	108	6
1	6	Stiff, dark sand	110	.....
23	6	Fine beach sand, water-bearing, somewhat muddy, and partly of a quick-sand nature, containing more or less wood, some floating sandstone, and clay lumps	133	6
1	.....	Black clay	134	6
12	6	Fine sand, water-bearing, containing wood, stone and mud, same as above	147	.....
3	6	Black clay, with thin layers of white sand	150	6
13	6	Fine sand, water-bearing, containing some mud, wood and stone	164	.....
14	6	Brown clay, very compact and solid, some wood, and its general appearance is of a vegetable nature	178	6
4	6	Brown clay, containing considerable sand and more wood. Rather dry. (At 173 feet 9 inches, and at 178 feet 6 inches, lumps of iron pyrites)	183	.....
8	6	Fine sand, water-bearing, containing some mud, wood and floating sandstone	191	6
.....	6	Dark clay	192	.....

SECTION OF JAMESBURG WELL—*Continued.*

Thickness. Feet.	Thickness. Inches.	Description of Material.	Depth. Feet.	Depth. Inches.
10	9	Coarser sand—a more free water stratum—a few floating clay lumps, iron pyrites, wood and blue clay	202	9
....	3	Bluish clay (on top of it a thin sandstone crust and wood)	203	.....
1	......	Sharp sand; water	204	.....
....	9	Fine, bluish clay	204	9
12	3	Sharp, clean sand, water-bearing	217	.....
....	3	Wood, worm-eaten	217	3
1	......	Coarse sand and fine gravel, well mixed, and with lumps of white clay	217	3
5	9	Sharp sand, with lumps of bluish clay. (At 223 feet 6 inches, crusts of iron pyrites.)	224	.....
7	......	Fine beach sand	231	.....
2	3	Sharp sand, coarser	233	3
....	3	Whitish clay	233	6
2	6	Sharp sand, with scattering whitish clay lumps	236	.....
1	......	Coarse sand and fine gravel, well mixed with white clay lumps	237	.....
1	......	Fine, lively sand	238	.....
1	9	Coarse sand and fine gravel, well mixed with white clay lumps	239	9
....	3	Whitish clay	240	.....
....	9	Sharp sand	240	9
....	3	Whitish clay layer	241	.....
10	......	Fine beach sand	251	.....
5	......	Coarse sand	256	.....
		(The above 15 feet of sand clean and free from other substances.)		
2	6	Augur below pipe, and struck a sandstone crust	....	.....
60	......	Dark blue clay	316	.....
17	......	Sandstone	333	.....
8	......	Dark blue clay	341	.....
4	......	Quick-sand	345	.....
20	......	Very fine sand	365	.....
18	......	Sand, not so fine as last	383	.....
12	......	Quick-sand	395	.....
6	......	Blue clay	401	.....
4	......	Coarse sand and wood	405	.....
4	......	Blue clay and pyrites	409	.....
15	......	Coarse sand	424	.....
4	......	Very coarse sand	428	.....
3	......	Fine sand	431	.....
4	......	Blue clay	435	.....
3	......	Quick-sand	438	.....
5	......	Red clay, sand and pyrites	443	.....
5	......	Quick-sand	448	.....
4	......	Fine sand and wood	452	.....
3	......	Fine white sand	455	.....
1	......	White clay	456	.....
6	......	Coarse sand	462	.....
4	......	White clay	466	.....
6	......	Coarse sand and gravel	472	.....
9	......	Coarse sand, white clay and gravel	481	.....

At this depth the tube crooked and telescoped, so that it could neither be sunk further nor used as it is. The water met in the well was soft, but it contained a very small quantity of iron, sufficient to sensibly discolor white clothes, and render it undesirable for washing purposes. It is decidedly chalybeate, tonic and healthful for drinking, and may properly be kept for that use.

The school is now supplied satisfactorily by collecting water from several springs which issue on the east side of the hill south from the school. The water from these is conducted into a reservoir near the buildings, and then pumped up to where it is wanted by a steam engine. The water is soft, clear and colorless, and meets their requirements, both for domestic purposes and for their extensive laundry work.

An artesian well of great depth has been successfully bored at Charleston, S. C., and as our own sea-shore, like that of Charleston, lacks a proper supply of pure water, inquiries in regard to that well have been made. The first of the following letters was obtained by favor of Walter Wood, Esq., and Mr. John Fries, of Philadelphia, from Zimmerman Davis, Secretary of the City of Charleston Water Works Company, and the other through Prof. C. U. Shepard, Jr., of Charleston, from Bishop P. N. Lynch, D. D., of that city:

LETTER FROM Z. DAVIS, ESQ.

CHARLESTON, S. C., November 22d, 1880.

Mr. Aaron Fries, Philadelphia, Pa.;

DEAR SIR:—Your favor of the third instant, in reference to our artesian well, is at hand, and I append an account of the geological strata underlying Charleston to the depth of the well. It is tubed the entire distance, beginning with a 6-inch pipe at the surface and terminating with only 2⅜-inch pipe at bottom. It flows 250 gallons a minute, and would rise through pipes to a height of about 90 feet. We only raise it about 15 feet above the surface to flow into the reservoir. It was bored by Mr. F. Spangler, who resides here, and cost about $25,000, but another one with a larger bore, say 12 inches at surface and 6 inches at bottom, to give a much larger flow of water would probably cost $30,000. I also enclose an analysis of the water made by Prof. Charles U. Shepard, Analytical Chemist of the Medical College of South Carolina. It is perfectly clear, and is unequalled for drinking or bathing and for all boilers, except that it is too soft for locomotive boilers.

Yours, very truly,

ZIMMERMAN DAVIS,
Secretary.

ARTESIAN WELL, CHARLESTON, S. C.—THICKNESS OF STRATA DOWNWARDS.

0 to 17 feet, sand.
17 to 50 feet, stiff blue clay.
50 to 61 feet, stiff sand.
61 to 65 feet, fine white sand.
65 to 320 feet, marl.
320 to 329 feet, hard rock with sand.
329 to 341 feet, marl.
341 to 344 feet, sandy limestone.
344 to 360 feet, marl.
360 to 367 feet, hard, sandy limestone rock.
367 to 1033 feet, marl.
1033 to 1215 feet, sand and clay.
1215 to 1221 feet, sandstone, hard.
1221 to 1230 feet, sand and clay.
1230 to 1310 feet, sandstone.
1310 to 1350 feet, sand.
1350 to 1390 feet, stiff blue clay.
1390 to 1405 feet, sand.
1405 to 1533 feet, sand and clay.
1533 to 1557 feet, hard sandstone.
1557 to 1560 feet, sand.
1560 to 1610 feet, clayey sand.
1610 to 1820 feet, blue clay.
1820 to 1845 feet, sand.
1845 to 1880 feet, sand rock and loose sands.
1880 to 1900 feet, blue clay and sand.
1900 to 1910 feet, sands.
1910 to 1925 feet, clayey sandstone.
1925 to 1970 feet, sand beds 8 to 10 feet thick, and sandstones 2 to 5 feet thick between the beds.
1970 feet, bottom on a sandstone not penetrated.

ANALYSIS OF THE WELL WATER BY PROF. C. U. SHEPARD, JR.

Residue on evaporation 65.05 grains to United States gallon, consisting of the following ingredients:

Organic matter and water of crystallization	1.73
Carbonate of iron	.34
Sulphate lime	.44
Sulphate magnesia	.17
Chloride of magnesium	.23
Chloride of sodium	11.39
Carbonate soda	47.26
Nitrate of soda	.55
Silicate of soda	2.52
Silica	.36
	64.99

LETTER FROM BISHOP LYNCH.

CHARLESTON, S. C., December 20th, 1880.

DEAR SIR:—Prof. Shepard has handed me your letter to him of December 7th, making some enquiries about the geology of our artesian well, with a request that I would reply, inasmuch as the geological character of the work fell to my share, in the committee of which we both are members.

The well is 1975 feet deep, the mouth being about twelve feet above high water level. It discharges about 250 gallons a minute, the head being about 103 feet, and the diameter of the well varying from five inches at top to two and eleven-sixteenths at bottom. You have the analysis of the water made at the termination of the work. Since then it has continued flowing and has become purer, the inorganic matters decreasing, I believe, fifty per cent. On this, however, Dr. Shepard can speak. All I know is that the water is *good*. Its temperature is ninety-nine and one-half degrees Fahrenheit.

After passing through seventeen feet of drift sand the well entered a *post pliocene*, clay and sand; at sixty-four feet it entered the *Eocene* marls of this State, which we divide into three groups: the Ashley marls, the Santee marls and the Buhrstone beds, here represented by clays and sands, with about ten per cent. of carbonate of lime.

At some depth, which we are inclined provisionally at least to fix at 441 feet, the well enters the *Cretaceous* formation. At 1975 it was still in the same, without any decisive indications of being nearly through it.

Both the Eocene and the Cretaceous formations are here found to consist of alternating layers, varying from sands and soft marls to indurated marls and soft sandstones, on to hard, sometimes very hard limestones and sandstones. These multitudinous layers, which rendered the work very tedious and difficult, varied in thickness from six inches to twenty feet. They lie nearly horizontal, dipping toward the ocean, about six or eight feet to the mile, and rising to the surface as one goes toward the Allegheny mountains or Blue Ridge, some 200 miles to the northwest, or more correctly and definitely, to the granitic ridge which shows itself on the surface from Augusta, Ga. through Columbia, S. C. and on to Raleigh, N. C. and Virginia, *i. e.*, about 100 miles northwest of Charleston.

The geological portion of our well does not correspond with that of Paterson, N. J., sunk on the red sandstone. It corresponds with those of Paris and London, and, in America, with those of Alabama. All of which seek water in the Cretaceous formations.

In our well water was found in almost every layer of sand, if this were of considerable thickness. I suppose a dozen streams were encountered, but they were not large enough for our purposes. It seems, also, that here the deeper the stream the purer was the water.

Would not a well on the sea coast of New Jersey, at least in its southern portion, penetrate the Cretaceous formation? If so I think you would most probably find a supply of fair water rising above the surface.

I am, very respectfully, your obedient servant,

P. N. LYNCH, D. D.,
Bishop of Charleston.

There is a want expressed of a full supply of pure and wholesome water at Atlantic City. The city is built upon the sand dunes of the beach along the ocean, and is five miles from the solid upland. The dunes are only half a mile wide, and there is between them and the upland more than four miles of salt-marsh. Several wells have been sunk on the beach, some of them more than 100 feet deep, but they have failed to get through beach sand and gravel. Two plans for supplying the city with water are now under consideration. One is to bring water from Absecon creek, across the marsh, to the city, in pipes. This water is of excellent quality, and the only difficulty is in the expense of bringing it across from the main land. The other plan is to bore a deep artesian well, from 1000 to 2000 feet deep, through the upper of the green-sand marl beds, where it is hoped a bed of water-bearing sand will be found. The depth at which the marl beds will be found under Atlantic City may be computed with some degree of probability. The marl beds dip towards the southeast at the rate of not more than 25 feet per mile, say 25 feet. It is 45 miles from the marl beds at Kirkwood to Atlantic City, which, at 25 feet per mile, would give a total descent of 1125 feet, but Kirkwood marl pits are 70 feet above tide, so that the marl bed should be only 1055 feet below tide level. From some observations made it is thought the dip may diminish towards the southeast, in which case the depth to be bored would be less.

At Winslow, which is 14 miles east of Kirkwood, and on a line from that place to Atlantic City, the Hon. A. K. Hay bored a well several years since and got a supply of water for a steam boiler. The materials passed through, as given by Mr. Hay, were as follows, (*Geol. N. J., p.* 290):

15 feet of surface earth dug away.
15 feet of blue and black clay.
95 feet glass sand, described as quick-sand.
35 feet miocene clay, described as hard, black clay.
107 feet micaceous sand, described as quick-sand.
43 feet brown clay, described as black, hard clay.
A gum log one foot in diameter found here.
20 feet green-sand, marl and white shells, teeth, etc.
15 feet pure green-sand—no fossils.

Water was met at the depth of 343 feet, and just as they passed through the bed of green-sand. This green-sand is probably the upper marl bed, and the Kirkwood (middle) bed is perhaps 20 feet below it. The water is soft, containing about 9.5 grains of solid matter to the gallon, the principal constituents of which are carbonates of soda and potash.

The water is only used at Winslow for making steam, but it is much purer than the Charleston well water; it is sparkling, and must be agreeable for drinking, for washing and for culinary purposes.

As the dip of the strata is towards the southeast, the water drawn from a well in this formation at Atlantic City, which is surrounded by salt water, will be replaced by rain or other fresh water, which must enter between the strata at their outcrop, which is many miles farther to the northwest. Sea water is not likely to get in the wells and contaminate them, as the layers of clay, marl, &c., overlying the water-bearing sand, effectually shut it out.

While it is not by any means certain that an adequate supply of water can be got by boring an artesian well at Atlantic City, or any other place on the sea beaches, there is encouragement to do it from the success at Winslow and at Charleston, and the expense is small in comparison with that needed for bringing water from the upland, and it will be a public benefit to have the trial made. Wells of six or eight inches in diameter can be bored and tubed for about $10 a foot.

There is an artesian well being bored at this time, at the Central stock yards in Jersey City. It is located some five hundred feet back from the shore line of the Hudson. Through the favor of Mr. S. H. Smith, we have received samples of the earth and rock passed through, and also of the water which has been obtained from the well. The first 70 feet was in mud and earth, and they were much troubled with bowlders. At that depth they met ordinary sandrock, and continued in it to a depth of 142 feet, when they met red sand rock. The latter continued down to 215 feet, where mica-rock (gneiss) was struck, and they have continued in it down to the present time, and to a depth of 455 feet. Water has been found, but the quantity is not yet determined—it is brackish. The well is tubed with an eight-inch pipe down to the rock, and from that down the bore is six and a half inches.

In the bored well at the Secaucus Iron Works, which was mentioned last year as having been sunk to a depth of 600 feet, the largest quantity of water was found between 200 and 250 feet down, and some water is obtained from it at that depth. It has now yielded, on pumping, a steady supply of eight gallons a minute for several months. From Mr. Pardee, superintendent of the works, we get the above particulars, and also learn that the water after being steadily pumped, yielded, on evaporation, 68.64 grains of solid matter to the gallon. It probably gets a little salt water in it from the Hackensack river, near which it is bored.

The Newark Aqueduct Company is drawing a large part of the water supply for that city from driven wells in the vicinity of their pump works on the Passaic river flat, a mile north of Belleville. A published report puts the quantity daily pumped from them at 5,000,000 gallons, and the quality of the water is satisfactory.

X. (a)

MISCELLANEOUS LABORATORY EXAMINATIONS AND ANALYSES.

ASSAYS FOR GOLD AND SILVER.

There have been many statements published during the year, of the occurrence of silver and gold in our State, especially about the old workings for copper in the red sandstone region. These statements have excited much attention and inquiry. So far there does not appear to have been sufficient evidence of the occurrence of these precious metals in quantity to warrant any excitement.

The following list of ores and assays gives the results reached in our laboratory. Silver has been found in eight of them, to the extent of three ounces and upwards in a ton. The lead from the Andover (Sulphur Hill) mine, Sussex county, carries from seventeen to nineteen and a half ounces to the ton. The assays show that all of the copper ores of the red sandstone formation carry a little silver. These ores are mixtures of the sulphide, oxide, silicate and carbonates of copper, and it is not known with which of them the silver is associated. The assays for copper found from 14.7 to 64.6 per cent. of metallic copper. And the ores containing the largest percentage of copper carry the most silver. The specimens examined are above the average product, and represent selected lots.* As the copper minerals are disseminated very irregularly through the rock, it is difficult to get average samples of the localities. And, generally, the percentage of copper at all the localities is low. These mines have not been worked in several years past. And the speculative nature of the copper mining enterprises has tended to discourage their working. The insufficient quantity of workable ore

*The specimens assayed from the copper mines were collected several years ago, when they were in operation and its leanness make it extremely doubtful whether any of the localities here mentioned can, even under the most favorable conditions, and with skill and prudence, be worked profitably.

The discovery of silver in our copper ores in rocks of the Triassic Age corresponds with recent developments in the west—in Utah and New Mexico—and is interesting to the geologist, although not thus far of much promise so far as any addition to our mineral resources are concerned. It is another proof of the very uniform conditions prevailing over wide areas in the earlier geological ages.

Gold has not been found in any of the ore and specimens tested. The reported discoveries of this metal in ores at Hopewell, Plainfield and other places, is not substantiated by these assays. The *pyrites* veins of a number of localities examined do not contain any gold. It is hoped that the result of these assays will be useful information to many, and serve as a caution to sanguine capitalists who are often tempted by designing and deluded speculators to engage in mining ventures.

ASSAYS.

1. Copper ore, Schuyler mine, Belleville, Essex county.
   Silver, 7.25 oz. to the ton of ore.

2. Copper ore, Green Valley copper mine, near Plainfield.
   Copper, 23.5 per cent.
   Silver, 3 oz. to the ton.

3. Copper ore, Field mine, Washington Valley, near Plainfield.
   Silver, 1 oz. to the ton.

4. Copper ore from the Bridgewater mine, northeast of Somerville.
   Copper, 18.95 per cent.
   Silver, 4.13 oz. to the ton.

5. Copper ore, on farm of Jas. Hoffman, near Pluckamin, Somerset county.
   Silver, ¾ oz. to the ton.

6. Copper ore, dressed sample, from Griggstown copper mine, Somerset county.
   Copper, 64.6 per cent.
   Silver, 15.1 oz. to the ton.

7. Copper ore from mine at Flemington, Hunterdon county.
   Copper, 14.7 per cent.
   Silver, 3.2 oz. to the ton.

8. Blue shale in city of New Brunswick, (carrying carbonates of copper.)
Silver, ¾ oz. to the ton. (The metallic copper in this shale amounts to about 3 per cent. of the mass.)

9. Copper pyrites—digging on land of B. H. Hise, Hopewell, Mercer county.
Silver, 2.33 oz. per ton of pyrites.

10. Same locality. Another sample gave only ½ oz. of silver.

11. Galena and zinc ore from Hematite mine, Sylvester Neighbor, German Valley, Morris county.
No gold or silver.

12. Iron pyrite, from east slope of Hogsback, Califon, Hunterdon county.
No gold or silver.

13. Pyrite, from near Washington, Warren county. From John Jameson.
No gold or silver.

14. Pyrite, Bald Pate mine, near Washington, Warren county.
No gold or silver.

15. Iron pyrite, near Swayze's mine, two miles north of Hope, Warren county.
Silver, 15.100 oz. per ton.
No gold.

16. Iron pyrite, Marble quarry, Harmony, Warren county.
No gold or silver.

17. Ore, from Albert Lantermann, Kittatinny mountain, near Blairstown, Warren county.
No gold or silver.

18. Copper ore, Pahaquarry mine, Warren county.
Copper, 7.6 per cent.
Silver, traces.

19. Pyrite, from Geo. Warren, Millbrook, Warren county.
No gold or silver.

20. Pyrite in conglomerate, Mount Hope gold mine, Orange county, N. Y. [This specimen is like much of the pyritiferous conglomerate in the Kittatinny or Blue mountain in New Jersey. The locality is near the State line.]
No gold or silver.

21. Copper ore, Howell farm, Jenny Jump mountain, Warren county.
Copper, 7.1 per cent.
Silver, 10.9 oz. to the ton of ore.

22. Pyrite, (two specimens), from Az. Davis' land, Jenny Jump Mountain, Warren county. It contains arsenic, (see previous annual reports), but no gold or silver.

23. Galena and rock, Andover, (Sulphur Hill) mine, Andover, Sussex county.
Silver, 19½ oz. per ton.

24. Galena and pyrite, same locality.
Silver, 17.02 oz. per ton.

25. Pyrite, iron mine, Canistear, Sussex county.
No gold or silver.

26. (Nickeliferous) pyrite, Hacklebarney mine, Morris county.
No gold or silver.

27. Pyrite, Chas. Davenport's near Russia, Morris county.
No gold or silver.

28. Pyrite, Williams mine, Snufftown, Sussex county.
No gold or silver.

29. Pyrite, Falls of Long House creek, Passaic county.
No gold or silver.

MAGNETIC IRON ORE, COOPER MINE,

CHESTER, MORRIS COUNTY.

	RED ORE	BLUE ORE.
Metallic iron	66.33 per cent.	61.59 per cent.
Sulphur	none.	4.62 per cent.
Phosphorus	0.078 per cent.	0.047 per cent.
Titanic acid	none.	none.

The specimens from the Cooper mine were sent to the Survey Laboratory by John D. Evans, of Chester, superintendent of the mine.

The *red ore* is found at the surface, and extending downwards a depth of seventy-four feet. The *blue ore* is from the bottom of the slope. [See page 122.]

BOG IRON ORE,

JACKSONVILLE, MIDDLESEX COUNTY.

Metallic iron	57.06	per cent.
Phosphorus	0.047	per cent.
Sulphur	0.288	per cent.
Titanium	none.	
Manganese	none.	

The sample was sent by Luther M. Harned, of Woodbridge, and it is reported to be an average of an extensive deposit of easily accessible ore.

BLACK-LEAD—PLUMBAGO—GRAPHITE.

This mineral has heretofore been chiefly got nearly pure from veins or pockets in the rock, and very little from the particles which are found disseminated in various crystalline rocks. But the gradual exhaustion of the veins, together with the increased demand for the mineral for making stove blacking and crucibles, and as a lubricating material, have led to various inventions to separate it from the rocks in which it is found.

Rock containing from ten to thirty and even fifty per cent. of black-lead, is found in a number of places in New Jersey, many of which have been described in former reports. Near High Bridge, in Hunterdon county, the mineral is found in considerable quantity, and two different mills and machines have been put up there within the last year. From one of them, American Chemical Manufacturing and Mining Company, C. H. Angel, president, we have received samples of the separated mineral, in which the work seems to be remarkably well done. It is in the form of thin, round scales, one-sixteenth of an inch or more in diameter. An analysis of these showed them to contain 95.79 per cent. of carbon and 3.6 per cent. of earthy matter, insoluble in acids. This is a very pure specimen of graphite.

GREEN-SAND MARLS.

1. Marl from pits near the W. J. M. & Tr. Co.'s pits, Barnsboro, Gloucester county. Sent by W. Warrick.

Phosphoric acid, 1.41 per cent.

2. Marl from Joseph Hurff's farm, near Barnsboro, Gloucester county.

Phosphoric acid, 1.41 per cent.

3. Marl from Richard Ware's pits, near Barnsboro, Gloucester county.

Phosphoric acid, 1.09 per cent.

The marls 2 and 3 were sampled by John Repp, of Glassboro, and were sent in by him.

4. Marl from Prospertown, Monmouth county. Hon. E. P. Emson, of Collier's Mills, Ocean county, sent the sample.

Phosphoric acid, 0.64 per cent.

All of the samples examined are from the Middle marl bed. They are low in the percentage of phosphoric acid, and that from Prospertown contains so little of this valuable constituent that it cannot be considered of much value.

XI.

STATISTICS OF IRON ORE, CLAY AND MARL.

IRON ORE.

The condition of the iron-mining industry, and notes of the production in 1873 and in 1879, have been given on pages ninety-eight and ninety-nine. According to official reports received from the offices of the Delaware, Lackawanna and Western Railroad Company, the Central Railroad of New Jersey, Easton and Amboy Railroad, the New Jersey Midland Railroad, the New York and Greenwood Lake Railroad, the Morris Canal, the Hibernia Mine Railroad and the Ogden Mine Railroad; and, according to careful estimates of ores hauled by teams direct to furnaces, the total amount of iron ore shipped from the mines of the State during the year 1880 was 845,000 tons. The production in 1879 was reported as 488,028 tons. The increase for 1880 is, therefore, 357,000 tons, or 73 per cent. Iron mining began in Morris county as early as 1710, and was considered to be in a prosperous condition from that time onwards; but it did not reach an annual product of 100,000 tons till about 1855. It has increased since that time more than eight-fold, and an inspection of the mines at work, as seen in the printed list of this report, will show that there is still room for a still greater amount of yearly product. It is not possible to ascertain how much of this aggregate for 1880 was mined in the preceding year, but it is probably a very small fraction of it, as the stocks were well cleared away during the latter part of 1879 by the demand which was very active throughout the closing months of that year.

The total production, and that for the year for the several mines, so far as learned, will be found under their respective heads in the list of iron mines, pages 101–130.

ZINC ORE.

The zinc mines of Sussex county have shipped, during the year, according to official figures, 28,311 tons. This sum exceeds that of 1880, by at least 6000 tons. The consolidation of the companies working on Mine Hill, Franklin, under one management, the New Jersey Zinc and Iron Company, promises to increase the aggregate production, and to develop more fully the vast mineral resources of that locality.

CLAYS AND BRICK.

The interest attaching to the clay deposits of our State is seen in the steady demand for reports describing them. And the results of the fire tests made in the Survey Laboratory, given on pages 140–152, make a very proper supplement to the report published in 1878. These fire tests show that our clays are unequaled in their degree of refractoriness or ability of resisting intense heat. Their superior plasticity is already well known. These two essential properties make them the best fire clays in the world. And the increasing demand for them shows that manufacturers and practical men are learning how to handle them, appreciating their excellence. The extent of the beds, their accessibility to main lines of communication and the variety of clays adapted to the various purposes of manufactures, add to the great value of our clay deposits. In the results of the fire tests it will be observed that the best foreign clays being those which are known by long practice to make a superior refractory material are classed comparatively low, showing that many of our New Jersey clays are more refractory than the demands of long practice actually need. Their purity and highly aluminous character no doubt explain this difference. And the experience of our fire-brick makers is a proof that the average of our fire clays is sufficiently refractory. This higher classification and greater degree of refractoriness indicates, possibly, special uses for some of our clays, where intense heat is to be resisted. The subject is important and a large one, beyond the limits of an annual report. It is certain that the development of our clay-mining industry has by no means reached its maximum point.

The clays suitable for pottery continue to be used as largely as heretofore. The improvement of inferior grades by washing is also being largely and very successfully carried on.

The following statistics of the clays mined in the State have been gathered by reliable correspondents engaged in the business of mining and manufacturing them:

Woodbridge,* Middlesex county, fire brick, fire-clay and other refractory materials shipped	90,800 tons.
Perth Amboy,† Middlesex county, fire-brick, fire-clay, &c., shipped	22,000 tons.
Clay banks on north shore of Raritan river,‡ Middlesex county, fire-clay, fire-sand and kaolin	85,000 tons.
Clay banks on south shore of Raritan, Middlesex county, fire-clay, fire-sand and other refractory materials	60,000 tons.
Total	257,800 tons.
Stoneware clay mined in Middlesex county‡	10,000 tons.

The clay-banks of John D. Hylton, on Pensauken creek, in Camden county, produced of

Fire-clay§	13,740 tons.
Kaolin	7,870 tons.
Fire-sand	3,930 tons.
Sharp-sand	5,000 tons.
Gravel for foundries	9,777 tons.
Spar	1,600 tons.
Total	41,917 tons.

The statistics of red brick made at the larger establishments in the State, as reported by careful business men, are as follows:

Raritan and South River, and Raritan Bay yards	60,000,000 bricks.
Trenton yards (including front or pressed bricks)	12,000,000 bricks.
Delaware River yards, Florence, and Fish House	11,000,000 bricks.
Total	83,000,000 bricks.
The yards on Matawan Creek and elsewhere in the State would make the total production nearly	100,000,000 bricks.
The number of fire-bricks made in the State has not been ascertained, An incomplete list aggregates	7,935,000 bricks.
The total product is estimated approximately at	10,000,000 bricks.

The adaptation of our clays to the manufacture of terra cotta was referred to in last year's report. The success which has come to the new enterprise at Perth Amboy is shown by the following letter, received from Alfred Hall, of that city, an old and successful fire-brick manufacturer, in relation to the subject. Mr. Hall's experience in this branch of industry is unequaled in our country, and his

* From Wm. H. Berry, of Woodbridge.
† From Chas. A. Campbell, of Woodbridge.
‡ From Otto Ernst, of South Amboy.
§ From John D. Hylton, of Palmyra.

skill is of the highest order. His standing and integrity are such as entitle his statements to respect and confidence:

"I am doing all I can to develop and bring into use the great varieties of clay which should be a great source of wealth to the State of New Jersey. We have in our employ men of all nationalities, who are familiar with the working of clay in all parts of the world, and their opinion is unanimous that the red and other colored clays of New Jersey are superior for making terra cotta to any in the world. There are also many clays that are now considered worthless that show qualities that I think will be of great value when applied to the uses for which they are adapted.

"Perth Amboy is the natural centre for the manufacture of architectural terra cotta, both on account of the abundance of the raw material and the great facilities for shipping, the docks here having been unimpeded by ice all through the late severe frost. The present works cannot supply the increasing demand, the sales of the six months' ending December 31st amounting to $72,916. January 1st there were orders exceeding $55,000, and several large works for which terra cotta is specified for which estimates have been given, aggregating nearly $200,000 more, and Perth Amboy ought to become as noted for terra cotta as Trenton is for pottery.

"ALFRED HALL.

"PERTH AMBOY, February 21st, 1881."

STATISTICS OF POTTERIES MAKING WHITE WARE AT TRENTON, ELIZABETH AND JERSEY CITY.*

Number of kilns	110
Average capacity (each)	$30,000
Amount produced, if fully employed	$3,030,000
Amount actually produced, about	$3,000,000
Amount produced in United States	$5,000,000
Amount imported, about	$4,000,000
Production of New Jersey (clays, flint and spar)	50,000 tons.
Coal used	50,000 tons.
Wages paid, yearly	$1,400,000
Hands employed	3,000

GREEN-SAND MARL.

Owing to the low prices obtained from farm produce, not so much marl is sold as formerly. The aggregate sales of the several companies amount to 69,578 tons as compared with 58,570 tons by the same companies last year, an increase of 11,008 tons, or 18 per cent. The following statements from the officers of the companies make up the items of the aggregate:

FREEHOLD AND NEW YORK RAILWAY.

J. E. Ralph, Secretary, Treasurer and Superintendent writes: The F. and N. Y. railway, for the year ending December 31st, 1880, hauled 279 car-loads, of 250 bushels each, or 69,750 bushels .... 3,487 tons.

*From Hon. J. H. Brewer, Etruria Pottery Co., Trenton, and President of the United States Potters' Association.

SQUANKUM MARL COMPANY.

W. E. Barrett, Superintendent, writes: I give as an approximate estimate of our sales, the amount of 250,000 bushels; equivalent to............ 12,500 tons.

SQUANKUM AND FREEHOLD MARL COMPANY.

G. D. Gilsen, Superintendent says: The amount of marl we have delivered in the year 1880 is.. 12,423 tons.

CREAM RIDGE MARL COMPANY.

Gen. G. Mott, Treasurer, writes that the company has sold and shipped during the year.. 5,010 tons.

PEMBERTON MARL COMPANY.

J. C. Gaskill, Superintendent, writes: Our sales of marl for the year past have been.. 8,000 tons.

VINCENTOWN MARL COMPANY.

Henry J. Irick writes: We have shipped from June 1st to Dec. 31st...... 3,410 tons.

FOSTERTOWN MARL COMPANY.

No report received.

KIRKWOOD MARL AND FERTILIZER COMPANY.

George M. Rogers, Superintendent, writes: We have run our sales up to 7,000 tons.

WEST JERSEY MARL AND TRANSPORTATION COMPANY.

I. C. Voorhies, Superintendent, says: This company has sold and delivered this year, marl.................................. .... 12,748 tons.

DICKINSON MARL COMPANY, WOODSTOWN, SALEM COUNTY.

John W. Dickinson writes: The amount of marl sold by the Dickinson Marl Company in 1880 was about.. 5,000 tons.

Total.. 69,578 tons.

MARLBOROUGH, MONMOUTH COUNTY.

J. E. Ralph writes: I hand you statements from three marl farms at Marlboro, having wagon deliveries, as below:

O. C. Herbert's	9,961 tons.
Uriah Smock's	4,750 tons.
C. M. Conover's	760 tons.
Total	15,471 tons.

All exclusive of shipments by F. & N. Y. railway.

XII.

PUBLICATIONS OF THE SURVEY.

The annual reports of the progress of the State Geological Survey are printed among the documents of the State, and they are very generally distributed by the members of the Legislature among their constituents. A liberal number of copies is also placed at the disposal of the members of the Board of Managers and the Geologist. The demand for them, however, is large, and those of 1876, 1874, 1873 and 1872 are all distributed, so that for those years no copies can be furnished.

The "Geology of New Jersey," an octavo volume, with a portfolio of maps, published in 1868, can still be supplied, though the number of copies left is not large.

The "Report on the Fire and Potters' Clays of New Jersey," with a map of the clay district, which was completed two years ago, has been widely distributed both at home and in foreign countries. The edition is probably sufficient for the present demand.

The large geological map of the State is mostly distributed, only a few copies being left.

The geological map of Northern New Jersey, which was printed in colors, and first distributed with the annual report of 1873, is out of print. A few copies in black are still left.

The Centennial map of New Jersey, on a scale of six miles to an inch, and showing geographical features only, was prepared by the survey, and has been distributed.

The proper method of making public the results of our Geological, Topographical and Economical Survey, is a question which has not been satisfactorily settled with us, and is equally unsettled in most other countries. At first the board resolved to sell the reports and maps at the cost of paper, printing and binding, and a considerable number of copies of the Geology of New Jersey and some of the maps were sold in that way, but there were always some copies at the disposal of the members of the board and of other State officers, and the chance of getting from these without paying for them, led those who really wanted them to delay buying. From the way the printing is done the amount of free distribution has increased, and the sales have ceased. As the object of the survey is to make known our natural products and resources, it may be said that we must do it by advertising—that is, by free publication and liberal distribution, just as in private business, and that the waste or misappropriation of a considerable part of the publication should not discredit the method so long as we continue to thrive in using it.

The Pennsylvania reports are sold at the cost of printing and paper, but in fact most of them are given away.

The results of the Geological Survey of Great Britain are prepared and printed with great care and at heavy cost, and the price put on them is so high that few buy them.

The French Geological maps, too, are held at high prices, and few of them are sold.

The Board of Managers of the Geological Survey are constituted a Board of Publication of the results of the work, and they have authority to publish and distribute the reports as in their judgment is best for the interest of our citizens. It is specially desirable that the reports and maps should go into all public libraries, and into the hands of those whose pursuits render the information contained in these publications of value. It is probable that no better way will be devised for the distribution than to leave it in charge of the members of the board; and applications to them for such reports as may be desired, or to the State Geologist, *with their approval*, will be answered as far as possible.

The names and post office addresses of the members of the board are on page 3.

XIII.

EXPENSES.

The expenses of the Survey have been kept within the appropriation. The cost of drawing and describing fossils increases the expenses considerably, but it is necessary that this should be met, if a proper presentment of our geology is to be made. And as accurate maps are absolutely essential, I have not felt justified in diminishing the expénse or the amount of work we are doing in surveying the country and preparing them. We have been enabled to put these parts of our work forward by Professor Smock's entering into the service of the Census Office for a part of the year, and by my relinquishing a part of my work and salary to engage in assisting to conduct the New Jersey Agricultural Experiment Station.

XIV.

PERSONS ENGAGED IN THE WORK OF THE GEOLOGICAL SURVEY.

Work has been carried on in the survey under my general direction, by

PROF. JOHN C. SMOCK, Assistant Geologist, in testing fire-clays, in some general work connected with iron mines and mining and in computations and statistics of the Meteorology of New Jersey, and in preparing this report. For a part of the year he has been in the United States service as special census agent, for collecting statistics of iron ore, iron and other metallic products in New Jersey, New York and New England.

EDWIN H. BOGARDUS, Chemist, has been steadily at work through the year in the analysis of clays, ores, marls, soils and waters, with other miscellaneous work, such as was needed for the chemical investigation of our work.

C. C. VERMEULE, C. E., Topographer and Surveyor, has been occupied throughout the year in surveying, leveling and drawing maps.

N. L. BRITTON, B. S., has been engaged for several months in collecting and preserving specimens of fossil fishes and plants for description. He is now engaged in revising and perfecting a catalogue of the plants of New Jersey.

PROF. J. S. NEWBERRY has in hand the description and drawing of the fossil fishes and plants of the red sandstone and the tertiary formations.

PROF. R. P. WHITFIELD has begun the description of the invertebrate fossils of the cretaceous and tertiary formations.

My own time has been mainly given to keeping the various parts of the work in progress, but I have found time to give some attention to tracing out Lawrence's partition line between East and West Jersey; and to noting the progress of agricultural, mining, and other economic developments in the State.

XV.

APPENDIX—CLIMATE

The mild and salubrious climate of New Jersey has been justly appreciated by its own people and by strangers ever since the first settlement of the State. Within the last few years, the extension of traveling facilities has made it convenient for great numbers of people to visit and enjoy the benefits of the sea air; villages, towns and cities have sprung up at various points on the seashore, which are thronged with visitors during the hottest season of the year. With this experience there has grown up a knowledge of the peculiar sanitary benefits possessed by these places. A residence on the sand beaches of the ocean shore is said to drive away hay fever in almost all cases. And the mild winter temperature along the shore has been found peculiarly agreeable and salutary to those affected by rheumatic and pulmonary disorders. The ameliorating influences, as well as the advantages which our mild climate bring to those engaged in agricultural or mechanical work, have led us to make special efforts to get meteorological statistics from all parts of the State so as to study and compare them. Records from about seventy places have been brought together.* The Smithsonian Institution and the United States Signal Service Bureau have furnished copies of the records of temperature and rain fall made at their stations in the State and at localities near our border, in the adjacent States. Weather records kept by private individuals have been received. These observations are as complete as can be had up to January 1st, 1881. The necessity of additional observations at certain points suggested six new stations, which were started at the beginning of 1880. The observations at Port Jervis, New York, made by Chas. F. Van Inwegen, M. A., and at the Dodge mines, Morris county, by Wm. Allen Smith, M. E.,

* The State map in this report has these stations indicated by circles in red. Reference to it will show at once their location.

are complete for the past year. The observations at Deckertown, Sussex county, made by A. C. Noble; at Schooley's mountain, by L. H. Hunt; at Phillipsburgh, by Jos. C. Kent; and at New Lisbon, Burlington county, by Eayre Oliphant, are incomplete. These records, not being quite complete as yet, they cannot be properly incorporated with the others and discussed. Some general results are, however, given here; and also the very full observations made at Newark for the long period of thirty-eight years, (1843 to 1880 inclusive,) by William A. Whitehead, Esq. The Newark series becomes invaluable to us as furnishing a basis for comparison with other places, even when these latter are continued only for a very few years, or even a single year.

TABLES OF TEMPERATURE AND RAINFALL.

In the tables of temperature and atmospheric precipitation, twenty places, or *stations*, are included. They are grouped to represent the following natural divisions of the State:

1. Goshen, Orange county, New York, representing the Kittatinny valley.

2. Lake Hopatcong, (rainfall only), representing the Highlands.

3. Newark, Bloomfield and South Orange, representing the eastern red sandstone country.

4. New Germantown, New Brunswick, Lambertville and Trenton, representing the western red sandstone country.

5. Freehold, representing the western part of Monmouth county.

6. Sandy Hook, Barnegat and Atlantic City, representing the Atlantic coast.

7. Burlington, Moorestown, Haddonfield, Atco and Vineland, representing the south central or interior part of the State.

8. Greenwich, representing the Delaware Bay shore.

9. Seaville and Rio Grande (consolidated observations), and Cape May, representing the extreme southern end of Cape May.

The table of temperature has the maximum, minimum and the mean temperatures for the several months of the year, during the period covered by the observations. That is, the maximum represents the warmest, and the minimum the coldest degrees recorded in the time observed. The mean temperature is the average of the several monthly mean temperatures. In this way the extremes and the range for each month are indicated. The temperatures of the seasons are the means for the months belonging to them. The extent of the series, its beginning and end are also given.

The table of rain and melted snow gives the average amount by months, seasons and the year during the period of observation. The depth is in inches and hundredths of an inch.

The comparatively short periods of observation at some of the stations admits small discrepancies and differences, both in temperature and rainfall, which may disappear as the observations are continued for a longer time. The true averages or means, and proper expression of these elements can only be obtained by long series of observations. Hence the value which attaches to the Newark series, especially as kept by the same observer.

The data of these tables show:

First—The progression or increase of heat going from north to south. It appears both in the mean and in the maximum and minimum temperatures.

Second—The influence of the water off the coast is seen in the case of Cape May. While in winter this station is, in order of temperature, going south; in the summer it is cooler than Vineland, Atco, Lambertville and other places further north. The modifying effect of the water in the summer is seen in the comparatively warmer autumn. Whereas, in spring the same difference does not exist. The same influence is probably felt at Newark as contrasted with Lambertville, as seen in the temperature of the autumn months as compared with that of the spring. The autumn at Lambertville is near that of Newark in mean temperature, while the spring is warmer. The heat retained by the water serves to keep up the temperature of shore stations later in the autumn.

Third—The greater heat of the southern interior is illustrated in the Vineland record. At this station the maximum of summer is 10° above Goshen, N. Y., whereas the difference in winter is only 8½°, or 1½° more.

Fourth—The slight differences in the means in the spring during the months of March and April, at Vineland and Goshen, indicate the more uniform temperature of that season. We have already seen that in summer the difference is 10° and in winter $8\frac{1}{2}$°. In September it is 7° and in October 9°. In March $2\frac{1}{12}$° and in April $2\frac{8}{10}$°.

The table of atmospheric precipitation shows the lessening rainfall, proceeding from south northward and from stations near the coast, inland. A comparison of Goshen or Lake Hopatcong with Newark or Vineland illustrates this decrease. Newark and Lambertville show the diminution, proceeding inland. The difference between Newark and New Brunswick, both long series, appear to show that even in so short a distance it is noticeable.

Second—The large rainfall at Sandy Hook as compared with Freehold, or Barnegat and Atlantic City, all covering about the same periods, is remarkable and suggestive of modifying agencies not yet understood. The light amount at Atlantic City is inexplicable.

Third—The excessive amount at Seaville and Rio Grande in Cape May county, as compared with Cape May and other stations, is very surprising and apparently incorrect. A study of the tables will suggest other comparisons and generalizations. The discussion of the subject and the publication of fuller records is reserved for a future report.

It is hoped that these tables will call a more general attention to the subject, and interest our citizens in the matter of observations, so as to bring out the features of our climate, and particularly those of the sea-shore and of the mountainous localities which are resorted to by so many visitors in search of health and comfort.

TABLE OF TEMPERATURE.

STATION.	JANUARY.			FEBRUARY.			MARCH.			APRIL.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
Goshen, Orange County, N. Y.	60	-30	25.26	60	-16	26.31	78	-5	36.51	84	10	47.42
Bloomfield, Essex Co.	57	-16	27.82	69	-9	27.85	74	2	34.92	84.5	16	46.91
Newark, Essex Co......	65	-12.7	29.11	68.5	-8	30.47	77.25	2	37.76	85.5	17	48.71
South Orange, Essex Co.	70	-22	28.7	70	-3	29.68	72	-0.5	36.54	88	24	47.86
New Germantown, Hunterdon Co. ...	63.7	-14.5	28.23	59	-4.5	27.72	66.5	-2	34.2	83	31	47.23
New Brunswick, Middlesex Co.	67	-12	28.35	67	-10	31.41	77	4	36.58	81	27	48.48
Lambertville, Hunterdon Co.	61	-20	29.72	67.4	-8.7	29.63	77	-0.7	38.12	85	14	48.41
Trenton, Mercer Co....	67	-13	31.44	68	-7	32.65	76	1	39.93	85	27	52.51
Freehold, Monmouth Co.	68	-8	29.95	69	-5	31.81	76	7	37.78	86	17	46.99
Sandy Hook, Monmouth Co.	61	-3	31.93	64	2	32.58	67	11	38.12	77	23	47.23
Barnegat, Ocean Co....	61	-12	32.23	70	-1	32.68	73	10	38.2	79	19	46.38
Atlantic City, Atlantic Co.	64	-3	33.08	71	-5	33.48	72	10	38.63	79	19	46.98
Burlington, Burlington Co.	65	-15	28.87	66	-5	31.39	80	4	39.1	86	20	49.85
Moorestown, Burlington Co.	69	-13	29.51	65	-5	31.51	79	2	37.85	86	26	49.94
Haddonfield, Camden Co.	67	-12	29.64	61	-3	32	78	4	39.03	84	22	50.86
Atco, Camden Co.......	70	-8	31.69	69	-2	33.36	74	8	38.52	92	22	49.18
Vineland, Cumberland Co. ...	69	-5	32.23	70	-6	32.92	81	2	39.11	90	22	50.21
Greenwich, Cumberland Co. ...	62	-9	31.26	67	2	33.68	70	7	40.16	83	25	52.59
Seaville and Rio Grande, Cape May Co.	62	-2	32.25	69	4	34.21	72	7	38.56	84	27	50.2
Cape May, Cape May Co.	55	1	34.73	56	2	34.7	61	18	40.3	76	24	48.37

TABLE OF TEMPERATURE.—*Continued.*

STATION.	MAY.			JUNE.			JULY.			AUGUST.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
Goshen, Orange County, N. Y.	93	26	56.22	96	36	64.73	96	42	68.7	91	36	67.64
Bloomfield, Essex Co.	94	34	59.64	99	48	68.43	102	53	74.01	99	45.5	70.62
Newark, Essex Co.	96	31	59.19	97	38.25	68.5	99.75	46.25	73.86	99	46.75	71.55
South Orange, Essex Co.	95	36	61.25	98	48	70.4	101	55	74.04	98	50	71.58
New Germantown, Hunterdon Co.	92	37.7	60.13	95.5	36.5	70.46	97	58	75.07	96	51	71.97
New Brunswick, Middlesex Co.	98	37	59.03	98	46	68.84	101	56	75.24	97	48	71.79
Lambertville, Hunterdon Co.	93.5	29	59.1	99.7	38	68.38	101.5	44	73.57	97.5	40	70.77
Trenton, Mercer Co.	94	31	61.8	95	39	71.85	99	55	76.6	96	53	73.99
Freehold, Monmouth Co.	94	32	56.59	96	40.5	68.55	99	50	74.02	98	46.5	71.4
Sandy Hook, Monmouth Co.	93	35	59.98	93	50	69.05	100	50	74.45	93	57	72.85
Barnegat, Ocean Co.	91	34	57.56	93	47	65.76	96	53	72.05	93	53	71.63
Atlantic City, Atlantic Co.	89	33	57.97	93	45	66.33	99	53	71.97	89	53	72.38
Burlington, Burlington Co.	90	36	60.17	99	50	70.09	98	52	74.57	94	52	71.36
Moorestown, Burlington Co.	97	36	60.13	99	48	71.42	102	58	75.56	98	54	72.7
Haddonfield, Camden Co.	85	37	60	96	50	71.13	102	58	75.1	97	51	72.7
Atco, Camden Co.	97	32	62.99	103	52	71.88	101	59	75.49	98	46	73.12
Vineland, Cumberland Co.	96	34	62.33	100	44	73.21	106	46	77.92	102	49	74.25
Greenwich, Cumberland Co.	87	40	61.36	94	50	71.14	95	51	76.03	93	53	73.58
Seaville and Rio Grande, Cape May Co.	97	32	58.8	102	42	71.21	102	52	75.58	102	50	74.53
Cape May, Cape May Co.	79	37	58.68	88	47	68.02	90	57	75.07	87	58	73.98

TABLE OF TEMPERATURE.—*Continued.*

STATION.	SEPTEMBER. Maximum.	SEPTEMBER. Minimum.	SEPTEMBER. Mean.	OCTOBER. Maximum.	OCTOBER. Minimum.	OCTOBER. Mean.	NOVEMBER. Maximum.	NOVEMBER. Minimum.	NOVEMBER. Mean.	DECEMBER. Maximum.	DECEMBER. Minimum.	DECEMBER. Mean.
Goshen, Orange County, N. Y.	88	32	59.76	82	14	48.81	78	4	38.79	62	-10	28.01
Bloomfield, Essex Co.	95	36	64.87	90	28	53.31	75	15	42.84	66	1	33.54
Newark, Essex Co.	93.75	43.5	64.11	82.75	22.25	52.94	73.75	8	42.38	68.5	-6.5	31.98
South Orange, Essex Co.	94	33	62.48	87	22	52.82	76	8	39.47	64	-8	30.26
New Germantown, Hunterdon Co.	90	38	63.63	77	22	50.84	70	6	37.4	60	-6	28.79
New Brunswick, Middlesex Co.	92	42	65.08	84	29	53.46	74	11	41.33	65	-8	30.8
Lambertville, Hunterdon Co.	97	32	62.93	88	20	51.17	75.5	10	41.38	70	-16	31.75
Trenton, Mercer Co.	92	39	66.45	83	28	55.65	74	9	44.46	64	-8	31.32
Freehold, Monmouth Co.	99	37	63.85	89	24.5	53.37	77	8	41.77	70	-11	32.66
Sandy Hook, Monmouth Co.	92	40	65.82	84	32	56.26	71	8	44.37	61	-5	34.24
Barnegat, Ocean Co.	90	41	65.52	82	28	55.51	73	11	43.81	63	-7	34.1
Atlantic City, Atlantic Co.	94	43.5	66.28	81	29	56.31	71	10	44.01	63.5	-7	35.03
Burlington, Burlington Co.	93	43	65.54	80	31	54.43	75	14	44.46	62	2	33.39
Moorestown, Burlington Co.	92	37	65.51	84	26	53.44	78	10	41.99	64	-9	31.27
Haddonfield, Camden Co.	90	45	66.69	78	27	52.64	72	19	43.13	62	2	32.73
Atco, Camden Co.	98	31	64.64	88	23	53.69	82	9	40.95	67	-15	32.69
Vineland, Cumberland Co.	102	37	65.86	92	25	54.6	80	9	42.27	70	-10	32.63
Greenwich, Cumberland Co.	89	42	66.15	79	29	54.11	73	17	43.52	67	1	33.88
Seaville and Rio Grande, Cape May Co.	94	40	67.38	88	26	55.1	70	12	43.32	58	1	33.3
Cape May, Cape May Co.	86	42	67.01	81	33	59.05	69	14	45.65	61	9	37.4

TABLE OF TEMPERATURE.—*Continued.*

STATION.	Mean Annual Temperature.	Maximum.	Minimum.	Range for Year.	Spring.	Summer.	Autumn.	Winter.	Series. Begins.	Series. Ends.	Extent. Years.	Extent. Months.
Goshen, Orange County, N. Y.	47.38	98	-30	128	46.72	67.02	49.12	26.66	Jan. 1835	Dec. 1849	11	....
Bloomfield, Essex Co.	50.36	102	-16	118	47.16	71.02	53.67	29.57	Jan. 1854	Dec. 1862	9	....
Newark, Essex Co.	50.88	99.75	-12.5	112.25	48.55	71.41	53.13	30.59	May 1843	Dec. 1880	37	8
South Orange, Essex Co.	50.42	101	-22	123	48.55	72.01	54.92	29.55	Sept. 1870	Dec. 1880	10	7
New Germantown, Hunterdon Co.	49.64	97	-14.5	111.5	47.19	72.50	50.69	28.24	Nov. 1868	Aug. 1876	7	10
New Brunswick, Middlesex Co.	50.85	101	-12	113	48.03	71.96	53.28	30.97	Mar. 1863	Dec. 1880	16	10
Lambertville, Hunterdon Co.	50.41	101	-20	121	48.54	70.91	51.83	30.37	July 1843	Dec. 1860	16	6
Trenton, Mercer Co.	53.22	99	-13	112	51.41	74.15	55.52	31.8	Jan. 1840	Dec. 1880	21	....
Freehold, Monmouth Co.	50.73	99	-11	110	47.12	71.32	53	31.47	Jan. 1857	Dec. 1880	14	....
Sandy Hook Monmouth Co.	52.24	100	-5	105	48.44	72.12	55.48	32.92	Oct. 1874	Dec. 1880	6	3
Barnegat, Ocean Co.	51.24	96	-12	108	47.38	69.81	54.78	33	Oct. 1874	Dec. 1880	6	3
Atlantic City, Atlantic Co.	51.87	99	-7	106	47.86	70.23	55.53	33.86	Oct. 1874	Dec. 1880	6	3
Burlington, Burlington Co.	51.1	98	-15	113	49.71	72.01	54.81	31.22	Mar. 1849	Mar. 1868	13	3
Moorestown, Burlington Co.	51.74	102	-13	115	49.31	73.22	53.64	30.76	Mar. 1861	Dec. 1880	19	8
Haddonfield, Camden Co.	52.14	102	-12	114	49.96	72.98	54.15	31.46	Jan. 1864	Dec. 1870	7	....
Atco, Camden Co.	52.35	103	-15	118	50.23	73.5	53.09	32.58	Jan. 1872	Dec. 1880	9	....
Vineland, Cumberland Co.	53.13	106	-10	116	50.55	75.12	54.24	32.59	Aug. 1867	Dec. 1880	13	5
Greenwich, Cumberland Co.	53.12	95	-9	104	51.37	73.58	54.59	32.94	Mar. 1864	Feb. 1873	9	....
Seaville and Rio Grande, Cape May Co.	52.87	102	-2	104	49.19	73.77	55.27	33.25	Mar. 1865	Dec. 1875	11	....
Cape May, Cape May Co.	53.66	90	1	89	49.12	72.36	57.57	35.61	Jan. 1872	Jan. 1880	6	....

TABLE OF ATMOSPHERIC

Rain and Melted Snow. Average Amount for each

STATIONS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Goshen, Orange Co., N. Y.	2.5	2.42	2.52	2.14	3.3	3.53	2.98	2.55	2.74	2.95	2.27	3.4
Lake Hopatcong, Morris Co.	2.37	2.44	2.79	3.47	4.67	3.66	3.95	4.31	3.98	3.77	3.67	3.45
Newark, Essex Co.	3.54	3.36	3.81	3.83	3.98	3.49	4.39	5.47	3.59	3.62	3.73	3.8
South Orange, Essex Co.	3.12	2.84	4.48	3.45	2.62	2.8	5.15	5.75	3.79	3.32	3.57	3.84
New Germantown, Hunterdon Co.	2.88	2.88	4.07	3.24	3.29	4.03	4.71	4.95	3 12	5.02	3.71	2.46
New Brunswick, Middlesex Co.	3.07	2.97	3.38	3.78	3.82	3.89	4 63	4.94	3.39	3.33	3.67	3.41
Lambertville, Hunterdon Co.	3.22	3.12	3.22	3.19	4.29	3.38	4.07	4.94	3.9	3.41	3.21	3.87
Trenton, Mercer Co.	3.25	2.59	3.87	3.86	3.1	4.01	5.61	5.89	3.61	3.67	4.43	3.11
Freehold, Monmouth Co.	3.28	2.77	5.51	3.82	2.34	3.	4.38	5.56	3.63	2.71	4.01	3.98
Sandy Hook, Monmouth Co.	3.67	2.79	6.07	5.22	3.5	4.16	4.96	5.68	4.56	3.21	4.95	4.05
Barnegat, Ocean Co.	4.13	2.77	5.43	4.49	2.46	3.67	4.62	4.66	4.47	3.04	5.26	4.78
Atlantic City, Atlantic Co.	2.46	2.29	4.06	3.37	2.11	3.45	3.36	4.49	3.55	2.35	3.52	4.6
Burlington, Burlington Co.	2.72	3.61	3.3	3.81	6.16	5.04	3.5	5.31	3.38	3.36	2.91	4.12
Moorestown, Burlington Co.	3.	3.	3.17	3.17	4.21	3.76	4.48	4.15	3.77	3.46	3.45	3.28
Haddonfield, Camden Co.	3.13	2.92	4.17	3.38	6.2	3.57	2.79	4.97	4.59	3 55	3.39	4.04
Atco, Camden Co.	3.16	2.99	4.24	3.22	2.76	4.18	4.32	5.98	3.97	3.48	4.09	3.96
Vineland, Cumberland Co.	3.85	3.42	4.68	3.35	3.85	3.92	4.58	5.53	4.67	3.1	4.11	4.08
Greenwich, Cumberland Co.	2.97	3.86	4.28	2.51	4.74	3.17	2.81	4.29	4.06	2.95	3.25	2.64
Seaville and Rio Grande, Cape May Co.	4.73	6.56	7.	5.37	6.27	5.4	5.83	4.72	3.7	5.66	6.1	4.73
Cape May, Cape May Co.	3.55	3 35	5.25	3.51	2.6	4.26	3.42	6.33	4.41	3.18	3.8	4.51

PRECIPITATION.

Month. Depth in inches and fractions.

STATIONS.	Spring.	Summer.	Autumn.	Winter.	Year.	Extent of Series. Years.	Extent of Series. Months.	Date. Beginning.	Date. End.
Goshen, Orange Co., N. Y.	7.96	9.06	7.96	8.32	33.3	11	...	1834	1849
Lake Hopatcong, Morris Co.	10.93	11.92	11.42	8.26	42.53	24	...	Jan., 1846	Dec., 1869
Newark, Essex Co.	11.71	13.35	10.94	10.7	46.21	37	8	May, 1843	Dec., 1880
South Orange, Essex Co.	10.55	13.7	10.68	9.8	44.73	10	5	Aug., 1870	Dec., 1880
New Germantown, Hunterdon Co.	10.6	13.69	11.85	8.22	44.36	7	10	Nov., 1868	Aug., 1876
New Brunswick, Middlesex Co.	10.98	13.46	10.36	9.45	44.25	27	...	Jan., 1854	Dec., 1876
Lambertville, Hunterdon Co.	10.7	12.39	10.52	10.21	43.82	17	2	July, 1843	Aug., 1860
Trenton, Mercer Co.	10.83	15.01	11.71	8.95	46.5	13	...	Jan., 1868	Dec., 1880
Freehold, Monmouth Co.	11.67	12.94	10.35	10.03	44.99	6	9	Apr., 1874	Dec., 1880
Sandy Hook, Monmouth Co.	14.79	14.8	12.72	10.51	52.82	7	...	Jan., 1874	Dec., 1880
Barnegat, Ocean Co.	12.38	12.95	12.77	11.68	49.78	7	...	Jan., 1874	Dec., 1880
Atlantic City, Atlantic Co.	9.54	11.3	9.42	9.35	39.61	7	...	Jan., 1874	Dec., 1880
Burlington, Burlington Co.	13.27	13.85	9.65	10.45	47.22	5	9	July, 1856	Mar., 1868
Moorestown, Burlington Co.	10.55	12.39	10.68	9.28	42.90	15	9	Apr., 1865	Dec., 1880
Haddonfield, Camden Co.	13.75	11.33	11.53	10.09	46.7	6	9	Feb., 1864	Dec., 1870
Atco, Camden Co.	10.22	14.48	11.54	10.11	46.35	9	...	Jan., 1872	Dec., 1880
Vineland, Cumberland Co.	11.88	14.03	11.88	11.35	49.14	15	...	Jan., 1866	Dec., 1880
Greenwich, Cumberland Co.	11.53	10.27	10.26	9.47	41.53	9	...	Mar., 1864	Feb., 1873
Seaville and Rio Grande, Cape May Co.	18.64	15.95	15.46	16.02	66.07	{ 3 { 7	1 6	Mar., 1865 June, 1868	Apr., 1868 Nov., 1875
Cape May, Cape May Co.	11.36	14.01	11.39	11.41	48.17	9	4	Sept., 1871	Dec., 1880

TABLE OF MAXIMUM, MINIMUM

By Months, at Newark, New Jersey. Period, 1843–1880.

Expressed in degrees and

YEAR.	JANUARY. Maximum.	JANUARY. Minimum.	JANUARY. Mean.	FEBRUARY. Maximum.	FEBRUARY. Minimum.	FEBRUARY. Mean.	MARCH. Maximum.	MARCH. Minimum.	MARCH. Mean.	APRIL. Maximum.	APRIL. Minimum.	APRIL. Mean.
1843	....	....	....	....	....	....	....	....	....	....	....	....
1844	49	3.75	25.49	52	8.5	31	65	22	40.39	82	24.75	54.31
1845	47	12.75	33.22	54.25	3.5	30.84	77	21	40.65	77	27.5	49.92
1846	53.5	3.5	30.63	50.25	1.5	27.05	65.25	8	39.1	85.5	32.25	52.42
1847	64	5	30.87	50.75	0.5	29.71	63.5	18	35.5	82	18.5	48.08
1848	56.75	0	32.92	54	6	30.4	72	6.75	36	75.5	27.75	49.53
1849	57.5	−2.7	26.33	45.75	1	24.82	69.5	18.75	46.17	67.75	22.25	47.27
1850	57.7	13	34.44	63	10	35.23	71	9.75	38.19	74	24.25	47.74
1851	59.7	7.5	33.55	60.5	10	36.99	77.25	26	42.15	71.5	31.5	49.51
1852	51.75	−2.5	25.46	59.5	6	31.39	70.75	14.5	38.02	67.5	26.5	43.93
1853	54	6.7	30.79	58	14.75	34.98	69.75	15.5	42.11	75.5	32	49.74
1854	54.25	3.7	29.41	55.75	10.75	30.77	76.25	14	38.37	84.5	23.75	48.5
1855	54.75	12	32.46	46.5	−8	25.92	61.75	14.25	36.73	85	21.25	48.95
1856	39.5	7.5	21.55	45	−1	24.28	50	2.5	30.56	74.75	19.5	49.27
1857	37	−12	19.33	68	7	35.97	60.25	7.5	35.81	62.25	17	43.4
1858	54	16	36.15	46	−0.25	26.47	64.5	6.5	36.81	77	30.5	48.61
1859	55.5	12.5	29.88	57	12	32.81	63	17.75	43.9	74	29.75	47.51
1860	51.5	1.75	29 87	63	−4	28.63	71	20	41.27	76.25	23.75	47.54
1861	43.25	−5	27.76	62	−7.5	34.43	75	9	37.8	84	27	43.61
1862	51.5	6	27.56	44.7	12.5	29.58	51	18.75	36.24	82.5	27	49.45
1863	57.5	10.5	33.04	50.5	−3	31.4	51	12	32.54	71.25	27.75	47.31
1864	56.7	6	29.81	55.5	2	32.88	56	18	37.4	74.25	32	47.15
1865	44	2.5	23.15	49.25	1	29.35	73.5	19.5	43.16	79.25	35	52.97
1866	45.2	−12.7	25.74	59	5	30.24	64.25	15.25	36.19	82.5	30	51.88
1867	39	0.5	22.67	54.75	15.25	35.67	63.5	15.25	34.54	74	32.75	50.64
1868	43	6	25.92	51.25	−4.25	21.86	61	2	37.27	72.50	21.25	45.14
1869	51.5	10.5	32.68	59.7	14.7	33.29	63	6	34.44	78.75	28.75	50.49
1870	57	15.5	36.05	52.7	9.75	30.67	55.25	18	34.79	80.75	31	51.12
1871	49	0	25.75	51.25	1.25	28.65	63	28	43.03	84.5	32	52.84
1872	47.75	6.75	29.07	53.5	10	29.49	63	2.75	30.23	83.25	29.75	49.46
1873	42.25	−12	24.77	47.75	−1.5	27.41	52	8.5	34.47	64.5	33.25	46.58
1874	61.25	9	32.61	68.5	3.25	29.66	63.25	15.5	37.83	66.5	20.75	41.48
1875	37	−3	22.92	48.75	1.5	22.92	56	10.75	31.84	68	22	43.42
1876	65	12.25	34.9	55.25	6.5	32.13	66.25	10.75	36.13	69.5	29	48.46
1877	42.5	7.5	25.8	49	11	34.46	59.5	13	37.56	78.5	30.75	49.4
1878	48.25	9.5	31	55.7	8	33.24	67	17.25	45.16	78.5	40	55.55
1879	46.75	−2	25.69	49.75	10.5	27.68	63	16.5	38.42	76.25	24.5	47.96
1880	60	13.5	37.64	62.7	8	35.1	67	16.2	36.4	82	26	51.18
Mean........	....	....	29.11	....	....	30.47	....	....	37.76	....	....	48.71
Extremes..	65 37	−12.7 15.5	37.64 19 33	68.5 44.7	−8 15.25	36.99 21.86	77.25 50	2 26	46.17 30.23	85.5 62.25	17 40	55.55 41.48
Range......	77.7		....	76.5		....	75.25		....	68.5		....

AND MEAN TEMPERATURES,

AS OBSERVED BY WILLIAM A. WHITEHEAD.

fractions of degrees.

YEAR.	MAY. Maximum.	MAY. Minimum.	MAY. Mean.	JUNE. Maximum.	JUNE. Minimum.	JUNE. Mean.	JULY. Maximum.	JULY. Minimum.	JULY. Mean.	AUGUST. Maximum.	AUGUST. Minimum.	AUGUST. Mean.
1843	85.9	38	56.68	92	38.25	60.25	99.25	61	72.89	86.75	56.25	71.31
1844	85.75	38	62.22	92	46	67.97	92.5	49.75	72.59	88	51.5	70.86
1845	86.5	36	58.93	93.5	43	69.01	98.25	46.25	74.19	87.5	57.25	73.07
1846	85	40.5	60.48	86	48	66.32	94	51.5	72.61	90.5	56	72.15
1847	86.75	34	57.04	91	45.25	65.63	93.5	51.25	74.26	84.75	49	70.51
1848	85	37	60.69	94.5	40.5	68.86	90.25	51	71.87	87.75	50.5	71.04
1849	83.25	37.5	55.52	96	48.25	70.15	99.75	51.25	73.84	85	55.25	72.13
1850	86.75	37.75	57.02	93	46.25	71.09	93.5	55.5	75.4	92	53	72.38
1851	86	34	59.54	93.25	41	66.88	90.5	55	74.2	88	48	69.54
1852	83.25	36.5	59.6	95.25	43.75	68.93	94	55	74.14	87.5	50	69.77
1853	88.75	39.25	61.64	97	45.25	71.17	90.5	55.25	73.13	95	51.5	73.17
1854	81.5	34	61.18	91	46.25	69.47	98.25	57.25	75.73	99	46.75	71.46
1855	83	32.75	59.09	96.5	48.75	67.16	94.25	54.75	74.75	84.5	49	69.44
1856	85.5	37.25	56.25	93	48.75	70.57	97	58	76.07	87.5	47.5	70.13
1857	80.75	36	57.26	85	50	65.48	87.25	50.75	71.76	89	50.75	69.93
1858	76	40.25	54.82	91.25	46	70.94	91.5	58.75	73.4	84.25	48	69.41
1859	82.5	41.5	59.51	91	40	65.38	91.5	52	70.23	88	47	68.74
1860	82.75	42.25	58.06	90	51.25	67.48	89.25	52.5	70.85	88	52	70.75
1861	77.5	31	54.72	85.5	48	67.33	91.5	51.5	71.55	89.25	52	69.77
1862	80	39.5	59.3	84	44	65.1	88.5	52.5	70.97	90.25	49.5	71.17
1863	87.5	38	60.52	87.5	50	64.76	86.5	60	72.94	90.75	52	73.69
1864	81.5	38.75	62.01	94.5	45	67.32	88.25	53	72.52	91.75	57.5	74.61
1865	82.5	42	59.27	89	57.5	71.72	91.5	54	72.49	88	49.75	69.83
1866	81	38.75	57.38	89.75	50	67.64	98.5	54	76.08	85.75	48.75	67.3
1867	79.5	34.5	55.31	84	45.25	66.9	88	56	70.94	84	50	70.79
1868	71	38	55.31	85.5	49.5	65.85	92	61.25	75.74	87	56	72.25
1869	83.5	38.25	57.37	86.5	47	68.42	91.75	56.5	72.15	91.5	51	70.32
1870	82	42.5	60.41	92.5	55.25	72.35	92.25	56	75.58	88	53.75	73.25
1871	87.75	40	59.65	85.75	53.5	68.2	86.25	55.75	71.48	85.5	56.5	73.12
1872	90	41.75	62.81	89.75	50.75	70.82	94	62.5	76.79	88.5	53.75	74.75
1873	83	36.75	57.97	88.75	47.75	68.59	91.5	58	74.13	88.5	56.5	74.4
1874	88.25	33.75	58.62	91	50.5	69.41	88.5	59.5	73.48	89	53.5	69.25
1875	85.25	36.25	60.13	92	47	68.75	91	58	72.88	83.75	56.5	70.94
1876	85.25	35.75	59.46	90	47.75	72.18	98	58	78.31	92.25	53.5	74.15
1877	87	37.25	60.56	93.5	53.75	71.58	99	60.5	77.86	94.75	60	76.57
1878	85	39	60.73	93.25	48.75	68.2	98.25	61.5	78.25	90.5	55	73.09
1879	88.7	37.8	63.8	93	48	71.6	99	58	75.4	93	54	71.7
1880	96	35	68.38	94	49.3	73.7	92	56.5	75.31	90	50.7	72.62
Mean........	....	....	59.19	....	....	68.5	....	....	73.86	....	....	71.55
Extremes..	{96 {71	31 42.5	68.38 54.72	97 84	38.25 57.5	73.7 60.25	99.75 86.25	46.25 62.5	78.31 70.23	99 83.75	46.75 60	74.75 67.3
Range......	65		....	58.75		....	53.5		....	52.25		....

TABLE OF MAXIMUM, MINIMUM

By Months, at Newark, New Jersey. Period, 1843–1880.

Expressed in degrees and

YEAR.	SEPTEMBER. Maximum.	SEPTEMBER. Minimum.	SEPTEMBER. Mean.	OCTOBER. Maximum.	OCTOBER. Minimum.	OCTOBER. Mean.	NOVEMBER. Maximum.	NOVEMBER. Minimum.	NOVEMBER. Mean.	DECEMBER. Maximum.	DECEMBER. Minimum.	DECEMBER. Mean.
1843	88	35.5	64.03	72	29	49.87	62.75	21	38.16	45.5	8.5	33.07
1844	87.25	39.75	63.61	73	33.5	51.08	66.25	23.5	41.86	61	10.75	33.16
1845	81	39.25	62.1	72.75	22.25	53.19	71	16	44.13	42	6	27.2
1846	89	40.25	68.64	82.5	27	52.08	63.5	19	46.31	61	10	32.19
1847	86.25	41	63.17	70.25	23.5	50.18	73.75	8.5	46.37	65.25	8	36.76
1848	87.5	34.5	61.75	73	32	52.45	61	17.5	39.96	68.5	10.5	40.31
1849	84.5	43	64.58	72	34.75	53.12	73.25	27	49.66	52.5	6	33.26
1850	85.75	42	65.75	74.75	32	56.21	67.5	25.75	47.02	56.75	11	33.79
1851	93.25	37.5	65.54	76.75	34.25	55.43	63	21.75	40.2	53	7.5	27.65
1852	90	42	63.92	80	31	55.54	63.25	23.25	41.42	64	16.5	39.79
1853	90.25	38.75	64.71	72.5	31	51.94	69.25	18.75	45.43	52.5	8.5	32.68
1854	93.75	36	64.45	77.5	28	53.77	68.75	21	43.94	50	2	29.05
1855	88.75	40	64.5	72.5	33	51.43	66	22	44.1	53.5	12	33.6
1856	87	42.25	64.57	76.5	28.75	51.98	69.5	24.25	42.34	53.5	1.25	29.81
1857	80.75	39	62.81	70.25	33.5	52.61	73	15.75	41.72	57.5	11	37.27
1858	82.25	38.75	62.94	82.75	35.25	55.11	61.5	21.75	38.08	55.5	11	32.86
1859	76.5	42	61.05	72	29	48.61	66.25	22.25	44.27	61.75	2.5	29.45
1860	83.75	39	60.2	72	34.75	52.26	70	9.75	43.62	44.75	6.5	28.77
1861	81.5	45.75	64.43	83	31	56.62	60.5	26	41.68	62.25	12.25	33.93
1862	81.5	43.75	64.44	81.25	31.5	54.29	67.5	25	42.31	66	5	33.56
1863	78.25	39	60.02	69.25	30	51.75	65	25.25	44.29	54.75	9.5	31.32
1864	76.75	44	62.22	70	32	51.61	67	21	42.44	59	5.5	32.67
1865	86	44	68.45	79.5	33	52.19	69.5	24	43.21	61.5	14	35.29
1866	84.25	43.25	65.23	73.5	33.25	54.17	62.75	23.5	44.95	56.25	-.5	30.92
1867	83.25	43.75	64.37	74.75	34.75	53.91	68	19	43.44	50.25	1.5	26.88
1868	86	41.25	63.86	67	28	49.84	68	28.5	42.25	42.75	8	28.12
1869	85.5	42.5	64.18	72	28.5	49.56	59.75	25	38.72	54.25	10.5	33.2
1870	83	47	65.3	76	32	55.39	64.5	26.5	43.73	53.25	5.75	33.43
1871	77.75	38.75	59.98	73.25	31.75	53.5	64.75	12.75	39.33	54.5	-1.5	28.96
1872	89	46.75	65.83	73.75	34.75	52.42	58	13	39.04	43.25	2	24.5
1873	84.5	42.75	63.89	71.75	30	53.37	57.25	20.5	36.12	64.75	16.75	34.38
1874	88.25	48	66.79	70.25	33.5	53.69	64.5	20.75	40.98	50.5	7.75	31.19
1875	85.5	41	62.5	69.5	33.5	51.83	61.75	8	37.98	58.5	2.5	32.3
1876	88	45.75	62.81	71.25	30.75	48.67	70	27.5	43.72	44	4	23.81
1877	85	47.5	66.74	75.5	35.75	55.57	65.75	25.75	44.82	58.5	22.75	37.65
1878	88	43.75	67.47	76.75	35	56.41	58	27	42.65	57.75	13.5	31.83
1879	86.7	38.8	62.4	82	26.5	59.4	71	17	41.8	59	11.5	35
1880	90	46.7	65.96	76	31.7	52.71	65	14	38.44	44	-6.5	25.5
Mean	....	....	64.11	....	....	52.94	....	....	42.38	....	....	81.98
Extremes	93.75 76.5	34.5 48	68.64 59.98	83 67	22.25 35.75	59.4 48.61	73.75 57.25	8 28.5	49.66 36.12	68.5 42	-6.5 22.75	23.81 40.31
Range	59.25		....	60.75		....	65.75		....	75		....

AND MEAN TEMPERATURES,

As observed by WILLIAM A. WHITEHEAD.

fractions of degrees.—*Continued.*

YEAR.	Mean Annual Temperature.	Maximum.	Minimum.	Range for Year.	Greatest Monthly Range.	MEAN TEMPERATURE. Spring.	Summer.	Autumn.	Winter.
1843	....	....	....	....	....	....	71.15	51.01	} 29.85
1844	51.21	92.5	3.75	88 75	67.25	52.3	70.47	52.17	
1845	51.29	98.25	3.5	94.75	56	49.83	72.09	53.14	32.41
1846	51.66	94	1.5	92.5	57.25	50.65	70.36	55.68	28.3
1847	50.67	93.5	0.5	93	63.5	47.14	70.13	53.21	30.92
1848	51 31	94.5	0	94.5	65.25	48.74	70.59	51.13	33.26
1849	51.39	99.75	-2.75	102.5	60.25	47.65	72.05	55.72	30.48
1850	52.85	93.5	10	83.5	61.25	48.32	72.96	55.32	34.31
1851	51.75	93.25	7.5	85.75	55.75	50.4	70.21	53.72	34.77
1852	50.99	95.25	-2.5	97.75	55.25	47.19	70.95	53.5	28.17
1853	52.63	97	6.75	90.25	53.25	51.16	72.49	54.64	35.18
1854	51.34	98.25	2	96.25	62 25	49.35	72.22	54.06	30.95
1855	50.68	96.5	-8	104.5	54.5	48.26	70.45	53.31	29.15
1856	48.95	97	-1	98	54.25	45.36	72.26	52.96	26.48
1857	49.45	89	-12	101	57.25	45.49	69.05	51.72	28.37
1858	50.47	91.5	-0.25	91.75	58	46.75	71.25	52.24	33.3
1859	50.11	91.5	-12.5	104	59.25	50.31	68.12	51.31	31.84
1860	49.94	90	-4	94	67	48.96	69.69	52.26	29.48
1861	50.3	91.5	-7.5	99	69.5	47.82	69.55	54.24	30.32
1862	50.33	90.25	5	85.25	61	47.72	71.08	53.68	30.36
1863	50.3	90.75	-3	93.75	53.5	46.71	70.13	52.02	32.67
1864	51.05	94.5	2	92.5	54.5	48.85	71.48	52.09	31.34
1865	51.76	91.5	1	90.5	54	51.8	71.35	54.62	28.4
1866	50.64	98.5	-12.75	111.25	61.25	48.48	70.34	54.78	30.44
1867	49.67	88	0.5	87.5	49	46.83	69.55	53.91	29.75
1868	48.62	92	4.25	96.25	59	45.91	71.28	52.09	24.89
1869	50.42	91.75	6	85.75	57	47.43	70.3	50.82	31.36
1870	53.51	92.5	5.75	86.25	51.75	48.77	73.73	54.81	33.31
1871	50.37	87.75	-1.5	89.25	56	51.83	70.93	50.93	29.61
1872	50.43	94	2	92	60.25	45.91	74.12	52.43	29.17
1873	49.67	91.5	-12	103.5	54.25	46.27	71.04	51.12	25.59
1874	50.41	91	3.25	87.75	65.25	45.97	70.7	53.82	32.21
1875	48.2	92	-3	95	56	45.13	70.86	50.77	25.67
1876	51.23	98	4	94	55.75	48.05	74.88	51.73	33.11
1877	53.21	99	7.5	91.5	50.25	49.14	75.34	55.71	28.03
1878	53.13	98.25	8	90.25	50.25	53.81	73.81	55.51	33.96
1879	51.74	99	-2	101	54	50.06	72.9	54.53	28.4
1880	52.73	96	-6.5	102.5	54.7	51.98	73.75	52.37	35.91
Mean........	50.88	....	....	....	....	48.55	71.41	53.13	30.59
Extremes..	{ 53.51 48.2	99.75 87.75	-12.75 8	111.25 83.5	69.5 50.25	53.81 45.13	75.34 68.12	55.72 50.77	35.91 24.89
Range	5.31	112 5		....	....	....	....	....	....

TABLE OF RAINFALL

Rain and Melted Snow. In inches and fractions of inches,

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1843	....	....	....	....	0.85	1.59	2.285	*22.485	3.61	5.905	3.92	4.145
1844	4.985	1.64	4.785	0.39	3.55	2.56	5.82	2.08	2.97	5.515	2.04	3.875
1845	3.37	4.21	3.765	1.275	2.155	3.4	2.175	4.8	2.455	2.255	2.875	3.735
1846	5.125	4.16	3.415	3.265	8.745	2.175	4.73	4.105	0.55	2.815	8.745	8.745
1847	4.655	6.075	4.145	0.85	3.155	6.25	3.305	2 89	11.3	3.46	2.84	5.91
1848	1.825	1.815	2.395	1.335	5.985	6 005	2.065	0.955	2.195	4.965	2.72	4.52
1849	0.64	2.69	4.855	0.91	4.235	1.09	2.365	8.085	1.6	6.93	2.18	4.47
1850	5.01	3.055	4.175	3.03	7.435	3.535	7.42	4.725	4.405	1.725	1.52	5.11
1851	2 01	4.5	3.967	6.09	3.93	1.105	6.435	1.52	0.625	3.66	4.61	1.93
1852	2.92	2.205	4 805	5 215	2.675	1.72	2.535	4.165	1.74	2.17	5.845	7.545
1853	3 09	5.22	3.145	3.015	4.675	3.655	3.25	11.225	5.03	5.08	3.67	1.285
1854	1.79	5.02	0.98	11.365	4.17	2.1	3.58	1.125	3.96	2.44	4.31	2.635
1855	4.03	3.466	1.875	2.47	2.365	4.525	4.47	4.16	2.25	5.26	2.89	6.5
1856	3.37	1.25	2	2.57	4.315	3.12	1.41	5.7	2.665	1.4	2.79	3.485
1857	3.83	1.5	1.99	7.155	6.03	5.345	5.08	4.015	3 81	3.955	0.87	5.785
1858	3.405	2.495	1.01	3.852	4.995	4.65	2.995	4.21	1.41	3.01	4.785	4.26
1859	6.055	3.8	6.885	5.305	2.25	3.945	4.025	6.265	6.985	2.55	3.785	5.2
1860	2.32	2.71	1.225	2.51	5	1.815	2.72	6.235	5.65	2.835	6 715	3.42
1861	4.466	1.885	4.915	4.92	5.19	2.6	1.12	3.97	3.26	2.865	6.425	1.99
1862	5.415	3.695	3.995	3.215	3.045	6.605	3.02	3.005	2.125	4.265	4.455	1.85
1863	4 27	4.25	5.25	5.835	4.49	1.045	5.955	4.975	1.3	3.445	2.61	4.575
1864	1.73	0.825	3.145	3.67	5.28	1.855	2.675	3.21	4.68	2.675	3.95	4.76
1865	4.09	4.57	4.89	3.34	5.73	3.485	6.735	3.935	3.21	4.685	3.3	4.385
1866	1.74	5.07	1.82	2.82	4.4	2.505	1.84	5.345	5.47	3.97	2.09	2.91
1867	1.61	5.64	4.395	2.575	6.55	9.745	3.755	10.615	1.235	4.62	1.945	2.045
1868	3.275	1.620	2.17	5.255	6.925	5.895	8.535	4.755	8.955	1.25	4.375	3.845
1869	3.42	5.055	4 67	1.15	4.67	5.845	3.69	1.555	2.54	6.82	3.085	5.435
1870	4.725	4.265	4.555	7	1.995	3.125	6.965	3.095	2.795	4.75	2.46	2.185
1871	3.035	3 045	4.99	3.685	3.95	7.105	4.14	5.81	1.99	6.026	3.99	2.175
1872	1.845	1 775	3.88	3.745	3.075	4.27	8.94	6.625	3.24	3.11	4.175	3.785
1873	5.82	3 885	2.76	5.835	3.755	1.715	6.615	7.765	3.55	3.74	4.67	2.47
1874	5.67	3.168	2.135	8.715	2.755	3.58	4.23	2.785	9.05	2.435	2.86	2.81
1875	3 31	2.4	3.82	3 135	1.595	2.335	5.985	10.215	1.93	2.87	4.36	2.61
1876	1.2	5 355	10	3.805	3.045	1.585	3.06	2.45	7.505	1.26	4.04	2.515
1877	3 06	1.65	6.075	3.125	1.01	4.17	5.98	7.73	1.47	7.735	6.915	0.92
1878	6 525	4.96	3.635	1.73	4.205	2.445	4.33	8.06	2.535	2.83	4.57	7.469
1879	2.89	2 53	3.745	4.76	2.175	3.038	5.05	9.12	3.75	0.32	1.94	5.83
1880	2.59	2 83	4.9	3.305	0.76	1.185	7.46	4.68	2.48	2.1	2.365	2.685
Mean........	3.544	3.359	3.812	3.83	3.979	3.493	4.388	5.472	3.589	3.624	3.729	3.798
Maximum	6.525	6.075	10	11.365	8.745	9.746	8.94	22.485	11.3	7.735	8.745	7.545
Minimum ..	0 64	0 825	0.98	0.39	0.85	1.045	1.12	0.955	0.55	0.32	0.87	0 92

* Very remarkable, perhaps unprecedented.

AT NEWARK, N. J.

As observed by WILLIAM A. WHITEHEAD.

YEAR.	Spring.	Summer.	Autumn.	Winter.	Year.	DAYS. Fair.	Rainy.	Snow.	Winter.	DEPTH OF SNOW. Feet.	Inches.
1843	....	26.36	13.345	....	....	....	....	....	....	......	......
1844	8.725	10.46	10.525	10.77	40.21	222	101	23	'43–44	2	7
1845	7.195	10.375	7.585	11.455	36.47	238	88	24	'44–45	3	3
1846	15.425	11.01	12.11	13.02	51.575	209	98	23	'45–46	4	4
1847	8.15	12.445	17.6	14.475	54.835	219	91	31	'46–47	4	....
1848	9.715	9.025	9.88	9.55	36.78	233	91	23	'47–48	1	10
1849	10	11.54	10.71	7.85	40.05	214	95	22	'48–49	3	9
1850	14.64	15.68	7.65	12.535	51.145	224	97	28	'49–50	2	7
1851	13.987	9.06	8.895	11.62	40.382	232	91	18	'50–51	2	1
1852	12.695	8.42	9.755	7.055	43.54	233	90	28	'51–52	5	3
1853	10.835	18.13	13.78	15.855	52.34	236	98	21	'52–53	2	1
1854	16.515	6.805	10.71	9.095	43.475	230	79	34	'53–54	5	11
1855	6.71	13.155	10.4	10.131	44.261	220	94	22	'54–55	3	9
1856	8.885	10.23	6.855	11.12	34.075	253	79	23	'55–56	5	5
1857	15.175	14.44	8.635	8.815	49.365	219	101	32	'56–57	4	4
1858	9.857	11.855	9.205	11.685	41.077	235	98	19	'57–58	2	4
1859	14.44	14.235	13.32	14.115	57.05	220	90	28	'58–59	3	11
1860	8.735	10.77	15.2	10.23	43.155	227	79	28	'59–60	4	3
1861	15.025	7.69	12.55	9.77	43.605	236	86	34	'60–61	4	....
1862	10.255	12.63	10.815	11.1	44.69	218	99	29	'61–62	4	4
1863	15.575	11.975	7.355	10.37	48	213	113	27	'62–63	4	2
1864	12.095	7.74	11.305	7.13	38.455	239	82	28	'63–64	1	10
1865	13.96	14.155	11.195	13.42	52.355	228	85	26	'64–65	4	....
1866	9.04	9.69	11.53	11.195	39.98	228	97	24	'65–66	2	11
1867	13.52	24.115	7.8	10.16	54.73	213	101	37	'66–67	5	2
1868	14.35	19.185	14.58	6.74	56.855	204	101	36	'67–68	6	3
1869	10.49	11.09	12.445	12.32	47.935	228	112	38	'68–69	1	10
1870	13.55	13.185	10.005	14.425	47.915	230	88	27	'69–70	1	6
1871	12.625	16.555	12.005	8.265	49.441	227	98	27	'70–71	3	1
1872	10.7	19.835	10.525	5.795	48.465	243	86	31	'71–72	1	4
1873	12.35	16.095	11.96	13.49	52.58	232	97	35	'72–73	5	3
1874	13.605	10.595	14.315	11.308	50.193	239	92	28	'73–74	3	....
1875	8.55	18.535	9.16	8.52	44.565	219	102	44	'74–75	3	7
1876	16.35	7.095	12.805	9.165	45.32	216	96	31	'75–76	1	11
1877	10.21	17.88	16.12	7.225	49.84	228	98	13	'76–77	2	11
1878	9.57	14.835	9.935	12.405	53.294	219	110	18	'77–78	1	2
1879	10.68	17.208	6.01	12.889	44.648	201	94	39	'78–79	2	11
1880	8.965	13.325	6.945	10.75	37.34	220	94	26	'79–80	2	5
Mean........	11.707	13.353	10.939	10.698	46.205	225	94	28	....	3	4
Maximum	16.515	26.36	17.6	15.855	57.05	253	113	44	....	6	3
Minimum	7.195	6.805	6.01	5.795	34.075	201	79	13	....	1	2

CLIMATE OF NEWARK, 1843-1880.—38 YEARS.

	Range of Fair Days.	Rainy Days.	Days of Snow.	Average Number of Fair Days.	Percentage of Fair Days.	Range of Dry Periods, Days.	Number of Rains over three inches.	RANGE OF TEMPERATURE. Days on which Temperature was 32° and below.	RANGE OF TEMPERATURE. Days on which Temperature was 85° and upwards.
January...	13—21	1—11	1—12	17	54.8	5—15	1	2[1]—22[2]	....
February..	12—21	1—11	2—13	16.5	58.4	4—14	1	2 —18	....
March......	13—23	2—16	1—11	18	58	5—16	1	0 — 7	....
April.......	12—23	5—13	0— 9	17.5	58.3	3—15	1	....	....
May.........	12—25	5—17	0— 2	18.7	59.9	4—14	2	....	0 — 8[5]
June........	15—26	5—15	....	20.5	68.3	3—20	1	....	0 —11[6]
July.........	14—25	4—15	....	19.75	63.7	6—15	3	....	1[7]—24[8]
August.....	14—26	5—15	....	19.75	63.7	5—20	8	....	0[9]—20[10]
September	12—24	3—14	....	18.75	62.5	3—21	8	....	0 — 6
October.....	12—24	3—12	0— 2	18	58	3—29	5	0 — 6	....
November	10—22	4—15	0—10	16	53.3	3—18	3	0 —21[3]	....
December	11—24	2—13	1—10	17	54.8	3—24	2	1 —28[4]	....

1 January, 1880. 2 January, 1867. 3 November, 1880. 4 December, 1880.
5 May, 1880. 6 June, 1880. 7 July, 1863. 8 July, 1878 (90° and upwards, 14 days)
9 August, 1875. 10 August, 1877.

List of Meteorological Stations whose Records Furnish Materials for Climatology.

STATIONS.	COUNTY.	STATE.	OBSERVERS.	SERIES. Beginning.	SERIES. End.	EXTENT. Years.	EXTENT. Months.
West Point	Orange	New York	Assistant Surgeon United States Army	Jan., 1824	Dec., 1870	46	5
White Plains	Westchester	New York	Prof. O. R. Willis	Jan., 1854	Dec., 1880	18	9
Goshen	Orange	New York	(Various Observers)	Jan., 1835	Dec., 1849	11	
Port Jervis	Orange	New York	Charles F. Van Inwegen	Jan., 1880	Dec., 1880	1	
Deckertown	Sussex	New Jersey	A. C. Noble	Jan., 1880	Sept., 1880		7*
Newton	Sussex	New Jersey	Dr. T. Ryerson, Jonathan Havens	Dec., 1868	——, 1880	4*	
Lake Hopatcong	Morris	New Jersey	Morris Canal Company	Jan., 1846	Dec., 1869	24	
Mount Olive	Morris	New Jersey	A. A. Titsworth	Aug., 1879	Aug., 1880		4*
Dover	Morris	New Jersey	H. Shriver	Oct., 1866	Jan., 1869	2	4*
Schooley's Mountain	Morris	New Jersey	L. H. Hunt	Jan., 1880	Feb., 1880		2
Easton	Northampton	Pennsylvania	S. J. Coffin, G. R. Houghton	Jan., 1855	Dec., 1859	5	
New York City		New York	(Various Observers)	Jan., 1844	Dec., 1880	31	11
Fort Columbus		New York	Assistant Surgeon United States Army	Oct., 1821	Dec., 1870	48	8
Jersey City	Hudson	New Jersey	T. T. Howard, Jr., F. S. Cook	Jan., 1871	Jan., 1879	7*	
Paterson	Passaic	New Jersey	W. Brooks, John T. Hilton	Oct., 1863	Dec., 1880	11*	
Bloomfield	Essex	New Jersey	R. L. Cooke, —— Merrick	March, 1849	Dec., 1862	10	7
East Orange	Essex	New Jersey	T. T. Howard, Jr.	June, 1877	Aug., 1878	2*	
Orange	Essex	New Jersey		June, 1872	Dec., 1874	2	6
South Orange	Essex	New Jersey	Dr. William J. Chandler	Aug., 1870	Dec., 1880	10*	7
Newark	Essex	New Jersey	William A. Whitehead	May, 1843	Dec., 1880	37	8
Passaic Valley	Union	New Jersey		Dec., 1863	June, 1864		2
Linden	Union	New Jersey	A. B. Noll	Nov., 1876	Dec., 1880	4	2
New Germantown	Hunterdon	New Jersey	A. B. Noll	Nov., 1868	Aug., 1876	7	10
Pleasant Run	Hunterdon	New Jersey		Sept., 1877	May, 1878		2*
Readington	Hunterdon	New Jersey	John Fleming	Dec., 1866	Nov., 1873	7*	
Lesser Cross Roads	Somerset	New Jersey		Nov., 1869	Feb., 1870		4*
White House	Hunterdon	New Jersey		May, 1869	June, 1869		2
Sergeantville	Hunterdon	New Jersey	J. T. Sergeant	Jan., 1857	March, 1858	1	3
Mount Horeb	Somerset	New Jersey	A. A. Titsworth	July, 1879	July, 1879		1*
Somerville	Somerset	New Jersey	William J. Morgan	——, 1878	——, 1880		
Roycefield	Somerset	New Jersey		Jan., 1872	Feb., 1873	1	2
Princeton	Mercer	New Jersey	Prof. Charles G. Rockwood	Jan., 1879	Dec., 1880	2	
Pennington	Mercer	New Jersey	Rev. Frank Miller	Feb., 1877	March, 1877		2*
New Brunswick	Middlesex	New Jersey	Prof. Geo. H. Cook, Geo. W. Thompson, Ag'l Coll. Farm	Jan., 1854	Dec., 1880	27*	
Lambertville	Mercer	New Jersey	L. H. Parsons	Jan., 1843	Dec., 1859	17	
Trenton	Mercer	New Jersey	Dr. F. A. Ewing, E. R. Cook	Jan., 1840	Dec., 1880	21*	
Morrisville	Bucks	Pennsylvania	—— Pierce, E. Hance	Jan., 1790	Dec., 1859	67	10

* Incomplete.

List of Meteorological Stations whose Records Furnish Materials for Climatology—*Continued.*

STATIONS.	COUNTY.	STATE.	OBSERVERS.	SERIES. Beginning.		SERIES. End.		EXTENT. Years.	EXTENT. Month.
Fallsington	Bucks	Pennsylvania	E. Hance	Jan.,	1860	Dec.,	1876	11	
Sandy Hook	Monmouth	New Jersey	United States Signal Service	Oct.,	1871	Dec.,	1880	6	3
Riceville	Monmouth	New Jersey		Jan.,	1861	Aug.,	1861		8
Middletown	Monmouth	New Jersey	Colb & Jenkins	June,	1831	March,	1849	3	2
Long Branch	Monmouth	New Jersey	United States Signal Service	Oct.,	1874	June,	1876	1	9
Ocean Grove	Monmouth	New Jersey	H. B. Beegle	Aug.,	1874	March,	1876	1	8*
Squan Beach	Monmouth	New Jersey	United States Signal Service	Oct.,	1874	Jan.,	1876	1	4
Barnegat	Ocean	New Jersey	United States Signal Service	Oct.,	1874	Dec.,	1880	6	3
Atlantic City	Atlantic	New Jersey	United States Signal Service	Oct.,	1874	Dec.,	1880	6	3
Somers' Point	Atlantic	New Jersey		Oct.,	1863	Oct.,	1863		1
Peck's Beach	Cape May	New Jersey	United States Signal Service	Oct.,	1874	Jan.,	1876	1	4
Freehold	Monmouth	New Jersey	Professors O. R. Willis and C. F. Richardson	Jan.,	1857	Dec.,	1880	13	
Hightstown	Mercer	New Jersey	Peddie Institute	Jan.,	1876	Nov.,	1876		8
New Lisbon	Burlington	New Jersey	Eayre Oliphant	Jan.,	1880	June,	1880		6*
Mount Holly	Burlington	New Jersey	Dr. M. J. Rhees and Dr. F. Ashhurst	Jan.,	1861	June,	1876	8	11*
Moorestown	Burlington	New Jersey	E. E. Thornton, J. W. Lippincott and Thos. J. Beans	July,	1849	Dec.,	1880	16*	
Haddonfield	Burlington	New Jersey	J. S. Lippincott, S. Wood and J. Boadle	Jan.,	1864	Dec.,	1870	6	9
Atco	Camden	New Jersey	H. A. Green	Nov.,	1871	Dec.,	1880	9	2
Elwood	Atlantic	New Jersey	J. S. Tritts	March,	1868	Sept.,	1868		9
Newfield	Gloucester	New Jersey	E. D. Couch	Oct.,	1867	July,	1870	2	10
Vineland	Cumberland	New Jersey	Dr. J. Ingram	Jan.,	1866	Dec.,	1880	15	
Florence	Burlington	New Jersey	J. Kennedy Barton	Jan.,	1876	Jan.,	1876		1*
Burlington	Burlington	New Jersey	Rev. A. Frost, Dr. E. R. Schmidt and J. C. Deacon	March,	1849	March,	1868	13	3
Progress	Burlington	New Jersey		April,	1863	March,	1865		
Camden	Camden	New Jersey	J. M. Vanhekle	March,	1877	Nov.,	1877		9
Philadelphia	Philadelphia	Pennsylvania	(Various Observers)	Feb.,	1831	Dec.,	1880	50	
Woodstown	Salem	New Jersey	G. Watson		1859		1859		3
Salem	Salem	New Jersey	W. B. Matlock	Jan.,	1877	Jan.,	1878	1	1
Fort Delaware		Delaware	Assistant Surgeon United States Army	Feb.,	1825	Sept.,	1870	18	10
Allowaystown	Salem	New Jersey		Nov.,	1871	Nov.,	1873	2	2
Dover	Kent	Delaware	J. H. Bateman	Aug.,	1870	Dec.,	1880	10	5
Milford	Kent	Delaware	R. H. Gilman	Dec.,	1857	April,	1878	9	6
Greenwich	Cumberland	New Jersey	Rebecca C. Sheppard	Jan.,	1864	Feb.,	1873	9	2
Seaville	Cape May	New Jersey	B. Cole	Jan.,	1865	April,	1868	2	
Rio Grande	Cape May	New Jersey	Mrs. J. R. Palmer	April,	1868	Nov.,	1875	7*	
Cape May	Cape May	New Jersey	United States Signal Service	Sept.,	1871	Dec.,	1880	7	4

* Incomplete.

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GEOLOGICAL SURVEY OF NEW JERSEY.
GEORGE H. COOK, STATE GEOLOGIST
JOHN C. SMOCK, ASST GEOLOGIST
THE
STATE OF NEW JERSEY
ECONOMIC GEOLOGY.
1880.
Scale: 6 Miles to 1 Inch
Statute Miles
JULIUS BIEN LITH.
Longitude West 75°00' from Greenwich
DELAWARE BAY
RARITAN BAY
NEW YORK BAY
PHILADELPHIA CITY
NOTE.
Iron Mines are shown in red
GEOLOGICAL SECTION,
SHOWING THE
FORMATIONS OF NEW JERSEY IN ORDER AND THEIR EQUIVALENT SOILS.
SOILS
COLORS
SECTION
FORMATIONS
Alluvial Soils
Oak Land Soils
Pine Land Soils
Upper Marl Bed
Middle Marl Bed
Lower Marl Bed
Clay Marl
Clay and Sand Soils
Red Sandstone,
Shale and Trap Soils
Limestone Soils
Slaty Soils
Limestone
Sandstone
Conglomerate Soils
Slate
Limestone
Sandstone Soils
Limestone and Granitic Soils
Alluvium
Glacial Drift
Gravelly Earth
Glass Sand and Sandy Clays
Upper Marl Bed
Middle Marl Bed
Red Sand Bed
Lower Marl Bed
Laminated Sand and Clay Marls
Potters and Fire Clays, and Sands
Conglomerates, Shales, Trap
Red Sandstone and Trap Rocks
Marcellus Shale
Cherty Limestone
Cauda-Galli Grit
Oriskany Sandstone
Lr. Helderberg Limestone and Wat. Lime
Red Slates and Sandstone
Sandstone and Cong. of Kittatinny Mt.
Shales, Roofing Slates, and Slaty Sandstones
Fossiliferous Limest'e
Magnesian Limestone
Sandstone, Slaty Grit and Green Pond Mt Conglomerates
Serpentine
Gneiss
Crystalline Limestone
Granite
POST TERTIARY
TERTIARY
CRETACEOUS
TRIASSIC
DEVONIAN
SILURIAN
AZOIC