GEOLOGICAL SURVEY OF NEW JERSEY.

ANNUAL REPORT

OF THE

STATE GEOLOGIST,

FOR THE YEAR

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His Excellency, George B. McClellan, Governor, and *ex-officio* President of the Board.....Trenton.

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George H. Cook, State Geologist.....New Brunswick.
John C. Smock, Assistant Geologist.....New Brunswick.

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

SIR—I have the honor herewith to submit my annual report on the progress of the State Geological Survey for the year 1878, as required by the "Act to complete the Geological Survey of the State, approved March 30th, 1864."

With high respect,

Your obedient servant,

GEORGE H. COOK,

State Geologist.

REPORT.

INTRODUCTION.

The Geological Survey of the State has for its objects—

1. To trace out and describe the various rocky and earthy strata and deposits which occur in the Geological Formations of New Jersey, and the soils which cover its surface;

2. Search out and describe the ores, marls, clays, limestones, waters and other useful natural products in it;

3. And to accompany the descriptions with such suggestions, recommendations and publications as may help to make them useful to the State.

The plans of the survey are made to carry out these important objects, and work has been done in all of them during the past year.

The results of the work done are arranged under the following heads:

1. The glacial and modified drift.
2. Preliminary classification and description of the soils of New Jersey.
3. Miscellaneous clay deposits.
4. Glass sand.
5. The United States Coast Survey, Triangulation and its progress in the State.
6. Topographical survey of the country between the Watchung mountains* and the Hudson.
7. Progress of the drainage works.
8. Water supply.
9. Laboratory work.
10. Statistics.
11. Publications of the survey.
12. Expenses.
13. Persons employed.

*The name Watchung occurs in the description of the tract of land purchased by the original settlers of Newark. The deed is dated July 11, 1667, and is there spoken of (East Jersey Records, Book 63,) as "the great mountain called Watchung." This is probably the oldest known name for the mountain, and in this survey and description it is proposed to use the name for this well marked range of trap-rock ridges.

1. ON THE GLACIAL AND MODIFIED DRIFT.

In the last annual report the fact was pointed out that the glacial or boulder drift was limited to the northern part of the State, and covered less than one quarter of its surface; and its southern border was traced across the State and described in general terms. This remarkable and interesting feature of the country has undoubtedly been produced by the action of a great glacier, which has covered the whole northern part of our country in recent geological times. The deposits it has left, and the influence it has had on the surface, soils and drainage of the country, make it desirable to present the description more in detail.

The glacial markings and drift are found at the top of the highest parts of the Blue Mountain, from the Water Gap on towards the northeast quite to the State line. And all the lower grounds are marked in the same way, except that near the frontal or southern edge of the deposit, the markings on the high grounds do not extend as far south as they do on the lower.

The directions of some of these markings, as observed in various places, are given in the following table:

TABLE OF GLACIAL MARKINGS.

MAGNETIC BEARINGS.

I. Western Slope of the Kittatinny, or Blue Mountain and Delaware Valley.

	Location.	Rock.	Direction.
1	Greenville road, one-half mile east of Carpenter's Point, Orange county, N. Y....	Oneida conglomerate.	S. 35° W.
2	Greenville road, summit of mountain, Orange county, N. Y.....	Oneida conglomerate.	S. 60° E.
3	Port Jervis and Coleville turnpike, one mile west of summit, Sussex county.....	Oneida conglomerate.	S. 45° E.
4	High Point (summit).....	Oneida conglomerate.	S. 75°–80° W.
5	Ledges near Hornbeck's mill, Montague, Sussex county.....	Cauda galli grit.	S. 80°–85° E.

I. Western Slope of the Kittatinny—(Continued.)

	Location.	Rock.	Direction.
6	Peters Valley and Newton road, one-quarter mile west of road to Walpack, Sussex county	Medina sandstone.	S. 45° W.
7	Newton and Flatbrookville road, western slope of mountain, Sussex county	Medina sandstone.	S. 16° W.
8	Newton and Millbrook road, top of mountain, Warren county	Oneida conglomerate.	S. 16° W.
9	Newton and Millbrook road, down mountain slope, Warren county	Medina sandstone.	S. 40° W.
10	Mountain, two miles northeast of Water Gap (on crest of western ridge), Warren county	Oneida conglomerate.	S. 30° W.
11	Mount Tammany, Water Gap, Warren county	Oneida conglomerate.	South.
12	Dunfield Hollow, Water Gap, Warren county	Medina sandstone.	S. 10°–15° W.

II. Southeastern slope of Kittatinny, or Blue Mountain.

1	Port Jervis turnpike, one mile north of Coleville, Sussex county	Slate.	S. 30° W.
2	Southwest of Long Pond and near the Newton and Walpack road, Sussex county	Slate.	S. 80° E.

III. Kittatinny Valley.

1	Hamburgh road, Mine Hill, Sussex county	Zinc ore.	S. 30° W.
2	Fredon road, Newton, Sussex county	Zinc ore.	S. 35°–40° W.
3	Newton and Millbrook road, one mile west of Stillwater, Sussex county	Zinc ore.	S. 35° W.
4	Ledges east of Nelson Cummins' and near Great Meadows, Warren county	Gneiss.	S. 20° W.

IV. Highlands (and included valleys).

1	Passaic Zinc Company's mine, Sterling Hill, Sussex county	White limestone.	S. 15° W.
2	Sparta Mountain, one-half mile northwest of Woodport, Sussex county	Gneiss.	S. 5° W.
3	On Green Pond road, west of Lyonsville, Morris county	Gneiss.	South.
4	Copperas Mountain, east of Green Pond, Morris county	Conglomerate.	S. 16° W.
5	Green Pond Mountain (western) slope, west of Green Pond, Morris county	Conglomerate.	S. 30° W.

V. Watchung (First, Second and Hook) Mountains.

	Location.	Rock.	Direction.
1	Gap, west of High Mountain, Second Mountain range, north of Paterson, Passaic county	Trap rock.	S. 30°–40° W.
2	Second Mountain, west of Paterson, Passaic county	Trap rock.	S. 80° W.
3	Pompton Furnace, near knife factory, Passaic county	Trap rock.	S. 15°–20° W.
4	Paterson, on Little Falls road, Passaic county	Trap rock.	S. 75° W.
5	Second Mountain, summit, on Mount Pleasant turnpike, Essex county	Trap rock.	S. 48° W.
6	First Mountain, summit, near Eagle Rock, Essex county	Trap rock.	S. 58°–60° W.
7	First Mountain, near foot, Centreville road, Essex county	Trap rock.	S. 72° W.
8	Hook Mountain, northwest slope, on Beavertown road, Morris county	Trap rock.	S. 25° W.
9	Hook Mountain, north slope, and near peat works, Morris county	Trap rock.	S. 60° W.

VI. Valley between Watchung First Mountain and Palisades Mountains.

1	Paramus, near Reformed Church, Bergen county	Red sandstone.	S. 30° W.
2	Newark, Hoehnle's brownstone quarry	Red sandstone.	S. 25°–30° W.
3	Snake Hill, near almshouse, Hudson county	Trap rock.	S. 20°–30° W.
4	Sparkill, Bergen county	Trap rock.	S. 15°–20° E.
5	Homestead station, foot of mountain, Bergen county	Trap rock.	S. 10° W.
6	Salterville, ledges on shore of Newark bay, Hudson county	Trap rock.	S. 10°–20° W.

VII. Palisades Mountain Range.

1	High Torn, Haverstraw, N. Y.	Trap rock.	S. 10° W.
2	Boulevard north of Alpine, on top of mountain, Bergen county	Trap rock.	S. 30°–45° E.
3	Palisades Mountain House, east of Englewood, top of mountain, Bergen county	Trap rock.	S. 35°–40° E.
4	Fort Lee, Bergen county	Trap rock.	S. 20°–25° E.
5	Hudson City, ledges in new reservoir, Hudson county	Trap rock.	S. 20° E.
6	West end of D., L. and W. Railroad tunnel, Bergen Hill, Hudson county	Trap rock.	S. 10° E.
7	Montgomery avenue, Jersey City, Hudson county	Trap rock.	S. 42°–45° E.
8	Newark and New York Railroad, east end of cut, Bergen Hill, Hudson county	Trap rock.	S. 35°–37° E.
9	Newark and New York Railroad, west end of cut, Bergen Hill, Hudson county	Trap rock.	S. 20° E.

The masses of sand, clay, gravel, loam, cobblestones and boulders which characterize this formation, are not distributed evenly over the surface. In some places they appear as rounded hillocks, in others as long ridges, in some instances straight, and in others curved—some as level topped hills or terraces—and others as uniform plains.

The materials are in two very different states of arrangement. In one part, and that usually the upper, the stones, sand and clay are all mixed together, and the stones which are in many instances angular, stand on edge, on end or in any way, as if the whole mass had been dumped pell mell, while in the other part, and that usually the lower, the materials are somewhat sorted and have a partial and limited stratification. This stratification is sometimes very oblique and quite wedgeform, and not in extended parallel layers. These two states of materials correspond very nearly with what are seen at every glacier at the present time and are known, the first as the superficial moraines, and the second as the bottom moraines. The one is formed by the stones, sand, clay and rock fragments which are torn or fall from the sides of the valleys upon the surface of the glacier, and are carried forward by its movement and finally deposited in piles at its end, or upon the bottom when the glacier melts away. The other is formed of the sand, stones and mud, which are ground between the solid rock of the valley and the under side of the glacial ice as it moves along. The latter material may become partially stratified by the action of the streams of water which come from the melting glacier, and find their way down between the ice and the rock. Examples of this characteristic feature of the drift are well seen in the various cuttings and railway approaches to the tunnels in Bergen Hill on the west side.

The materials of which the drift is composed, are collected from all the rocks over which the glacier has moved in its passage from the north towards the south. From the friction and wear to which they have been exposed it will readily appear that the fragments of the softer rocks will soon be worn to mud, that the hardest will last the longest, and of course may be carried the furthest, and such is the case. The boulders and specimens of stone large enough to be identified with the solid rock from which they came, are found five, ten, twenty, thirty,

and possibly many more miles south of the parent rock, and in the same pile it is not uncommon to pick out specimens of granite, gneiss, hornblende rock, trap-rock, conglomerate, sandstone, slate, limestone, chert, quartz, feldspar, silicified fossils, &c., all of which are identical with rocks found to the north of them.

They differ from the stones found in a stream of running water, which are all worn and round, inasmuch as some of these are quite angular, having been carried on the glacier without friction, and others are marked with straight scratches, generally running lengthwise of the stone, as if the stones had been held firmly and pushed forward over sand and gravel stones to produce these marks. These scratches are best preserved on stones of limestone or hard slate, and are indistinct on granitic stones or on sandstone.

The mass of material varies much in its consistency, being more sandy when the rock from which it was worn was mainly sandstone or quartzose, and more clayey if the original rock was feldspathic, or slaty or trappean, and different mixtures of these give earths and soils of the most varied degrees of toughness, composition and agricultural quality.

A short account of the phenomena attending glaciers, at the present time, may enable the reader to better understand and appreciate these relics of the old glaciers which formerly covered all the northern part of New Jersey.

Glaciers are immense masses of ice which remain throughout the year, neither melting nor materially diminishing in the heat of summer, though they extend down to a level from 3,000 to 4,000 feet below the line of perpetual snow. The best known glaciers at the present time are in Switzerland, where they occupy many of the upper valleys in the Alps. The Norwegian glaciers are also well-known. There are a few small glaciers on Mount Shasta in California, and some on the highest mountains of Oregon; but they are inconspicuous and have been seen by few geologists. Greenland is almost entirely covered with glaciers, more than 300,000 square miles being covered by ice and snow. Careful observations have proved that glaciers retain their permanent places not because they are not melted by the summer's sun, but because the ice of which they are composed is slowly moving down the valleys in which they exist, and continue to do so until at their lower ends they melt away as fast

as they move. When this point is reached they *appear* to remain stationary. The movement of the Alpine glaciers averages 8 or 10 inches per day, while one of the great Greenland glaciers has been seen to move more than 40 feet in a day. The motion is more rapid in summer than in winter, and the advance of Alpine glaciers is so slow as not to have attracted attention till recent times, and has only been proved by careful and well devised experiments and observations—though they have been known as far back as history goes.

The cause of the movement of glaciers is not evident. Some have attributed it simply to gravity, assuming that the sloping ground, on which the ice lies, allows it to slide down like a body on an inclined plane. This is not quite satisfactory, for if it slides down it ought to acquire momentum and a more rapid movement, but it does not. Others have attributed the movement to the daily expansion and contraction which the ice undergoes as it melts in sunshine and freezes in darkness. During the day the ice becomes partly filled with water melted on its surface, and at night this water freezes and expands, forcing the ice to move down the slope. The movement going on in winter when the ice does not melt as well as in summer, is an objection to this theory.

Others assert that as ice is capable of being moulded or pressed into different shapes without being crushed or broken into pieces, and as the ice of a glacier does fit itself to the valleys down which it descends, narrowing and widening as the valley narrows or widens and fitting itself perfectly to the inequalities of the surface, the explanation of the movement must be found in this property. And they say that the gentle slopes on which the ice moves are quite sufficient to produce the effects observed, or that even if the ground on which the glacier lies were flat and the upper surface of the ice inclined, as it is in all glaciers, there would be a movement from the higher surface towards the lower; just as a mass of pitch or thick fluid of any kind on a level surface slowly spreads out until its upper surface becomes itself level or flat.

Glaciers are formed from snow which accumulates in the valleys and other depressions of mountains, above the line of perpetual snow. Snow in these places becomes partially melted and wet in summer and then freezes in winter and finally be-

comes solid ice. The amount of ice which accumulates in this way is perfectly enormous—it becomes hundreds of feet thick. Professor Agassiz records sounding 700 feet down an opening in a glacier without reaching the bottom. These immense masses of ice press slowly forward and down the valleys, losing considerable thickness from the melting on their upper surface every summer, but not entirely melting for years or until they have passed down 2,000, 3,000 or even 4,000 feet below the line of perpetual snow. The glacier known as the Mer de Glace near Chamouni in Switzerland, has its lowest end at Bois only 3,680 feet above the sea level, while the line of perpetual snow is 8,500 feet high. In Norway at 60° north latitude the Nygaard glacier descends within 900 feet of the sea level, while the line of perpetual snow is 5,000 feet above that level, and in Greenland the glaciers come down to the sea though the line of perpetual snow is 2,900 feet above it.

The force with which these masses of ice move is beyond ordinary estimation. As they move down the valleys, rocks, stones and earth detached from the mountain and hillsides are continually falling on the ice and then moving on down with it. On the Mer de Glace a block of granite was seen this summer which was estimated to weigh 5,000 tons, and thousands of other blocks of all sizes from that down were to be seen. At the lower end of the glacier were immense piles of earth, stones and boulders which had been brought down by the glacier, and dropped as the ice melted from under them. The terminal moraine or pile of loose boulders, gravel and earth of that glacier is near 150 feet high. The glacier does not come against this now, but is back from it nearly 1,000 feet. Within 30 or 40 years, however, the glacier did extend to and against the moraine and pressed so hard as to cause it to move forward and the loose stones and boulders to roll down the slope in front, to the great danger and alarm of the village just below.

It is difficult to get a clear conception of the condition of things which would have allowed the whole surface to become covered with thick ice, when that surface was nearly as it is now, and some points are not satisfactorily explained. It can be understood, however, that extreme cold was not necessary, for we see forests, pastures and grain fields about the lower ends of the present glaciers. There has been found in the terrace of

modified drift at Trenton the tusk of a mastodon, which was evidently washed there when that mass of matter came down the valley of the Delaware with the torrents of water from the melting ice. It was about 14 feet under the surface, and the gravel and stones were partially stratified over it. From these the inference seems plain that the climate at that time admitted of the growth of animals like the elephant in size and habits. Whatever theories or hypotheses may be adopted in regard to glaciers, the piles and other deposits of loose boulders, gravel, sand and clay and the scratched rocks under them, which are found everywhere in Northern New Jersey, are wonderfully like the deposits which are made by modern glaciers, and there is scarcely a feature in one but what can be paralleled in the other.

SOUTHERN LIMIT OF THE GLACIAL DRIFT.

The southern limit, or boundary line, of the great terminal or frontal moraine as it has been traced across New Jersey, from the mouth of the Raritan river to the Delaware river at Belvidere, is described as follows, and is also marked on the State map accompanying this report:

The general course of the line from the Raritan is north-northwest to Morristown; thence, north to Denville; thence, westerly through Dover, across the Succasunna Plains (valley) over the Schooleys mountain table land to the Musconetcong valley, near Hackettstown; thence, west-southwest to Belvidere and the Delaware river.

At Perth Amboy the Raritan cuts the southern edge of the moraine and is the line of division between the glacial drift and the stratified sand and gravel drift, although it is not the northern limit of the latter formation. Perth Amboy also marks the extreme southern point of the moraine, as both to the east and also westward it trends towards the north. On Staten Island it is traced northeast, following the shore closely to Great Kills; thence, north-northeast to the foot of the serpentine ridge, and then, again leaving the latter to the left, on an east course to the Narrows. Westerly from Perth Amboy, the south line of the moraine follows the river to Eagleswood, where bending a little more towards the north, it crosses Crow's mill brook near the clay pits of the Woodbridge Clay Company, and then runs near

the clay pits of the Crossman Clay and Manufacturing Company to Ford's Corners, or Fairfield; thence to Metuchen its course is almost parallel to that of the Amboy and Metuchen road. From Metuchen the line runs a northerly course to Scotch Plains; and then a more northeast direction to the Springfield mountain which it meets near the Feltville and Westfield road. Across Middlesex county and to the Springfield mountain the line is traced with accuracy, as the surface inequalities of the moraine are in contrast with the plain country west and south of it. The red shale earth distinguishes it across the Plastic Clay Formation. This earth is the matrix in which are imbedded the angular stones, pebbles, cobblestones and boulders of shale and sandstone, of trap-rocks, of gneissic and other crystalline rocks, of Green Pond mountain sandstone and conglomerate, and of rocks from other more distant formations. The moraine here forms the well-known Short Hills, noted for their irregular slopes and lack of arrangement or order of grouping. These extend from Ford's Corners to Scotch Plains, and they attain a maximum elevation of 240 feet in Poplar Hill near the Woodbridge and New Brunswick road. There are several small ponds shut in among them, besides many swampy and wet basins—all without any apparent outlets. At many of the clay banks southwest of Woodbridge the excavations for clays, cut through the upper glacial drift and the lower stratified yellow sand and gravel drift. These show a general thickness of about 20 feet for the former, although in the higher hills it must be greater—probably 100 feet in the highest of them.

North of Scotch Plains the line ascends the mountain, and crossing it, descends a little into the valley between the two trap-rock ranges and meets the Second mountain just south of Summit. Here it makes a turn towards the west and crosses the Passaic near Stanley. The line is quite plainly seen on the First and Second mountains as on the south the trap-rock outcrops make a much more stony surface. On the north they have been buried under the boulders and boulder earth and the surface is more adapted to farm purposes. Along the Passaic river and west of Summit there are heavy banks and knolls of glacial drift, lying upon the foot of the Second mountain. The uneven surface east of Summit is also characteristic of the moraine and

known to all travellers over this part of the Delaware, Lackawanna and Western Railroad.

West of the Passaic river the moraine line is seen ascending and running northward up the side of Long Hill and sweeping around the north end of that ridge, about a quarter of a mile south of Chatham, and at an elevation of 350 feet. Scattered boulders are found 40 feet higher, but not to the top of the ridge, but the moraine is beautifully and distinctly traced over the end of the hill, and thence, southwest, on its western slope to the head of the more recent formation of the Great Swamp. From this point, on Long Hill the line pursues a northwest course, at the foot of the hills to Morristown. This range from Long Hill to Morristown is a prominent feature in the topography of that part of the country. It differs from the Short Hills in its more nearly level top towards the south, as if that edge of the moraine had been somewhat modified by the action of water, which has rearranged its materials.

This drift boundary line is plain through Morristown. Thence its course is northwest, west and then north, following the foot of the Highlands and at the western border of the Morris Plains to the Morris Plains station. Leaving the Plains, the Delaware, Lackawanna and Western Railroad line thence to Denville follows it quite closely. It is not, however, so well marked here as it is southward. Entering the Highlands it is somewhat obscured by the hills, some of which appear to have been high enough to rise above the upper surface of the ice, and, therefore, above the upper limit of the moraine.

Going westward from Denville there are some short gaps, which may have been caused by subsequent removal of the moraine at these points, or may have been original breaks in its continuity. The line is recognized on the north end of Snake Hill, where the drift mass appears wrapped around its northeast foot and rising upon it to a height of 670 feet. It is seen on the next ridge to the west and southeast of Rockaway. Thence southwest it appears in the valley of the Mill Brook south of the Rockaway. At Dover the moraine fills the valley and its southern limit winds around the northern base of the hills, through the town and over the point of Clinton Hill. Between Morristown and Dover there is a large proportion of Green Pond Mountain conglomerates and sandstones in the mo-

raine mass, and they assist greatly in tracing its limits since these stones are not so common south, whereas the gneissic fragments and weathered blocks are common over all the Highlands. These conglomerates and sandstones are not seen west of Drakesville. Their absence shows that the movement was not southwest but rather more to the southeast. At Dover the uneven—knoll and basin—structure appears. It is also characteristic of the terminal moraine through Port Oram and in the valley west to Drakesville. The boundary line on the south runs around the little hollow near the Dover R. C. Church and by the Jackson mine to Port Oram. Thence its course is southwest for about 2 miles, as far as the Scrub Oak mine, where it turns to the west and runs across the Morris canal to the McCainsville sandstone ridge. It bends around the north end of this ridge, attaining an elevation of 870 feet, and in a curving course returns to the hills at the Drakesville station. Here there is a gap where the line is not made out. It appears, however, about a mile to the westward, and thence is traced on the north of the Drakesville and Stanhope road for a mile, where it crosses that road and runs a general westerly course to the north shore of Budd's Lake Thence it continues the same direction to the brow of the mountain, where it turns southward and descends obliquely down the mountain side into the Musconetcong valley. On the high land of Schooley's Mountain the moraine is a very marked feature in the topography, forming hills and hollows and having a wonderfully varied and uneven surface. And there is scarcely any stratification of the materials in them. They are confused heaps of earth, pebbles and boulders. The highest of these moraine summits are between 1,200 and 1,300 feet high—the highest points in the line of this moraine in the State. Here the blue limestones, slate rocks and boulders from the Kittatinny, or Blue Mountain, begin to appear more frequently and particularly west of Budd's Lake. One of these on the Osborne farm is so large that it has been a quarry for years past. In the Musconetcong valley we find the moraine pushed further south, and its limits not far from Hackettstown. The glacier extended itself further south in all the valleys which it encountered and left these tongues of drift further south than its line over the hills and table lands. And in this valley as in that of the Pequest also, the contrast between the plain surface

of the valleys south and that of the moraine north of our line, is very marked and attracts the attention of all familiar with the country. The same difference is very plain in crossing the hills from Hackettstown to Vienna or to Townsbury. The south line of the glacial drift runs about a mile north of Hackettstown across the Morris canal, and thence, in a course a few degrees south of west, over the hills across the Vienna road and to the Beatteystown and Danville road near the intersection of the Hackettstown and Mount Bethel road. Thence it runs south of the former mentioned road and turns southward and follows on the east side of the Pequest valley to a point one-third of a mile north of Amos Hoagland's residence. Turning to the west and northwest it runs thence to the creek at Townsbury. West of Hackettstown the moraine has a maximum elevation of 1,000 feet; in the Pequest valley the upper limit is about 600 feet. Beyond Townsbury the high crests of the Townsbury Mountain and the steep Frome's Hill seem to break up the moraine into detached bodies, and the line is traced with difficulty in a general southwest course and near the creek to the hills north of Oxford Furnace. It runs easterly from the valley of the Pequest and the Furnace brook, crossing the Butzville road to Oxford Furnace about a mile north of the latter place and then turns to the northwest and approaches a creek near Butzville. Thence its course is westerly and south of the stream until it enters the valley of the Delaware near and south of Bridgeville. In this valley also it makes a detour southward, and runs nearly to Oxford Church, following the western base of the gneissic rock mountain and the eastern border of the valley. From the last named point its further course is west-northwest across the blue limestone valley to the Pequest at Belvidere, where it meets the slate hills. This glacier appears to have reached its most southerly extension at this point in the Delaware valley, as to the west, in Pennsylvania the trend of the moraine is northwest to the valley of the Jacobus Creek and thence more westerly through Bangor to the Kittatinny Mountain near the Wind Gap.

Along the valley of the Pequest and that of Beaver Brook, south of the Jenny Jump Mountain, very much of the material of this moraine appears to have undergone a rearrangement and has been used in the formation of terraces which rise from that of the present flood plain to 405 feet above it. The upper limit

of the moraine as measured on the Manunka Chunk Mountain and other hills, and also in the valley at Belvidere is between 500 and 560 feet. From these and other like measurements it is possible to get at an approximate estimate for the thickness of the ice along this whole line. In another report it is proposed to describe more in detail this boundary line of the glacial drift and to give all the facts connected with this moraine and and from these to draw some conclusions in regard to the glacier itself.

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 boulders and boulder 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 boulders and scarcely any boulder 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 boulders, 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 lowlands and valleys is much more uneven and looks more like that of the frontal moraine. And in some localities there are immense heaps—rising into hills and ridges —of earth, gravel, cobblestones and boulders, which mark lines along which the glacier may have halted for a time, or to which it may have again advanced and heaped up the loose materials in front of it. One of the most beautiful of these later moraines, is that which stretches across the valley of the Wallkill at Ogdensburg in Sussex county. In fact, the village is on it. There is a great bank of earth and boulders, &c., stretching from the gneissic slopes on the east to the white limestone of the Pimple Hills range on the west. This bank, or ridge, has a convex southward front showing that it was left here by a glacier which moved southward up the valley of the Wallkill. It is interrupted at the west side of the valley by a gorge or gap through which the kill now flows. It is about 100 feet high above the valley level north of it and above the creek in the gap.

At Hamburgh there are some very large hills of drift lying near the southern end of the Vernon valley. And these with others near McAfee valley look as if they had been left there by a glacier which moved down, southwestward through the Vernon valley. Another well marked moraine is at the north end of Green Pond, which stretches across what seems to have been the former outlet to that lake.

In the valley of the Rockaway near the Sparta turnpike there is a group of flat-topped hills which fill the valley, excepting the narrow depression winding through them in which the Rockaway finds its way. Similar hills are seen in the same valley further to the north and near the Pequannock.

The valley of the Passaic is very full of drift. East of Montville large and heavy banks of drift are cut into by the Boonton branch of the Delaware, Lackawanna and Western Railroad.

And to the northeast there are hills along on both the east and west sides of the Pompton Plains. These appear to be very nearly of the same height and are, apparently, of the same age and the deposits of one agency. The hills about the Ponds neighborhood and Oakland in Bergen county are also of glacial drift. At Allendale, and thence to Sufferns, there is a great thickness of the drift, entirely concealing the underlying red sandstone. On the eastern border of the same—red sandstone valley—between Demarest's station and the State line, there is an irregular line of hills lying at the base of the Palisades Mountain. These latter are not frontal moraines, but more like the lateral, or side moraines, or, possibly, accumulations which took place under the glacier, as part of a bottom, or ground moraine.

Many other such drift hills and ridges have been examined. and they might be added to this list, but those above mentioned illustrate their nature and show how widely they are distributed. In a future report they will be described in all their relations and be mapped so that it shall be possible to indicate the probable source of their material and the movement of the ice mass as learned from their composition and structure.

In many of the larger valleys the drift is stratified and there are flat-topped hills and banks of earth, gravel and boulders—evidently the result of the action of water. Such terrace hills and shelves are common along the Delaware valley, west of the Kittatinny, or Blue Mountain, in the valley of the Paulinskill, and more or less throughout the whole extent of the Kittatinny valley. There are beautiful sand and gravel flats along the Horse Pond brook, northeast of Rockaway; along the Rockaway, between Denville and Powerville; along the Wynokie, or Ringwood creek; Pompton Plains; the lowlands bordering the Passaic river, above Little Falls; and along the Saddle river and the Hackensack river in Bergen county. These are all north of the glacial drift limit and they must at some time have been covered by that formation. In many of them the older drift has been in part worked over and sorted by water and, in part, covered by these stratified, or sorted deposits. Some of these have been lake basins, which are yet only partially drained.

There are a number of terraces, on ground open towards the

sea, which have their upper surfaces almost at equal heights above tide level. The terrace on both sides of the Pennsylvania railroad, near Trenton depot, is one of them. It is between 50 and 60 feet high. The gravel bed at the railway depot at New Brunswick and also that on Bayard street are nearly the same level. The terraces at the Narrows in New York harbor are also on the same level, and others along the west bank of the Passaic, in Newark, are of nearly the same height. It can also be recognized along Bergen Hill, both on the North river and the Newark bay sides. Up the North river, near Peekskill, similar terraces are very conspicuous, but their height above tide is about 90 feet. In New Jersey, in the more southern part, terraces are seen, but they are at a somewhat lower level. The whole of them, taken together, indicate that at some former time, perhaps at the close of the glacial period, the ocean level was somewhat higher than it is now, enough higher to bring it just over the tops of these terraces, and water bringing stones and earth from the higher ground would deposit them when it reached sea level, in these steep flat-topped terraces. The terrace at Trenton is just where the valley of the Delaware comes down to this level, and where it widens out to allow room for such a deposit to accumulate. These are good examples of terraces of the Champlain Period.

There are also some well marked and large sand banks a few rods south of the terminal moraine at New Providence, in Union county, and at Townsbury and Oxford, in Warren county, which appear as if the glacier had terminated in water and these sand deposits had been washed out of the coarser and unsorted materials brought there with it, and deposited in these banks.

2. PRELIMINARY DESCRIPTION AND CLASSIFICATION OF THE SOILS OF NEW JERSEY.

The soil is that surface coating of the earth which is capable of supporting vegetation, and when cultivated, of producing crops. It is usually but a few inches in thickness, and is always characterized by containing a little decaying vegetable matter which gives it a color somewhat darker than the earth or subsoil under it. It also differs from the subsoil in its consistency, being more mellow and crumbling.

However different the soil from the subsoil under it both are derived from the same materials, that is from the rocks underlying them, or from the sands, gravels and clays upon those rocks. The difference has been produced by the long continued action of air and moisture, the varying temperatures of the year, and the action of the growing and decaying vegetation upon the mineral substances of the earth or rock surface. It is only necessary to examine a pile of earth, crumbled rock, or even of cinders or broken bricks, which has been exposed to the weather for a few years, and the beginnings of a soil will be seen—fine particles have gathered in protected places, weeds, grass, and perhaps trees have begun to grow in it, and it is taking the dark color and mellow consistency of a soil. And this change will go on until the coating of soil is so thick that the agencies of change can no longer act. Soils made in this way can be seen on the embankments of any of our older railroads or canals. There is one near New Brunswick made entirely of red shale about forty years ago, which now has the mold or soil on it two to four inches deep, and is covered with grass, bushes and some trees. The cinder heaps at Oxford which may be fifty or sixty years old, have some large trees on them, grass is growing in patches, and they promise to be soon entirely covered with soil. In looking at the cut edge of any excavation the several layers of soil, subsoil and underlying rock or earthy material are plainly seen, and the change from one to the other may be studied and compre-

hended. The nature of the changes which the underlying rocks or earth have been subjected to are various. In the granitic and crystalline rocks there has been a decomposition by which the feldspar has become clay, the quartz is sand, and the mica or hornblende is a more or less reddish sandy earth. On the limestone rocks, the soil has been made by the slow dissolving of the carbonate of lime in water, and leaving as a sediment the original impurities of the rock to cover the surface and constitute a soil. Slates crumble down fine and make a clayey soil with very little chemical change from the original rock. Other kinds of rock, by their crumbling or decay, produce soils of different qualities.

As soils then are formed from rocks, they must necessarily have some qualities in common with the rocks, and in any particular district or country the easiest and most systematic classification of soils is based on its geological structure.

The designation of soils as sandy, loamy or clayey is common in all countries, and conveys some idea of their consistency, but it is merely a comparison of soils on the same farm or in the same neighborhood. As applied in different parts of New Jersey the terms are very inaccurate; that which is called a clayey soil in the southern end of the State, would be called a sandy soil at the north. Such a classification also gives no information as to the composition or capabilities of a soil. On the contrary, a classification of soils based on their geological origin does give some idea of the nature and promise of the soil, even if its surface materials have been somewhat sorted by rains, so as to leave it more sandy in some places, and more clayey in others.

A classification of our New Jersey soils may include the following kinds, viz:

Granitic soils.
Limestone soils.
Slate soils.
Red sandstone and shale soils.
Trap rock soils.
Clay district soils.
Drift soils.
Marl region soils.
Tertiary soils.
Alluvial soils.

The portion of New Jersey southeast of the marl district and covering two-fifths of its surface, has not been considered so fertile as other parts of the State, and more than three-fourths of it is still in forest. There are large tracts of it, however, especially in Cumberland county, which are in a state of high cultivation, and are productive and profitable.

The general geological structure or division of the State into belts which traverse it in a northeast and southwest direction, prevails in this part the same as in the north and west, but the strata are nearly horizontal, and being not very thick, the wash of rains and the drainage of the country, which is by streams running south, southeast and east, has cut across and through the strata in such a way as to present characteristic soils in broad belts or tracts, running from the northwest towards the east, southeast and south.

The geological strata exposed in this part of the State consist of thick beds of white sand, some of which are of excellent quality for glass-makers' use—of beds of marly earth, some of which are used for fertilizers—and of a thick deposit of gravelly loam, which originally overlaid the others, and still occupies the highest grounds.

The soils of this portion of the State then, are gravelly loams, and white sands, or from the trees on them the lands may be designated as oak lands and pine lands, and the intermediate as oak and pine lands.

An attempt is made on an accompanying map to designate approximately these varieties of land in Southern New Jersey. The accurate mapping out of these different soils will be of much value. It will prevent the attempt to clear up and cultivate the white sands which are really almost worthless for cultivation, and should be kept in forest. The gravelly and sandy loams may be cleared up to the profit of the settler, and the benefit of the State. And when that is done, and the tracts of good land are opened throughout, the tracts of woodland will be to some extent isolated and protected from the sweeping fires which now destroy large bodies of timber, and render property in forests so uncertain that it loses more than half its real value.

The map accompanying this report has on it the approximate outlines of the different belts of pine and oak lands, into which southeastern New Jersey is divided. There will be found many

limited exceptions to these bounds, and the map must only be considered as a first attempt, put forth with the hope of bringing together on a later one, the facts now scattered among many observers, and which can easiest be secured by the criticism and correction of this map.

1. HOMINY HILLS PINE LANDS.

The most northerly of these belts of pine land is in Monmouth county. It runs west and north of west from the ocean, north of Shark river and south of Poplar to the Hominy Hills in Atlantic township. It is crossed by the New Jersey Southern Railroad between Eatontown and Shark river, and also by the Colt's Neck and Farmingdale road. It is at least 10 miles long and from 2 to 4 miles wide. There are several quite high hills in it, as the Cranberry Hill, which is 178 feet high, and the range known as the Hominy Hills. The surface is somewhat rolling, although a part of it is rather flat and wet. Isolated and small clearings have been made, but the greater part is a white sand and white sandy gravel surface which is covered with huckleberry bushes and scrubby pine trees. Frequent fires run over much of the timbered area so that the wood on it is of comparatively little value. The contrast between this belt and the rich farm lands of the marl districts on each side of it is very marked and tends to depreciate it. A careful survey will, no doubt indicate parts of this belt which are capable of profitable clearing and farming.

2. SQUANKUM OAK LANDS.

South of the above described belt are the heavier soils of New Bedford, Squan and the country along the north bank of the Manasquan river, forming a continuous belt westward to Blue Ball and the more thickly settled parts of Monmouth county. The lands of this belt are largely in farms as can be seen along the Freehold and Squan Railroad, which traverses it lengthwise. Convenience to the marl outcrops has greatly promoted the clearing up of these lands.

3. MANASQUAN RIVER PINE LANDS.

Going southward on the line of the New Jersey Southern Rail-

road a narrow belt of pine land is crossed north of Bricksburg and south of the Squankum Belt. It is said to be connected on the southeast with the sands between the Manasquan river and Burrsville. The Squan and Burrsville road crosses it near the shore. There it is a coarse white sand. West of the railroad it runs northwest along the upper part of the north branch of the Metedeconk river. At present nearly all of this belt is in pine and oak forest. On account of its nearness to railroad communications and to marls much of its surface may yet be profitably cleared and farmed.

4. BRICKSBURG OAK LANDS.

The next belt on the south is that of Bricksburg and Bennett's Mills. It has the south branch of the Metedeconk for its southern limit. The lands about Jackson's Mills are also included in it. Its extension beyond Bricksburg towards Burrsville has not been traced. The sands along the road from Squan to Toms River seem to cut off the eastern end and connect the last described pine belt with that south of this belt. The best lands of the Bricksburg Land and Improvement Company, lying north of the Metedeconk and northwest of the village are in this belt. The good natural soils of this belt, their accessibility to railroad communication and the rich marls of Squankum, not too far away for team transportation, will soon cause nearly all of it to be cleared and made into farms.

5. BRICKSBURG PINE LANDS.

This belt of pine land, which is so plainly defined by the creek at Bricksburg and the high grounds on the south, near Mount's crossing and the old Seven Stars site, runs eastward to the headwaters of Barnegat bay. From the New Jersey Southern Railroad to the bay its length is eight miles. It is two to three miles wide. Some of the clearings of the Bricksburg farmers, south of the village, are on it. Excepting these, it is all in forest and nearly all of it yellow pine timber. Analysis number 14 of table of analyses shows the chemical composition of the poorest of the white sand soils of this belt.

6. TOMS RIVER OAK LANDS.

Parallel to the last mentioned belt and bordering it on the south is what may be termed the Toms River belt of oak lands. The most southern farms on the Bricksburg tract, the white oak bottom lands and the farming country north of Toms River are in this belt. Its northwest extension is crossed on the line of the New Jersey Southern Railroad, between Mount's Crossing and the Ridgeway Branch. White's bridge and Ridgeway stations are in it. Beyond these points it extends towards Goshen and Vanhiseville, in Jackson township. Its boundary on the northeast coincides with that of the higher grounds and runs east of Cedar Grove and northeast of White Oak Bottom. On the southwest it stops at the Toms River. As the belt has not been followed to its west end the length is undetermined. It is three or four miles wide. Its surface is somewhat undulating and much of it between 50 and 120 feet above tide level. The soils contain some clay and very generally some gravel. A large part of it east of the railroad is now in farms and one of the best farming districts of Ocean county is on it and near the old Freehold road north of Toms River. The analyses Nos. 8, 9 and 10, of table, show the natural richness of these soils as compared with those of the pine land belts. Wherever there are woods the oaks are seen mixed with the yellow pine. The nearness to transportation and the supply of natural fertilizers are advantages, which must tend to the clearing up and cultivation of these lands.

7. TOMS RIVER PINE LANDS.

South of Toms River there is another belt of pine land. Its limits are not at present known, except that it stretches from the Bay shore westward to Manchester and thence into Jackson township. The roads from Toms River to Double Trouble, Dover and the Toms River Branch Railroad cross it. Along the New Jersey Southern Railroad it is five to six miles wide—from the Ridgeway Branch nearly to Whitings Station. This belt is rather low, although there are some hills and ridges, south of Toms River. There are some fairly good soils under cultivation on the Manchester Company's tract, and careful surveys will doubtless show that much of it is capable of permanent improvement and will make farms. Very much the larger part of it is now covered

by yellow pine of second growth and stunted by frequent fires. Analyses Nos. 16 and 17 of the table show the composition of the lightest of these sands.

8. LACEY OAK LANDS.

Going southward, the clearings at Forked River, Lacey, Bamber and Whiting's stations, indicate an east and west strip, or belt, of better land. The road from Forked River to Bamber, and thence to Whiting's runs through it and gives an impression of it. The breadth does not exceed four miles. It cannot be given accurately, as on the south this belt appears to merge itself gradually into the next belt of pine lands. Gravelly soils prevail, and the vineyards of Lacey, Forked River and Bamber are on these. The cleared areas are still small and confined to the vicinity of the villages above mentioned. The timber is pine and oak mixed.

9. FORKED RIVER PINE LANDS.

The pine lands belt, which lies southwest of Forked River, west of Waretown and south of Bamber and Whiting's, appears more irregular in its outlines, although at present, these seem almost undefined. It is traversed by Guise's road, the Webb's Mill road, and the Balcony road, and by the Tuckerton Railroad between Waretown Junction and the neighborhood of Bamber. Towards the west it is crossed, near Hanover, by the railroad to New Lisbon. There are hardly any clearings in this belt, and the timber is scrubby pine, with cedar swamps in the wet grounds along the streams.

10. CEDAR BRIDGE OAK LANDS.

The next alternating belt of country is one of heavier soils, and its boundaries on the south are better defined. The Mannahawken creek and then the Cedar Bridge and Red Oak Grove road are near its southern margin. The Forked River Mountains are on the north—also Wells' mills. Wheatland is on it, and the road thence to Cedar Bridge and Barnegat runs through it. From the bay to the New Jersey Southern Railroad, west of which it has not been traced; it is sixteen miles long. It has

an average breadth of four miles. The surface is from 50 to 200 feet above tide-level, and is the water shed between Oyster and Cedar creeks on the north, and the branches of Wading river on the south. The soil of the higher portions is gravelly loam, quite clayey in spots. The hill slopes are more sandy—while the hollows are more loamy. Oaks and pines make up the forests, which now cover all of it, except the small areas of a few farms at each of the above named places. An analysis of quite stiff, gravelly-clay loam, from the Cedar Bridge roadside, west of Barnegat, shows the character of the better grades of natural soils and subsoils. South of this belt we come to a broad district of pine lands, which may be provisionally termed

11. THE BURLINGTON PLAINS PINE LANDS.

It is the broadest belt and includes within its bounds some of the poorest lands in the State. It is represented as extending to the Atsion river—on the southwest—a distance of fifteen miles and comprising a large part of the country drained by the Wading river. On its eastern side there are the well known barrens of East Plains and West Plains—several thousands of acres destitute of timber and covered by low shrubs and dwarf pines. On the west side of the New Jersey Southern Railroad this belt is said to extend quite to the marl districts, so that it includes in its bounds much of eastern Burlington. Along the shore there is a narrow strip of farm land from Mannahawkin, Tuckerton, New Gretna and Bass River to Egg Harbor. Excepting this shore strip and a few farms about Shamong and Woodmansie, the whole belt is an unbroken wilderness of fire-scarred, scrubby pines. The surface is generally coarse white sand and white, sandy gravel. In some places, as on the Plains, the subsoil is quite heavy and apparently capable of improvements, but the soils, in general, are too light for profitable farming. Towards the southwest this belt joins the Atsion River Pine Lands belt.

12. ATSION RIVER OAK LANDS.

This is a wedge-shaped belt, which follows the northeast bank of the river, by Atsion, and there widens out and includes within its bounds the cleared lands of Shamong and Tabernacle. It is

narrow below Atsion. At present its limits are somewhat doubtful and are left undefined. A considerable area about Atsion is under cultivation.

13. ATSION RIVER PINE LANDS.

This is a narrow strip of pine lands on the south of the Atsion river. It is crossed by the New Jersey Southern Railroad between Atsion and Atco, and Atsion and the Bates mill branch of that stream. The northwestern end of this belt is north of Jackson and in the townships of Evesham and Medford. A part of the Hammonton tract and the northern part of the Egg Harbor tract are included within its boundaries.

14. RAILWAY OAK LANDS.

The clearings and farm lands of Atco, Winslow, Hammonton, Elwood and Egg Harbor City, indicate a belt of heavier soil, extending from the marl district southeast through the eastern part of Camden and across Atlantic county to tide water. The lines of railroads to Atlantic City run through the central portion of this belt and hence its designation as the railway belt. It is one of the largest of these oak lands districts and the larger part of it is still in forest. The timber is oak and pine mixed. The success which has attended the settlements above mentioned, indicate the natural adaptation of these lands to the purposes of farming, and its railway facilities have made it easily accessible and given it good communication with Philadelphia and New York markets.

15. GREAT EGG HARBOR RIVER PINE LANDS.

This belt bounds the Railway oak lands belt on the south. It can be traced from near the mouth of this stream for twenty-five miles through Atlantic and into Camden county. It is between two and three miles wide, and below Weymouth, is confined mostly to the eastern side of the river. It takes in the Penny Pot sands, south of Winslow, and extends northwest almost to Williamstown. On account of its nearness to tide-water much of this belt has been cleared, as at Mays Landing and Weymouth, and a little of the extreme southern part of the Ham-

monton tract. There is not much white gravel on the surface, but nearly everywhere white sand, which is in contrast with the better soils of the belts on each side of it.

16. OAK LANDS OF THE ATLANTIC AND DELAWARE BAY DIVIDE.

This district comprises nearly the whole area between the Great Egg Harbor and the Maurice rivers. It constitutes the southwestern part of Atlantic county and the eastern part of Cumberland. About one-third of the latter is in it. The New Jersey Southern Railroad crosses it between Cedar Lake and Vineland, and the old stage road through Cross Keys to Tuckahoe runs through it. The road from Mays Landing to Vineland crosses it, as does the Manumuskin and Tuckahoe road. The soil is characterized as a gravelly loam. Its natural excellence and adaptation to farming is shown by farms and settlements within its limits, as also by the size and thriftiness of the oak and pine timber. The soils of Vineland are on it, as are those of Forest Grove and some good farms near Leaming's Mills, Manumuskin, Estelleville and Tuckahoe.

17. MAURICE RIVER PINE LANDS.

This name is given to the long and narrow strip of sandy land which borders the Maurice river from Malaga to Port Elizabeth, and thence extends southeasterly, on both sides of the Millville and Cape May Railroad quite to the Cape May county line. It is confined almost wholly to the east side of the river at Vineland, and is from one to two miles wide. At Millville it is two miles wide. To the south it widens, reaching nearly to Cumberland Furnace. At Belle Plain its breadth is said to be five or six miles. The length from Malaga to the county line is not quite 30 miles. Like the Great Egg Harbor river belt it appears to be dependent upon the topography of the country, and it includes the lowlands along the river. Rising on the higher grounds, both on the east and on the west its limits are crossed, and a heavier, gravelly loam soil is reached. The surface of this belt is, in general, excessively poor, consisting of coarse white sand, with very little loam and scarcely any vegetable matter. Where the sand is finer grained, and the loam admixture is larger, the soils are better. Some of these have been cleared and

farmed; others have been abandoned as unprofitable soils. With large areas of good land in the oak belts on each side of this Maurice River belt, equally accessible, and offered at equally low prices, it is not desirable for settlers to attempt the clearing and farming of these white sand soils. They are needed to produce wood for the better lands and for climatic reasons.

18. CAPE MAY OAK LANDS.

The county of Cape May is all fairly included in the oak-growing lands. The soil is alluvial in character, of good quality, and, when well farmed, productive. The clearings have been mostly confined to those parts bordering on the Atlantic or on Delaware Bay, and the greater part of the county is still in woods. Its distance from markets, has heretofore prevented its being cleared up rapidly, but now that it is opened by convenient railroad communications with both New York and Philadelphia it offers great inducements to settlers.

19. THE SALEM BARRENS PINE LANDS.

The only other tract or belt of white sand which has been traced out, is that which is generally known as the "Barrens," in Salem county. It is west of Stow creek and northwest of Shiloh and Jericho. It is of quite limited extent, being about 2 miles wide and not more than 8 miles long—from northeast to southwest. It is covered by yellow pine timber and of better quality than much of the timber further northeast, and has some good oak timber on it. The sand of the surface layer is dug and taken to Bridgeton and Quinton for making glass.

The area occupied by these belts of land may be set down approximately as follows:

		ACRES.	
		PINE LANDS.	OAK LANDS.
1	Hominy Hills Pine Lands	20,000	.....
2	Squankum Oak Lands	.....	45,000
3	Manasquan River Pine Lands	20,000	.....
4	Bricksburg Oak Lands	.....	10,000
5	Bricksburg Pine Lands	15,000	.....
6	Toms River Oak Lands	.....	50,000
7	Toms River Pine Lands	70,000	.....
8	Lacey Oak Lands	.....	40,000
9	Forked River Pine Lands	50,000	.....
10	Cedar Bridge Oak Lands	.....	40,000
11	Burlington Plains Pine Lands	240,000	.....
12	Atsion River Oak Lands	.....	35,000
13	Atsion River Pine Lands	60,000	.....
14	Railway Oak Lands	.....	200,000
15	Great Egg Harbor River Pine Lands	55,000	.....
16	Divide of Ocean and Bay Oak Lands	.....	230,000
17	Maurice River Pine Lands	50,000	.....
18	Cape May Oak Lands	.....	100,000
19	Salem Barrens Pine Lands	10,000	.....
		590,000	750,000

There are in addition to the above oak lands, the tract on the west side of Maurice river in Cumberland, Gloucester and Salem counties, which contains 240,000 acres, and the total area is 1,580,000 acres, of which 350,000 acres are now in farms, leaving 1,230,000 acres still uncleared, of which the oak lands fit for clearing, amount to 640,000 acres.

The country included in the above area occupies all the Southern and Eastern portion of the State. It borders on the Atlantic from Deal to Cape May, and on Delaware bay from the mouth of Maurice river to the ocean. On the north and west it is limited by the marl region, and the high grounds which make the back bone of the State. It is 100 miles long from north to south, and 35 miles wide from east to west.

The climate is mild, the mean temperature of the summer months at Vineland for 3½ years being 75½ degrees Fahrenheit, and the mean winter temperature 32 degrees Fahrenheit. And the extremes from these are not large.

The annual rainfall is 48 46-100ths inches, which is pretty evenly distributed through the year. Very little snow falls, and the winters are so mild that plowing can be done every month in the year.

The climate is salubrious, and has been specially noted by its

entire freedom from malarial influences. It is specially liked by those who suffer from asthmatic and pulmonary diseases; and many come here for the relief they obtain from such ailments. The sea-side resorts are continually increasing in number and enlarging in size; and throngs of visitors come to enjoy the delightful air.

The water of this country is pure and soft. It is drained by many large rivers which are chiefly remarkable for their full and equable flow, being very little affected by storms or by drouths. They furnish excellent water power for manufacturers' purposes. Those at Mays Landing, Weymouth, Batsto, Atsion, Millville, Bricksburg, Manchester and Toms River, are of this kind, and there are a great many other good ones.

The soil is light but easily cultivated, and when well managed is productive. Mr. Hay's farm, at Winslow, is a model of productiveness for all South Jersey. The improved lands at Vineland, Hammonton, and Egg Harbor City, are yielding large crops and promise well for the future.

The staple productions are wheat, rye, oats, Indian corn, hay, potatoes and sweet potatoes. Melons are raised in abundance. Apples, pears, peaches, grapes, blackberries, raspberries, strawberries and currants grow remarkably well.

The means of communication are good. There is an abundance of gravel for road making, and the benefits of good roads are highly appreciated. Cumberland county claims to have more good roads than any other county in the State. The West Jersey Railroad, the Glassboro and Millville, the Millville and Cape May, the New Jersey Southern, the Camden and Atlantic, the Philadelphia and Atlantic City, the Mays Landing branch, the Pemberton and Manchester, the Tuckerton, the Toms River branch, the Toms River and Waretown, and the Freehold and Squankum branch to Squan are all railroads in this district, and every point in it is within an easy drive of railway communication, and, by this, is within three or four hours ride of the best markets on the continent.

The following table of the analyses of soils is presented as a beginning of the work that needs to be done in this direction. It is not complete geographically, and is not full enough to be taken as an average of the soils. But it is all that could be done up to this time, and it is hoped that its imperfections and deficiencies may be corrected and filled up hereafter.

ANALYSES OF SOILS.

Soils and Subsoils from Granitic Formations.

	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 Subsoil, Flanders, Morris county	2.300	63.300	16.490	9.200	0 252	0.070	0.041	0.198	traces	traces	.....	8.500	100.351	0.044
2 Soil, Washington, Warren county	1.550	72.250	19.573		0.312	0.130	0.014	0.127	0.055	0.002	0.019	5.850	99.832	0 034
3 Soil, Pohatcong Mountain, Warren county	2.000	63.800	16.150	8.840	0.504	0.190	0.120	0.154	traces	0.017	0.014	8.850	100.640	0.220
Magnesian Limestone Subsoil.														
4 Subsoil, Johnsonsburg, Warren county	1.400	70.160	3.877	5.016	0.576	0.240	4.235	0.307	traces	traces	5.380	8.050	99.241	0.131
Soils from the Trap Rock Ranges.														
5 Soil, Palisades Mountains, Bergen county	3.700	76.300	6.186	8.510	0.288	0.145	0.140	0.089	0.004	0.012	0.150	4.750	100.274	0.041
6 Soil, Ten Mile Run Mountain, Middlesex county	3.2'0	52.200	23.050	11.320	0.304	0.190	0.120	0.077	traces	0.020	0.025	9.500	100.056	0.023
7 Soil, Rocky Hill, Mercer county	1.650	72.200	18.370		0.302	0.130	0.100	0.131	0.014	traces	0.029	7.000	99.926	0.051
Soils and Subsoils from the Oak Lands of Southeastern New Jersey.														
8 Soil, White Oak Bottom, Ocean county	1.500	89.250	4.797	2.014	0.216	0.080	0.015	0.084	0.005	trace	0.017	2.300	100.278	0.035
9 Soil, Geo. W. Cowperthwaite, Toms River	0.350	94.300	1.070	1.400	0.252	0.040	0.021	0.031	0.021	0.002	.....	2.150	99.640	0.042
10 Subsoil, Under No. 9	0.450	92.450	1.814	1.966	0.200	0.045	0.014	0.020	0.012	.....	.....	2.250	99.220	0.028
11 Soil, East of Whiting's, Ocean county	0.250	94.500	1.705	1.870	0.114	0.025	0.007	0.025	traces	traces	0.017	1.650	100.160	0.027
12 Subsoil, Cedar Bridge road, Ocean county	1.150	83.180	8.375	3.099	0 076	0.055	0.005	0.026	0.0014	0.0017	.....	3.050	99.921	.....
13 Soil, Egg Harbor City	0.225	90.160	1.200	0.796	0.056	0.036	0.011	0.019	0.0008	traces	.....	1.375	99.885	0.018

ANALYSES OF SOILS—(*Continued*).

Soils and Subsoils from the Pine Lands of Southeastern New Jersey.

	Water (Moisture)	Sand, (Insoluble in acid.)	Alumina.	Oxide of Iron.	Magnesia.	Potash.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Carbonic Acid.	Organic Matter.	Total.	Nitrogen.
14 Soil, Bricksburg tract	0.100	98.910	0.293	0.087	.....	0.001	0.0017	traces	traces	traces	.....	0.700	100.093	.....
15 Soil, Dillon's Island, Toms River	0.250	98.590	0.212	0.248	trace	trace	trace	trace	traces	trace	.....	0.650	99.950	0.017
16 Soil, Two miles south of Toms River	.....	99.420	0.318	0.024	0.010	0.011	trace	0.018	trace	.....	.....	0.200	100.000	.....
17 Subsoil, Under No. 16	0.500	98.120	0.472	0.510	0.011	0.007	0.018	0.023	.....	traces	traces	0.250	99.916	0.014
18 Soil, East Plains	0.200	98.440	0.269	0.452	traces	0.035	0.025	0.038	0.0007	0.0005	.....	0.200	99.600	.....
19 Subsoil, Under No. 18	0.200	97.020	0.663	0.792	0.054	0.031	0.012	0.045	0.017	traces	.....	1.050	99.884	.....

Soils from the Intermediate Oak and Pine Lands of Southeastern New Jersey

20 Soil, Dr. T. T. Price, Tuckerton	0.300	97.460	0.427	0.230	0.014	0.033	0.012	0.023	0.0017	traces	.....	1.500	100.000	0.015
21 Soil, Mauricetown	0.850	94.440	2.489		0.050	0.040	0.017	0.031	0.0007	0.0013	.....	1.075	99.890	0.030
22 Soil (No. 1), Thorofare, Gloucester county	0.400	90.056	0.904	0.860	0.065	0.095	0.105	0.100	0.024	.....	.....	1.330	99.940	0.053
23 Soil (No. 2), Thorofare, Gloucester county	0.450	94.200	0.624	1.080	0.132	0.133	0.110	0.096	0.027	.....	.....	3.600	100.450	0.065

GRANITIC SOILS.

1. Subsoil, Flanders, Morris county. The specimen was taken from the roadside, south of the village. Reddish in color. Contains some undecomposed and other partially decomposed rock fragments.

2. Soil from Washington, Warren county. This specimen was obtained near the village and on the side of the road to Oxford Furnace. It is yellowish red in color and free from pebbles. Contains some small rock fragments. It represents the natural red soils which are common in the valleys of the northern part of the State.

3. Soil from the summit of Pohatcong Mountain, on New Hampton and Pleasant Valley road, Warren county.

The specimen came from the road side. It is reddish in color. A few small fragments of gneiss, much decomposed, in it. It is derived from the gneiss.

MAGNESIAN LIMESTONE SUBSOIL.

4. Subsoil from side of Long Bridge road, one mile southeast of Johnsonsburg, Warren county. Brownish color. The earth is mixed with the blue limestone in small, angular pieces. It is a representative of the red soils which are seen in many places overlying the limestone formation. This subsoil is close to the rock in place. It makes a good soil.

SOILS FROM THE TRAP ROCK RIDGES.

5. Soil from Woodland on the top of the Palisades Mountain, near the New York line, Bergen county. Brown; contains a little fine gravel and some decomposed rock fragments. It appears to have been derived mostly from the trap rock underlying it, but mixed with this earth and rock there is a little drift material. This soil is retentive and supports a heavy growth of timber.

6. Soil from the side of the county line road, 1½ miles northeast of Kingston, Mercer county. Yellowish color. Very little rock in it. Soil here is close to the trap rock and is derived from its decomposition. It makes a good soil, but rather tight bottom.

7. Soil from the top of Rocky Hill, 2 miles north of Princeton, Mercer county. Yellowish color; much like the last. It is derived from the weathering of the trap rock of the hill and well represents soils of such origin.

SOILS AND SUBSOILS FROM THE OAK LANDS OF SOUTHEASTERN NEW JERSEY.

8. A yellow sandy loam containing some gravel. It is from the side of road, in woods, near White Oak Bottom, and three miles south of Bricksburg, Ocean county. Specimen represents one foot from surface downward. Timber mostly oak. This represents the clayey and gravelly loams of the southern part of the Bricksburg tract and some of the White Oak Bottom soils.

9. Soil from farm of George W. Cowperthwaite, Toms River, Ocean county. The specimen is greyish in color; contains a small proportion of coarse sand and small pebbles. It represents the natural soil of the oak lands near and north of the village of Toms River.

10. Subsoil under the last named; yellowish, some small pebbles in it.

11. Soil, one mile east of Whiting's Station, Ocean county. This soil was obtained from woodland near the Bamber road. It was ten inches thick and underlaid by a yellow, sandy subsoil. Some fine roots in the sample. Timber of locality is second growth oak, with a little yellow pine.

12. Subsoil from Cedar Bridge road, about three miles west of Barnegat, Ocean county. Reddish color. An unusually heavy subsoil for this part of the State. It contains no gravel. It represents the best of the clayey subsoils—especially those which are free from gravel—of Southeastern New Jersey. Locality is in woods (oak and few scattered pines).

13. Soil from vineyard of Julius Hincke, Egg Harbor City, Atlantic county. Ash-colored, sandy loam, containing some quartz pebbles. Unmanured. This specimen represents the natural soil, which is said to be adapted to grape growing.

SOILS AND SUBSOILS FROM THE PINE LANDS OF SOUTHEASTERN NEW JERSEY.

14. Soil from woods on Bricksburg tract, about two miles southeast of the s ation. The specimen represents one foot sec-

tion of the surface and the poorest of the soils in this pine lands belt. It is coarse white sand, with some fine rootlets. The timber consists of a few scattered and shrubby pine trees. Under this sand there is a yellow, sandy subsoil.

15. Soil from Dillon's Island, Toms River, Ocean county. A coarse, greyish-white sand taken from pine woods on top of the hill, near the west end of the island. It supports a low, stunted pine tree, here and there, with the intervening spaces covered by moss.

16. Soil from the (Stanton) tract, about two miles south of Toms River, Ocean county. The specimen was taken from a little eminence in the pine barrens and as representing the poorest soil of the tract. It is twenty-four inches thick. A few pine trees on this hill.

17. The subsoil under No. 16. The soil is a white sand, finer grained than the soils 15 and 16. The subsoil is yellow, and also fine grained.

18. Soil 150 yards southeast of the Watering Place, East Plains, Burlington county. A coarse white sand, bare, excepting moss in spots. This white sand layer is one foot thick.

19. The subsoil under the last mentioned, yellow; contains a few quartz pebbles one foot thick. This locality appeared to be the poorest of the East Plains. There are no trees which are over six feet high on these soils. Analyses of two other subsoils from this tract show them to be more promising than this one.

20. Soil from woodland of Dr. Theo. T. Price, half a mile northeast of Tuckerton, Burlington county. Specimen a good average of the soil, which, after scraping off the pine twigs and leaves, is three inches thick. The subsoil is a yellow, sandy loam. Timber is thrifty growth of yellow pine.

21. A natural soil from woodland, side of the Buckshutem road, two miles north of Mauricetown, Cumberland county. A drab colored, sandy loam. Contains some rootlets; free from pebbles; ten inches thick. Timber here is mostly oak, with some pine and some holly. The soil represents the sandy loam soils of this part of Cumberland county. They are easily tilled and respond well to good farming.

22. Soil from Thorofare, Gloucester county. A yellow sandy loam which was taken from a field of sweet potatoes, which rotted badly.

23. Soil from same farm as No. 22, but newly cleared. On this the potatoes were healthy.

The following table shows the pounds of potash, lime and phosphoric acid in several of the soils, analyses of which appear in the table.

The calculation is based upon the estimated weight of an acre of soil six inches deep, a cubic foot of which is assumed to weigh 80 pounds. The weight of soil on an acre is then 1,742,400 pounds; and 1 per cent. of any constituent represents 17,424 pounds; one hundredth of 1 per cent, 174 pounds; and one-tenth, 1,742 pounds, or nearly one ton.

1. Table showing the amount in pounds of Lime, Phosphoric Acid and Potash in various soils, taken on one acre, and six inches deep.

Classes.	Locality.	Potash, Pounds.	Lime, Pounds.	Phosphoric Acid, Pounds.
1 Gneiss	Flanders, Morris county	1,305	713	3,450
2 Gneiss	Washington, Warren county	2,242	200	2,190
3 Gneiss	Pohatcong Mountain, east of Pleasant Valley, Warren county	3,276	2,069	2,656
4 Magnesian Limestone	Subsoil southeast of Johnsonsburg, on road to Long Bridge, Warren county.	4,180	73,702	5,348
5 Trap Rock	Subsoil, top of Palisades Mountain, near New York line, Bergen county.	2,526	2,438	1,560
6 Trap Rock	Soil, Ten Mile Run Mountain, 2 miles northeast of Kingston, Middlesex Co.	3,310	2,090	1,340
7 Trap Rock	Soil, Rocky Hill, 2 miles north of Princeton, Mercer county	2,258	1,724	2,242
8	Soil, White Oak Bottom road, 3 miles south of Bricksburg	1,380	258	1,448
9	Soil, Geo. W. Cowperthwaite, Toms River	688	361	533
10	Subsoil, under No. 9	783	243	348
11	Soil, on road to Bamber, 1 mile east of Whiting's Station	431	120	431
12	Subsoil, Cedar Bridge road, west of Barnegat	951	71	452
13	Soil, Julius Hincke, Egg Harbor City	627	191	330
14	Soil, 2 miles southeast of Bricksburg	17	29	.....
15	Soil, Dillon's Island, Toms River	.....	.....	.....
16	Soil, (Stanton) tract, 2 miles south of Toms River	241	.....	310
17	Subsoil, under No. 16	129	310	482
18	Soil, Watering Place, East Plains	609	435	670
19	Subsoil, under No. 13	540	209	783
20	Soil, Dr. Theo. T. Price, Tuckerton	568	207	396
21	Soil, from Mauricetown	690	292	534
22	Soil, (No. 1), Thorofare, Gloucester Co.	1,655	1,829	1,846
23	Soil, (No. 2), Thorofare, Gloucester Co.	2,323	1,916	1,672

2.—Crops and mineral matters taken from an acre of soil in a five years' rotation:

Year.	CROP.	WHOLE CROP. Pounds.	Bushels.	ASH OF CROP. Pounds.	POTASH. Pounds.	LIME. Pounds.	PHOSPHORIC ACID. Pounds.
1	Red clover	4,000		268	92	91	27
2	Red clover	4,000		268	92	91	27
3	Indian corn	3,444	61.5	49	14	2	22
	Corn stalks	4,375		240	85	26	20
				289	99	28	42
4	Irish potatoes	17,920	298.6	400	223	8	50
	Irish potato tops	10,080		180	50	31	14
				580	273	39	64
5	Wheat	1,500	25	25	7	1	11
	Wheat straw	3,000		153	18	9	8
				178	25	10	19
	Total five years' rotation			1,583	581	259	179

3.—Crops and minerals substances taken from an acre of soil in another five years' rotation:

Year.	CROP.	WHOLE CROP. Pounds.	Bushels.	ASH OF CROP. Pounds.	POTASH. Pounds.	LIME. Pounds.	PHOSPHORIC ACID. Pounds.
1	Timothy hay	4,000		280	81	26	30
2	Timothy hay	4,000		280	81	26	30
3	Indian corn	3,444	61.5	49	14	2	22
	Corn stalks	4,375		240	85	26	20
				289	99	28	42
4	Oats	2,000	66.6	58	10	2	11
	Oat straw	3,332		170	33	14	4
				228	43	16	15
5	Rye	1,400	25	19	5	1	9
	Rye straw	4,200		168	29	15	6
				187	34	16	15
	Total five years' rotation			1,264	338	112	132

The chief constituents of a fertile soil which are liable to be soon exhausted, are, besides organic matter, lime, potash and phosphoric acid. The first table above gives the number of pounds per acre, of these constituents in various soils. The second and third tables show the amount of them taken out by five years' rotations of good crops. An inspection of the first table shows that a very few years of cropping would be sufficient to entirely exhaust some of these soils of their fertilizing constituents if they were all sold off the farm.

In all good farming, however, more or less live stock is kept to consume the coarser and heavier products of the farm, and the animals are sold, while the manure is returned to the soil to enrich it. Much of that taken out of the soil is restored to it again in this way. In the rotation above given, the clover, the cornstalks, the straw and the potato tops are all kept on the farm, and a part of the wheat, potatoes and corn, and the lime, potash and phosphoric acid in them, are restored to the soil in the manure from the stables and the cattle sheds, so that not one-third of that taken out of the soil by the crops is sent off the farm. Skillful farmers will always manage to make the waste from selling the fertilizing elements of their soil, just as little as they can. If good crops taken from the soil would exhaust it in ten or fifteen years,—it can be kept in order three times as long if only one-third is sold off.

To replace the potash taken out from one acre in the five years rotation, would at the lowest present prices of potash cost $40.67, and to replace the phosphoric acid would cost $17.90,—or per acre, nearly $12 a year. The value of land must then depend to a considerable extent on the amount of these constituents naturally in the soils, this value being modified by the condition of the soil and the ease with which it is managed and tilled. In soils from the northern part of the State the amount of these constituents is much greater than it is in those from the southern part. To counterbalance this, however, the cost of cultivating land in the southern part of New Jersey is much less than in the northern, and there is much less loss of time from cold and wet weather.

The principle however must everywhere be admitted and acted on that crops take valuable substances from the soil, and these must be restored in some form, or the capability of the land for

growing crops will be destroyed. Attention to this principle enables farmers on the lighter lands of Southern New Jersey to raise as good crops as are grown in the northern part of the State.

The land needs in addition to barnyard manure, however, other fertilizers to some extent in order to cultivate them to the best advantage. Of fertilizers, those which can be used to the best advantage in most places are muck and greensand marl. Every bushel of marl contains at least 5lb of potash, and 1½lb of phosphoric acid, and it can be bought for from 4 to 10 cents, according to the distance from the marl pits. Twenty bushels of marl make a ton, and five tons are enough to supply the whole of the potash and phosphoric acid for the five years rotation,—or a ton a year, which may cost from $1 to $2. It is true the potash and phosphoric acid in the marl are both so combined in it that they do not dissolve in water and so become fertilizing. But under the influence of the vegetable matter in the soils, or of the farm yard manures with which they may be composted they gradually become soluble; and under the influence of muck or of muck and lime they undergo the same change. There is then an abundant supply of potash and phosphoric acid to be had cheaply in greensand marl. An analysis of the average marl is here inserted.

Composition of various marls:

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Phosphoric Acid	1.14	1.33	1.02	2.24	2.69	2.56	3.58	3.87	2.58	2.30
Sulphuric Acid.....	0.14	.00	.27	.39	.26	0.22	0.97	0.31	1.89	.00
Silicic Acid and Sand.	38.70	46.03	50.23	50 80	49.40	51.50	53.15	54.75	59.80	57.67
Carbonic Acid.....	6.13	.....	.....	.....	.....	.....	.....	.....	.....	.....
Potash	3.65	5.67	6.32	5.18	6.31	4.62	3.75	4.11	4.25	3.53
Lime	9.07	2.01	1.40	2.13	2.52	1.26	3.27	5.46	2.97	1.26
Magnesia	1.50	3.47	3.45	3 54	3.24	3.95	1.75	2.99	2.00	3.67
Alumina	10.20	7.86	7.94	8.77	8.90	6.01	8.79	6.46	6.00	10.10
Oxide of Iron.....	18.63	25 23	20.14	17.63	17.11	21.04	15.94	15.20	11.98	14.16
Water.....	10.00	8.40	9.00	9.66	9.10	7.39	8.98	6.85	8.32	7.25
	99.16	100.00	99.77	100.34	99.53	98.55	100.18	100.00	99.79	99.94

No. 1 is an average of the variety of marl most largely used in eastern Monmouth. It is from the Lower Marl Bed, not par-

ticularly rich in phosphoric acid, but remarkable for containing from 10 to 20 per cent. of carbonate of lime in fine powder.

2. Marl from the Cream Ridge Marl Company, Hornerstown, Monmouth county.

3. Marl from the Pemberton Marl Company's pits, Pemberton, Burlington county.

4. Marl from Kirkwood, Camden county, and from the Middle Marl Bed.

5. Marl from the pits of the West Jersey Marl and Transportation Company, near Barnsboro, Gloucester county.

6. Marl dug at Dickinson's pits, at Woodstown, Salem county.

7. An average of five analyses of Squankum marls from as many different marl banks, near Farmingdale (Squankum), Monmouth county.

8. An average sample taken from a heap of 100 tons sent by the Squankum and Freehold Marl Company to New Brunswick.

9. Marl dug at the pits of the Squankum Marl Company, near Farmingdale.

10. Marl from the pits of the Vincentown Marl Company, near Vincentown, Burlington county. This comes from the green marl layer of the Upper Bed.

The above analyses are, of course, only averages. Single samples from any of them may be found which are much richer, and others which are much poorer. Complaints are frequently made that the marl is not good. Some of these may be well founded, but others are not. Those selling can supply equal to these analyses, and it is their interest to do so. The difficulty may sometimes arise from injudicious use, or from dry seasons. Marl is not a quick, but it is a lasting fertilizer. Its quickest and best effects are seen upon clover and grass.

Muck or black earth is abundant in all the swamps and wet grounds of southern New Jersey. It is vegetable matter partially decayed, and while in the swamp is undergoing no further change. It has then no fertilizing value, but when dug out and exposed to sun, air, moisture and to frost, it soon begins to change and decay. Its change can be hastened by the addition of lime, lime and salt, or barnyard manure. It is then in good condition to apply to the soil. Its office appears to be to improve the texture of the soil to increase its power of absorbing moisture from the air, to furnish a solvent for the mineral substances in the soil and in mineral fertilizers, and to become the medium of

communication between the soil and the growing crops. It does not contain more potash or phosphoric acid than is found in ordinary soils, and of course can of itself only help to exhaust them quicker, but mixed with marl or other fertilizers in the soil, it increases the crop very largely. Two experiments on a five years' rotation made accurately, at the Agricultural Exhibition Station of the East, at Nancy, France, by Professor Grandeau, upon crops grown in soils fertilized with phosphate of lime, but without muck; and other soils fertilized in the same way, but with muck added, showed that those grown on the soils with muck were 60 per cent. larger than the others, and this result is in accordance with common experience.

Analysis of a Muck from a pine swamp bottom, on lands of George W. Cowperthwaite, Toms River, Ocean county:

Organic matter	77.800
Water	7 950
Matters insoluble in acid	13.800
Alumina	0.174
Oxide of iron	0.250
Lime	0.031
Magnesia	0.216
Potash	0.070
Phosphoric acid	0.026
Carbonic acid	0.008
Chlorine	trace
Sulphuric acid	0.034
	100.359
Nitrogen	1.039

The sample was a good average, and was taken from a ditch bank. The deposit, of which this is representative, has an average depth of about three feet. Deposits of this kind are common throughout Ocean, the eastern part of Burlington, Atlantic, Cumberland and Cape May counties.

With these two fertilizers, both of which require little money, the tillage of these gravelly and sandy loam lands can be begun in an economical way. The first crops upon them will be light, but gradually their fertility will develop, and with good management very satisfactory crops can be produced. The soils are rather deficient in lime, the marl may supply this deficiency, or larger quantities of common slaked lime may be used to profit.

3. MISCELLANEOUS CLAY DEPOSITS.

Clays suitable for yellow ware, Rockingham ware, terra cotta, fire-brick and common red brick are found quite generally distributed throughout the southern and southeastern parts of the State. The openings at nearly all of the localities where they occur, are small, and limited generally to a few small pits, so that the facilities for the examination and study of these clays in their relations to other associated beds have not been such as determine their geological place. The absence of fossil remains, excepting fragments of wood and indistinct leaf impressions at a very few localities, leaves the subject extremely doubtful, and renders their identification difficult and at present uncertain.

There is a great similarity in the general appearance of the white clays, as if all of them belonged to the same bed and had been deposited under like conditions. From this it is probable that they are all of the same geological epoch. But whether that was in the latter part of the Tertiary Age, or was the glacial epoch of the Post-Tertiary it is not possible at present to decide. The great gravel formation of the southern part of the State was deposited during the latter part of the Tertiary epoch. The clays may belong with it, or what seems more probable from their position, in places under the gravel, they may be earlier Tertiary in age.

Some of the clays here described, especially those near the level of tide-water—as the Bridgeton and Maurice river clays—appear to be more recent. The occurrence of beds of fossil oyster shells in and at the top of these clays also indicate their recent origin. It is quite probable that some of these may have been deposited during the Historic Period. Very gradual changes of level would in the course of several thousands of years suffice for their deposition and the re-elevation of the land to its present height.

The localities here described have, with two or three exceptions, been visited and notes as to the extent, thickness, quality and uses of these clays have been collected. There may, possi-

bly, be others of which the Survey has not been informed. And there are, no doubt, many other places at which clays crop out, or may be found near the surface, to which no attention has been directed. Careful surveys and explorations will add to the list of localities and perhaps discover beds of greater extent and of more value.

All of these clays, even the best of them, are quite sandy and do not compare with those of Woodbridge and Amboy in purity and richness. They are all more or less stained by oxide of iron and by thin streaks of yellow earths, and consequently none of them are pure white, but of yellowish or reddish tinge. These impurities do not affect them injuriously for many uses, such as for drain pipe, terra cotta, common fire-brick and yellow and Rockingham wares. Selected lots may do for inferior grades of white ware, or, possibly, for No. 1 fire-brick and glass pot mixtures. At present they are used to a limited extent by the local potteries and other works and supply a home market.

The analyses of the clays are tabulated below. This table shows that all of these clays are quite sandy, and that in all there is a considerable percentage of potash. The oxide of iron, also, is comparatively large in amount. And from these figures there is the proper inference that none of them are very refractory. A comparison of these figures and those of the table on page 72 of the Report on Clays will suggest their trial for making stoneware. The lime and soda were not determined, as these bases are present but to a very small amount. Titanic acid also is present. It was not deemed of importance to be determined. And it is weighed with the alumina. The iron appears as sesqui-oxide.

		Sand and combined Silica.	Alumina.	Oxide of Iron.	Magnesia.	Potash.	Water (combined and hygroscopic)	Total (determined.)
1	White Oak Bottom	72.20	19.20	1.30	.....	1.05	6.20	99.95
2	East Plains	71.70	17.70	1.40	0.47	1.90	6.50	99.67
3	Tuckerton	59.40	23.88	3.02	0.69	1.93	10.80	99.72
4	Egg Harbor City	73.70	17.21	1.29	0.39	1.85	5.60	100.04
5	Elmer Earl's	65.10	22 28	1.67	0.68	1.95	8 20	99.88
6	Conrad's	64.00	23.30	1.50	... .	1.77	8.60	99.17

The arrangement of the descriptions of localities is a geographical one, beginning at the northeast, in Ocean county, and proceeding southwestward to Delaware Bay.

BRICKSBURG TRACT.

Clays suitable for red brick have been found at several localities on this tract. A considerable amount has been dug at the pits east of the old Seven Stars tavern, and between Chestnut and Locust streets and River Avenue and Vermont Avenue. The clay is very stiff and tough, and most of it is some shade of yellow or red, although it is said that some of it is white. A gravelly earth four feet thick covers this belt of clay. Selected lots might be used for pipe or for some kinds of pottery.

Two specimens of clay were sent to the laboratory by H. Severance, of Bricksburg, who reported that they came from borings on high ground on the Bricksburg tract, and that the top dirt was eight to ten feet thick, and the clay bed about five feet thick. The specimens were submitted to a fire test. One of them, coarse-grained and white, stood the fire. The other, a pinkish clay, was fused in spots.

BENNETT'S MILLS.

A white, sandy, but quite tenacious clay crops out on lands of Charles H. Appleget, near Bennett's Mills and near a tributary of the Metedeconk creek. The locality was not visited the past season, nor has the extent of the deposit been determined.

HERBERTVILLE CLAY.

This clay locality is half a mile west of the Manasquan river and a mile south of Herbertville, Ocean county. The clay forms the surface—soil and subsoil—in rather low and flat ground. The extension of the deposit is covered by sand in the knolls around it. The clay bed is not over twenty feet above tide-level, and is six feet thick. Under it there is a brown sandstone. The clay is white and sandy. It was used years ago for fire-brick at the Bergen iron works—now Bricksburg. At present it is made into red brick at a small yard, near the pits.

WHITE OAK BOTTOM CLAY.

White Oak Bottom is in Dover township, Ocean county, four miles north of Toms River. The clay bed has been opened on lands of N. C. Whiting, and extends on the adjoining lands of Mrs. H. A. Dunham. The clay forms the surface over a small area, and as opened, the top dirt was soil and subsoil, which were clayey. The top clay is somewhat stained by thin, filmy coatings of reddish-yellow, ochrey earth. The bed has a mean thickness of ten feet. Under it there is a fine, white sand. An analysis of an average specimen of the clay of these pits showed that it contained of

Sand and (combined) silicic acid	72.20
Alumina	19.20
Oxide of iron	1.30
Potash	1.35
Water	6.20
Total	100.25

From these figures it will be seen that the sand makes up quite one-half of the whole mass. In composition it approaches the typical stoneware clays of Amboy, although more sandy than they are. The pits were worked in 1877, and the clay was carted to Toms River, and thence shipped to a pottery firm in Brooklyn. Specimens were sent to Trenton to be tried in white ware. Borings about the pits indicate a considerable extent of clay. It is all above the natural drainage and about forty feet above tide level, so that it can be worked without much trouble or expense from water. As it is only two miles from navigable water at Mosquito Cove, or head waters of Barnegat bay, the transportation also would be comparatively inexpensive. The locality is deserving of further attention and examination.

TOMS RIVER.

Clay for red brick is abundant in the high ground north of this village. And it appears probable that there is a more or less continuous clay bed under all of the high ground between this point and White Oak Bottom, although, as illustrated by these, there may be quite a variation in the material of the bed

from point to point. At Dubuisson's brick yard, one mile north of the village, there is a drab colored clay having an average thickness of thirteen feet and covered by sand and gravel to a depth of four feet. This clay is said to burn light colored and to make smooth, but not very strong, brick. It has not been used excepting at this yard for common, building brick. By careful sorting the best of this clay might answer for drain pipe.

East of the village, on Dillon's Island, and near the Island Heights camp ground, a white and sandy clay appears in the bluff or river bank. The bluff is thirty-five to forty feet high, and the layer of clay is about twenty-five feet above tide level. It is three feet thick. White clays are reported in digging wells on the camp ground, west of the bluff.

(STANTON) TRACT.

On this tract, formerly owned by Amos P. Stanton and later by S. H. Shreve, there has been considerable work done in searching for clays. Ex-sheriff Ivins bored fifteen to twenty-five feet at many points, but did not discover any beds of value, although at one point, a tough, blue clay was found in a bed ten feet thick. Sands and gravels were the prevailing strata, and very thin layers of clay. Some digging and boring made by Mr. Shreve near Sunken Branch, three miles west of Toms River village, opened two layers of yellowish-white clays, each eighteen inches thick and separated by sand. These borings stopped at a depth of ten feet.

LARRABEE'S CLAY PITS.

These pits are a quarter of a mile west of the yard of Larrabee and the New Jersey Southern Railroad, and about a mile north of Whiting's station. The pits are in wet and flat ground near the head of one of the branches of the Union branch of Toms river. There is a gravelly earth and salmon-colored sand on the clay, and this top dirt varies from one to six feet in thickness. The clay is yellowish-white and streaked by a little yellow loam which covers fractures in it. Occasionally a pebble appears in it. The depth of the pits was not ascertained, nor the thickness of the clay bed. The clay was made into building brick at the yard on the railroad. They were of poor quality. Evidently the

clay is too rich in alumina and too hard to burn for such uses. It might do better for admixture with other clay for terra cotta, or stone ware, or, possibly, for fire-brick.

CLAY AT MOUNT MISERY.

Clay was formerly dug near Mount Misery, Burlington county, for making the brick used at the Hanover furnace. The pits are near the old road to Brown's Mills and one mile south of Hanover station. When visited, they were nearly filled up by the sand and earth washed in from the surrounding surface, and the top clay only was seen. That was two feet below the surface and was yellowish-white and sandy. The deeper clay was probably white and of a better quality. The thickness or extent of the deposit could not be ascertained. On the hill a few rods east of the old pits a red clay crops out in the road cut. These pits are about a half mile northwest of the little hamlet known as Mount Misery.

A yellow, sandy brick clay is found a few rods south of the stream and at the settlement. Years ago there was a brick yard here, and red brick were here burned for the buildings at Hanover Furnace.

TOWNSEND'S CLAY, WHEATLAND.

This locality is one and a quarter miles southeast of Wheatland Station, Ocean county. It is on the water shed between the Delaware river and the ocean and according to barometric observations, very near two hundred feet above tidewater level. The pits are at the side of the Wheatland and Cedar Bridge road, and on what is known as the Webb mill tract, and are owned by a company in Toms River. The clay is dug and used by E. N. and J. C. Townsend in their pipe works at Wheatland Station. The strata met with in digging, according to Mr. Townsend, occur in the following order and thickness:

(1) Gravelly earth and clayey sand	7–10 feet.
(2) Black, sandy clay, full of lignite and pyrite	1–4 feet.
(3) Blue, pipe clay	3–8 feet.
(4) Reddish yellow, sandy clay	2–3 feet.
(5) Sandy earth with some clay lumps, (locally called a *kaolin*)	2–3 feet.
(6) Sand with some gravel at the bottom	

The black, sandy clay (No. 2) is a heterogeneous mixture of sand and a chocolate colored astringent earth and contains much lignite in the shape of small sticks, pieces of bark, &c. Leaf impressions also occur in it. It is described in this report, under the head of Miscellaneous Work of the Laboratory, and an analysis of it and some notes about its use as a fertilizer are appended.

The blue, pipe clay is quite sandy. The sand in it is very fine grained. This layer is found to be very uniform throughout all the pits. The reddish clay at the bottom is very thin in places. The clays are carted to the works at Wheatland and used in sewer and drain pipes and in chimney tops. The blue clay mixed with a little of the so-called *kaolin* has been tried in fire-brick. Very little has been done for two or three years past and when visited last season there was a large stock of clay and of pipe also at the works.

The location of the works so far inland and from the larger markets of the country, makes the freights large as compared with localities on tide-water and nearer to large cities and trade centres.

UNION CLAY WORKS.

These works are a few rods east of the Woodmansie and Cedar Bridge road and three miles from the New Jersey Southern Railroad at Woodmansie. They are in Ocean county, but near the Burlington line. The ground is high, being on the divide between the waters which flow eastward to the ocean, and those flowing westerly into the Delaware river. According to barometric observations, the clay bed is 175 to 180 feet above tide-water level. There has been considerable digging and there are three distinct groups of pits. At the pits north of the works there is—

(1) Gravel and yellow, loamy clay	4 to 9 feet.
(2) White clay	10 "
(3) Sand and gravel	4 "
(4) White sand at the bottom.	

East and southeast of the works the digging showed the following section:

(1) Thin covering of reddish, gravelly earth	
(2) Clay of inferior quality	8 feet.
(3) Micaceous clay and sand	4 "
(4) White clay	10 "
(5) Gravel at bottom of the pit.	

The best clay was No. 4 of the latter section. The clay of (2) was not worth much for pipe, except in mixture. These figures do not apply to all the pits as there is some variation from pit to pit. In digging a well at the works, sixty-two feet deep, the strata cut were the following:

(1) Loamy gravel and clay (thin layer.)	
(2) Clay	8 to 10 feet.
(3) Gravel (thin layer.)	
(4) Clay, of good quality	2 to 3 "
(5) White sand	22 "
(6) Sandy gravel at the bottom.	

These figures are from P. H. Lauth and A. L. McCall, who were managers of the works and superintended the digging. They show how the strata vary from point to point and the irregular alternations of clay, sand and gravel.

On the adjoining lands of Daniel Brewer and east of the works the ground is lower and the clay is near the surface. The well at the house, thirty-six feet deep, was dug through the clay.

Borings made about the works for testing the ground show, it is said, a workable clay area, of nearly seventy acres. Of the top clay some is reddish in streaks. It was used in making red brick. The best clay of these pits is white and rather sandy. The works used the materials from the several pits. The best clay was put into drain and sewer pipe. This was mixed with the micaceous sand, which came from below the clay bed. The pipe manufacture was started here in 1866. Previous to that date the clay was tried for fire-brick and common pottery. For the former it was not sufficiently refractory, although the brick were smooth and hard. For pottery it was said to answer very well. These uses were rather of an experimental nature, and the principal business was the making of pipe. It was tried for glass pots, and when mixed with German crucible clay the result was quite satisfactory. The clay looks like some of our

stoneware clays, and it appears to be better adapted to stoneware, or to terra cotta, than to pipe.

The works have been run at intervals and by several firms. They are now idle. There is a considerable stock on hand and some in the kiln unburned. The development of this property began about eighteen years ago, when the first pits were dug. Previous to that time the clay had been known, and the colliers of the neighborhood had been accustomed to use a little of it to chink up their cabins.

SHAMONG.

A bed of yellowish white, sandy clay, four feet thick, was worked several years ago for common, red brick. This clay burned to a cream color. These pits are northeast of the village.

ATSION.

One mile east of Atsion and north of the Atsion river a white, tenacious clay has been discovered, but its extent and thickness have not been ascertained.

EAST PLAINS.

Thin layers of white clay crop out at the Watering Place on Governor's Branch, where the Cedar Bridge road crosses that stream. A little of it has been dug and used by coal burners for their coalings and for chinking up their cabins. A trial pit dug last summer cut through a bed of white clay four feet thick and then struck a brownish sandy earth. The clay which was taken from it is quite white, containing a few thin streaks of yellow earth, and moderately sandy. A partial analysis of the specimens collected at that time gave the following percentages:

Sand and combined silica	71.70
Alumina	17.70
Oxide of iron	1.40
Potash	1.90
Lime	.....
Magnesia	0.47
Water (combined and hygroscopic)	6.50
Total (determined)	99.67

The sand (quartz) was not determined but it amounts to 50 per cent. at least of the whole. Such clay might be used for some kinds of pottery. The locality is so far from railroad or boat (seven to ten miles) and the beds, as tested, are so thin that its use does not promise to be at all extensive.

From these outcrops and from those on the West Plains, it seems quite probable that there is a clay formation extending throughout these Plains and the adjoining high lands. According to barometric observation the elevation of this clay at the Watering Place is, approximately, ninety feet, or about seventy-five feet lower than the clay bed as it is opened at the Union Clay Works, which is ten miles to the northwest. These Plains clays may belong to the drift and be of the same age as the great gravel formation of this part of the State.

WARETOWN.

A white, sandy clay occurs at the bottom of a gravel pit a mile southwest of Waretown and a half a mile west of the shore road. It has not been used except as thrown out with the gravel for roads. The locality was not visited. A specimen was received from Samuel Birdsall, of Waretown.

TUCKERTON CLAYS.

White clays have been found at several places within three miles of Tuckerton.

One of these localities is on the farm of Jonathan Nugent, one and a half miles northwest of the village and southwest of Shurd's Mill branch. The clay is found within a foot of the surface in a basin-like depression and about twenty feet above tide-level. Several small trial pits have been dug and the clay has been found seven feet thick. Much water and sand is found at the bottom of the pits, and that is supposed to be the limit of the clay. These pits are all quite near together, so that the extent of the deposit is not known. In the adjoining higher ground it is probably covered more deeply.

The top clay has some thin streaks of yellow, ferruginous earth, which gives it a slightly mottled aspect. That from lower down is not so much streaked. An average specimen representing the deposit was analyzed and found to contain:

Sand and combined silica	59.40
Alumina	23 88
Oxide of iron	3.02
Potash	1.93
Magnesia	0.69
Water (combined and hygroscopic)	10.80
Total (determined)	99.72

The sand (quartz), the soda and the lime were not determined.

A small lot of the best clay of these pits was tested in the pottery at New Brunswick, for stone ware. It did not do well, as it was too hard to burn and too *fat* for stone ware. It appears more like a fire-clay, or it may answer in mixture for terra cotta.

This locality is so near both to railroad and tide-water that it has good facilities in the way of transportation. The labor supply of Tuckerton, and cheap fuel also, make it promising and worthy of the attention of manufacturers.

A clay very like the above is reported on the farm of Eayre Oliphant, about three miles southwest of Tuckerton. Its thickness was not ascertained.

Thin layers of white clay have been met with in wells near the village.

CONRAD CLAY PITS.

The following is taken from the "Report on Clays," 1878:

"These pits are at Conrad, one mile south of Tansborough, Camden county. The Williamstown railroad runs a few rods west of them. The existence of clay here has long been known, and it has been used at times by the people of the neighborhood as a whitewash for out-buildings, fences, &c. About seven years ago the first pits were dug for clay, to make pipe, and about that time works were erected here for the manufacture of pipe, terra cotta and fire brick. The pits go through a bearing of six inches to three feet, and then the bed of clay, five to sixteen feet thick.

"Under this latter there is white and yellow quartz sand. In some places there is a stony layer, from two to four inches thick, consisting of sand cemented together by iron oxide, between the clay and the sand. James Conrad, the former proprietor of the

pits and works, says that this clay can be traced for a mile southeast of his pits; he has found it at several points in borings in that direction.

"This clay varies considerably in its appearance. Generally the best of it is at the bottom, near the stony layer. All of it is sandy, and some of it is mixed with earth in streaks. Its colors are bluish-white, buff and chocolate shades. The chemical composition is expressed by the following analysis of an average specimen:

"Alumina*	23.30	
"Silicic acid	29.50	
"Water (combined)	7.00	
		59.80
"Sand	34.50	
		34.50
"Potash	1.77	
"Soda	0.16	
"Lime	.....	
"Magnesia	.....	
"Sesqui-oxide of iron	1.50	
"Water (moisture)	1.60	
		5.03
"Total		99.33

*Including titanic acid.

"These figures show that this clay cannot be refractory enough for the best fire brick. They indicate a composition like that of some of our best stoneware clays.

"All of this clay answers for pipe. Some selected lots were used in fire brick, but nothing was learned of their character. For some of the finer and ornamental terra cotta ware the crude clay is washed, sifted and pressed. The ware made of it has a pleasing and soft shade. Some of the statuary looks very well. For the latter, the unwashed, crude clay can be used. The products of the works are shipped over the Williamstown railroad —a side track running to the works. The thickness of the clay, the thin covering of soil, and the location so near the railroad favor this place."

EGG HARBOR CITY CLAYS.

Clays for the manufacture of pottery and for red brick have been dug at several points on the Egg Harbor tract. One of these is Gabler's pit, near Hamburg avenue, and on the west side of the town. A small pit was dug at this locality to a depth of six feet. The clay which was obtained from it was used in a small pottery in the city. There is a thin covering of soil and subsoil on the clay bed. The top spit is gravelly. The lower part of the bed is sandy and the best of the clay contains a considerable proportion of sand. It is white, but reddish-yellow earthy films on the fracture surfaces give it a slight yellowish tinge in the mass. Some of this clay was tried for white ware, but with what result was not learned. A partial analysis gives the following percentages:

Sand and combined silica	73.70
Alumina	17.16
Oxide of iron	1.24
Magnesia	0.39
Potash	1 85
Water (combined) and moisture	5.60
	99.94

Borings made in the flat ground north and northeast of this pit indicate the extension of the bed in those directions.

Clay is reported to occur in the higher ground west and northwest of the Gabler pit.

Another opening for clay is south of the Camden and Atlantic Railroad and a quarter of a mile west of the depot. Several small pits have been dug. There is at the surface a gravelly earth which goes down two to four feet; then the clay bed is struck and that is from ten to twelve feet thick. At the bottom the pits reach a sand bed. The clay is whitish and sandy. It burns cream-colored. Several years ago there was a brick yard near the pits and many brick were made for buildings in the town. A little of it was used at a pottery in flower vases. No clay has been dug for several years past.

These white clays are not so desirable for common brickmaking, as they are not so easily burned, nor do they give the deep red

color so much desired. For some grades of stoneware and for terra cotta they may yet supply a local demand.

Clay for red brick is dug northeast of the town and east of the Catholic Church. It is yellow and loamy and makes a deep, red brick. The clay is covered by a gravelly bed.

A fourth locality where clay is dug, is north of the brick yard and about a quarter of a mile northeast of the brewery. The pit is on a side hill, and the gravelly earth occurs here also, overlying and capping the clay. The latter is buff colored and rather sandy. It has been used in making drain pipe and chimney tops.

East of the town a thick bed of white clay is said to have been discovered in digging deep wells. Beyond the fact of its discovery nothing further could be learned.

These several clays in and about Egg Harbor City appear to be nearly in the same horizon, and all are about fifty feet above tide-level. The white clays look like those found elsewhere in South Jersey, and they are, probably, parts of an extensive formation which overlies the glass-sand bed. The common, brick clays are more nearly related to the great gravel formation, which here constitutes the surface of all the higher parts of the country, and they are of a later age. From these general statements it follows that the list of localities, where such clays may be obtained, can be largely extended by careful searching.

MAYS LANDING.

A white, sandy clay was formerly dug, east of the village and near the Great Egg Harbor river, just south of Babcock creek. The upland bank is about fifteen feet above high tide level. Of this, the upper half is sand and gravelly earth and is eight feet thick. The top clay is white, streaked red and yellow. As the old pits are full of water and top dirt, which has run down into them, the thickness of the clay bed could not be ascertained. No digging has been done here in several years. The clay which was dug was used for drain pipe at a pottery on the river below the village.

The same bed of clay crops out on the west bank of the Watering Place Branch and near the old grist mill site. The locality is a quarter of a mile northeast of the railroad depot. The clay

resembles that seen at the old pits. In digging wells in the village it is found five to six feet below the surface, and is, generally, four feet thick. The wells are seventeen to twenty feet deep.

On the west side of the river and west of the village there is a large, but shallow, pit, where brick clay has been dug. It is at the side of the Weymouth road. The surface layer is a gravelly loam, which is on the average, three feet thick. The clay is bluish-white and sandy. Under it there is a white sand and the bottom of the clay is 5–10 feet above tide level. It is supposed that this clay belongs to the bed, which is found in the wells in the village, and in the river bank east of the village.

At High Bank Landing, one mile south of Mays Landing a clay crops out in the upland bluff, and according to the following section:

(1) Yellow, dune sand	2 to 3 feet.
(2) Yellow sand, with some gravel	12 "
(3) Black clay (to water level)	3 to 4 "

This clay is quite impregnated with *copperas*. In it there are some small quartz pebbles also, but these are sparingly scattered through it. At the water (tide level) there is a stony layer, which may limit the clay. This clay is very tenacious and is adapted to red brick. It is not fit for refractory material or for wares. It is so unlike the Mays Landing clays that it cannot be classed, technologically nor geologically, with them. And yet it occupies the same relative position and is at very nearly the same level. It is more probable that it is of a very recent age, though older than the gravel.

VINELAND.

Clays for the supply of the brick yards are dug at several points on the Vineland tract. At Forest Grove there is a very red clay in a bed which is five feet thick. At pits northeast of the Vineland station a potters' clay has been dug. It is used with Amboy clays in the pottery here.

MAURICE RIVER CLAYS.

Clays have been dug at several points along the Maurice river, between Millville and Buckshutem and Port Elizabeth.

On the west side of the river and one and a half miles from Millville there is the bank of Isaac Mulford. It is at the side of the Buckshutem road and the clay bed appears in the road ditch. The top of the bed is at least thirty feet above tide level. The bank has not been worked in several years and has so caved in as to hinder measurement of its thickness. A careful estimate of Mr. Mulford puts the amount dug at two thousand tons. The larger part of it was shipped to a terra cotta works in Philadelphia. About twenty-five tons were sent to potteries in Trenton. What the results of these trials were was not learned. A specimen of this clay received from Mr. Mulford is white and contains much fine sand. It looks like a good material for stone ware. The bank is so near tide water that it can be put on vessels at small cost or it can be carted to railroad at Millville. Millville offers a convenient location for a pottery that could use these clays of the vicinity and supply in part the home demand. Further exploration and tests of this clay are desirable.

Clay for red brick is dug on the farm of Isaac Hilliard, on the west bank of the river, and three miles below Millville. There is at this bank a very thin covering of loam and top earth. The clay is just above tide-level. It is of a greyish shade of color and is considered a first-rate material for brick. It is carried to the yard of John L. Sharp, at Millville, and there made into common building brick.

A bed of clay similar to the above has been opened on the same side of the river, about a quarter of a mile north of Hilliard's sand dock. The clay from it went to a brick yard.

On the east side of the river and opposite Hilliard's dock, there is the clay bank and brick yard of A. E. Burcham. The vertical section of the bank includes the following:

(1) Sandy loam, with a few scattering pebbles	2 feet.
(2) Bluish-grey clay	10 "
(3) Gravel	3 "

At the bottom there is fine white sand, which is thought to be the glass sand bed. The bottom of the clay is at the level of high tide. The top dirt is used to temper the clay. The bricks made of this clay are of good color, hard and strong.

What is supposed to be the western extension of this clay bed is uncovered at the Hilliard sand pits. These are a quarter of a

mile west of the dock. There the clay bed is five feet thick and lies upon the glass-sand.

The same bed is recognized in the east bank of the river, on the farm of Mrs. Jonathan Lore, near Port Elizabeth. The clay bed is at least seven feet thick and extends down to tide-water. At the top there is a bed of oyster shells two feet thick. As these are of recent age, the clay is most probably more recent than the drift, and, possibly, of the Historic Period. This locality was described and the section figured in the "Geology of New Jersey 1868," *pages 303–304.*

A well dug nine years ago near the Hilliard farm house, discovered a clay bed much like this, and also containing recent shells. The shell-bearing clay was covered by (1) a clayey loam twelve feet thick at the top, then (2) a layer of stone six inches thick. Under it there was the glass-sand bed. The shells obtained from this well were very tender and crumbled on handling. The mass was applied to a spot of ground and its good effects are still visible.

ELMER EARL'S CLAY PITS.

Earl's pits are on his farm, south of his residence, one mile southwest of the Centreton School House, Fairfield township, Cumberland county. They are in rather flat ground, near the head of Cedar creek and about eighty feet above tide-level. The top dirt, or *bearing*, consists of a clay loam and coarse gravel and is one and a half to three feet thick. The bed of clay ranges from five to eleven feet in thickness. Under it there is a coarse gravel and sand. The upper part of the bed is traversed by thin layers of yellow earth. Under this streaked clay there is the white and best clay of the pits. And this is more dense as we get near the bottom of the bed. In all of these there is some sand, but it is fine-grained, which gives compactness and density. The best is selected as a fire clay. The other is sent to potteries. An analysis was made of the best clay of the pits and the following results were obtained:

Sand and combined silica	65.10
Alumina	22.28
Oxide of iron	1.67
Potash	1.95
Magnesia	0.68
Water (combined and hygroscopic)	8.20
Total (of determinations)	99.88

The percentages of oxide of iron and of potash show that the clay cannot be very refractory. These figures agree closely with those of the analyses of the stoneware clays of South Amboy and indicate that they may do well for stoneware.

The original clayey surface of this part of the field led to the discovery of the clay, and the first pits were dug in 1870 and 1871. Since that time several pits have been dug and the clays have been carted to Millville, and most of it shipped to Philadelphia, where it has been used in yellow and Rockingham wares. A little has been used at the rolling mill in Bridgeton, and trials of it in the mixtures for glass pots at the Millville Glass Works are reported. The results of these trials are not definitely known. It has been used in furnace construction. Trials of it for fire-brick are also reported.

In consequence of the flat ground, the drainage is by a long ditch—and this only three feet below the clay surface. The water below that level has to be raised by a steam pump. The pits furthest south show an increasing thickness of the top dirt and a very slight dip of the clay bed towards the south. The ground rises a little in that direction.

The pits are six miles from Millville and four miles from tide-water navigation at Cedarville.

The elevation of this bed of clay and the character of the clay indicate that it is entirely distinct from either the Maurice river, or the Bridgeton brick clays and that it is an older bed, which belongs in the higher grounds only. It is highly probable that it can be found elsewhere, of workable thickness and desirable quality, and careful searches will yet find it at points near transportation and where it can be cheaply worked whenever there is such a demand for these clays as to start exploration.

BRIDGETON CLAYS.

On the farm of B. F. Lupton, a mile and a half south of Bridgeton, and on the west bank of the Cohansey creek, a brick clay is dug and used in Lupton's yard. In its general appearance and in its relations to the glass-sand bed it resembles the Maurice river clays and belongs, apparently, to the same recent formation.

The vertical section of the bank is as follows:

(1) Earth and a little gravel	6 to 7 feet.
(2) Greyish-blue clay	5 to 8 "
(3) Cemented sand	6 inches.
(4) Coarse yellow sand at the bottom	

The sand at the bottom may be the glass-sand bed.

In digging a well a few rods west of the bank there was found:

(1) Loam and gravelly earth	12 feet.
(2) Clay	15 "
(3) "Hardpan"	2 "
(4) Coarse sand	4 "

And the bottom, forty feet deep, was in sand.

At the bank and in the well the clay bed is all above the level of high tide.

CLAY AT FISH HOUSE, CAMDEN COUNTY.

The Fish House clay banks and brick yards are on the Delaware, three miles northeast of Camden. There are two large banks where brick clay is dug and a third opening in the fire-clay bed.

The most northerly of these banks is a quarter of a mile northeast of the railroad station, and on the east side of the track. The ground rises quite rapidly going from the river eastward, and the surface about this opening is forty to fifty feet above tide-water level. The digging has gone down very nearly to that level. This affords a good working face. The surface material to a depth of one to four feet, is a reddish earth and coarse gravel, and included in it there are some cobblestones and small water-worn boulders. Next underlying the top stratum is a reddish-yellow brick earth, which grades downwards into a dark-colored clay, and which appears to be a part of the same bed, weathered and changed in color near the top. The lower, dark-colored clay is sandy and has a laminated structure, and contains some mica in fine spangles. A laminated sand is said to underlie the clay bed. Shells and casts of the genus *Unio*, the fresh-water mussel, have been found in the clay near

the bottom of the bed. These indicate that it is more recent than the plastic clay formation of the State, which belongs in the Cretaceous Age. These banks afford a workable thickness of twenty to forty feet of clays and have natural drainage. They supply material to the brick yards of Hatch & Bro., west of the track and on the river bank. Common and pressed brick are made, and the capacity is said to be 10,000,000 brick a year. Facilities in the working of the bank and the handling of the clays and nearness to markets have made the location a good one, and the aggregate products of the yards have used all the clay from an area of three or four acres.

AUG. REEVES' FIRE-CLAY BANK.

This bank is southeast of the brick-clay bank and about forty rods east of the railroad track. There is considerable variation in the thickness and succession of the strata at the several points of this opening. At the southeast there is loam, sand and gravel over the clay, and in places these have a thickness of twenty feet. These materials are in thin layers, irregularly alternating and varying from loam to fine gravel. The fire-clay under this top dirt, or *bearing* is white, very sandy, and looks like the so-called *kaolin* (micaceous sand) of Middlesex county. Underlying it is a bed of red clay.

Towards the northwest and at the more recently opened part of the bank, the following section was observed:

(1) Very sandy clay (called *kaolin.*) .....
(2) Red clay..... 5 feet.
(3) White fire-clay..... 3 "
(4) Sand at the bottom of the pits, which is little above tide-level.

The sand in all of these clays is fine-grained, and there is very little mica in them. The red clay is in part white, and rather mottled. They resemble the clays at Florence and the more sandy clays of Woodbridge and Amboy. The composition of the best fire-clay of this bank is given in the following analysis:

Sand and combined silica	73.35
Alumina	17.26
Titanic acid	1.50
Oxide of iron	1.09
Magnesia	0.20
Potash	0.50
Water (combined and hygroscopic)	6.25
Total	100.15

The presence of titanium in this clay adds to the number of localities where this element occurs and shows its general distribution.

These pits have been worked by Dr. J. S. Hylton under lease which has just expired. The clays went into the market as fire-clays. Hereafter they are to be worked up by the proprietor of the bank at his works, ("Pea Shore Brick and Terra Cotta Works,") on the river, near Fish House Station. The vertical section of this bank corresponds to that of Hylton's banks along the Pensauken creek bluff, in the order of the strata, though these are not so thick and the whole height of the section is much less. It is the same formation and of the Cretaceous age, and, consequently, much older than the brick clays of the neighboring bank. These latter may lie upon and abut against the older fire-clays. Further excavation may show their superposition. They have partially filled the older and broader valley of the Delaware, excavated in the Cretaceous age.

CLAYS NEAR CAMDEN.

Several small pits of clay have been dug near the Mount Holly Railroad junction, and near Baldwin's Run. The *bearing* on the clay is gravel and gravelly earth, the lower part of which is, in places, cemented into a stone-like mass. The excavation of the railroad companies has removed most of this top earth, excepting a stony covering or hardpan, which is two to three feet thick. The top of the clay bed is about three feet below the tracks, and is estimated to be fifteen feet above high water level. It is said to be six or seven feet thick. The clay is mottled, or spotted, red and white, and resembles the spotted clays of the Woodbridge and Raritan river clay banks.

A short distance south of the above described locality sands and some reddish, sandy clays have been dug in shallow excavations made near the line of the railroad. The red, sandy earth and gravel, covering ten to eighteen feet thick, has been removed by the railroad. The clay is in thin layers, and the sand is sharp-grained and somewhat like the Woodbridge *feldspars*. These materials are used in foundries. They are regarded as in the southwest extension of the Cretaceous clay formation.

4. GLASS-SAND.

In the "Geology of New Jersey 1868," *page 690*, the following general statements appeared regarding the glass-sands of the southern part of the State:

"The glass-sand used in the southern part of the State is mostly obtained from a bed which appears to be uniform throughout the whole of that part of the State. It has been represented in the detailed geology as one of the subdivisions of the Tertiary Formation.* It is co-extensive with the Tertiary Formation, and can be seen almost everywhere within the bounds of that geological district, from Shark River to Cape May, and from the outcrop of the upper marl bed to the Atlantic ocean. Near the surface it is not always recognizable on account of the discoloration in it, due to oxide of iron. The remarkable uniformity, or even fineness of the grains, is a characteristic of it everywhere. * * * * * * * * * *

"This sand is generally fine, angular, even-grained and so pure that at many of the glass houses it is used for making window glass without any preparatory washing. But most commonly it is washed to remove the little clay and ashy loam, which may be mixed with it. The sand should be free from all gravel, although it is best if quite coarse. The more angular the grains the better. Smooth, rounded grains, or sand, which is very fine, cannot be used without much difficulty on account of its settling in the *batch*, and so preventing an even mixture with the flux. Clay and loam can be washed out, though the best sand is that in which the grains are clear and white."

In the course of the field work of the past season nearly all of the localities were revisited and notes as to their deposits collected. It has b en thought best to use these notes for this report, and they have been arranged and supplemented by a few notes of previous years, so as to present a general review of the whole

*It is most probably, Pliocene, being newer than the Shiloh marls which are Miocene and older than the gravel.

field, together with such details as have seemed necessary to make it instructive and plain to all seeking information in this direction. It will, therefore, be understood that this is only a preliminary report, introductory to a more full and systematic one to follow this another year. It is hoped that a more detailed survey of Southern New Jersey will discover the geological position of these several outcrops and indicate their relation to one another, as well as to other associated beds. At present they appear as parts of one thick bed, which dips very gently towards the southeast and whose outcrops form the greater part of the belts of pine lands. At some of these localities the bed is at the surface and hence the pits are shallow,—mere trenches and holes. In others, as along the Maurice river and also near the Cohansey, it is covered by clay beds of recent age. The arrangement of the descriptions of localities is geographical.

LEBANON GLASS WORKS.

Sand for these works is said to have been obtained near them.

TAUNTON GLASS-SAND.

This locality is a little over a mile north of Taunton and within a few rods of the Medford road. The sand forms a thin, surface bed, or layer, on gently rising knolls. Shallow pits have been dug here and there, over an area of several acres. In consequence of this sandy surface the growth of wood is limited to scattered yellow pine. In digging, the turfy layer, about six inches thick, is removed. The sand has an average depth of one to two feet and lies upon a yellow, loamy sand. The glass-sand is white, and the grains quite angular and irregular in shape as well as of varying sizes. Occasionally there is a little earth in it and yellow quartz grains. These are removed by washing. The washed sand is carted to the works of Yarnall & Trimble, at Medford, three miles distant, where it is made into hollow ware.

TUCKERTON GLASS-SAND.

The glass-sand bed has been uncovered in a gravel pit on lands of Dr. Theo. T. Price, a few rods west of the railroad and one mile north of Tuckerton. There is at this place:

(1) Gravelly loam..... 4 feet.
(2) Glass-sand..... 7 "
(3) Sand and gravel at bottom.....

The bed of gravelly loam is dug for road-making material. The sand is white, uniform in size of grain and contains but little loam, in a few thin streaks. The bed has not been worked. The surface of the ground is about twenty-five feet above tide-level, and the sand bed is, therefore, about fourteen to twenty-one feet high. As it is not wet and is so near navigable water, and has cheap labor at hand, it would seem to be a locality which should command attention from parties who may be looking for new deposits of sand for glass-making.

EGG HARBOR CITY.

In some of the wells dug in Egg Harbor City, and at the clay pits, a bed of sand has been struck at seven to twelve feet below the surface. Some of it would answer for glass-making.

ABSECON GLASS-SAND.

The glass-sand bed was uncovered southeast of the village of Absecon, in the cut of the Camden and Atlantic Railroad. The vertical section in this cut is as follows:

(1) Soil and yellow, gravelly loam..... 2 to 3 feet
(2) Gravel, in layers alternating irregularly with sand..... 8 "
(3) Bed of glass-sand (to bottom of cut)..... 4 to 10 "

The sand in the gravel is marked by lines of false bedding, and the gravel by many fossiliferous pebbles. The thickness of the glass-sand is not known as the cut does not get through it. Practical glass-blowers have pronounced this sand to be of remarkably good quality. It has not been tried. It is near both railroad and navigable water, and can be worked easily as it is above the water level and the natural drainage.

MAYS LANDING GLASS-SAND PITS.

Glass-sand has been dug at several places south of Mays Landing and near the Estellville road. The first of these, going from

Mays Landing, is on the east of the road and a quarter of a mile from the village. The surface is very gently mamillated, in low, flattened knolls; and it is almost clean white sand. The pits are two to three feet deep. At the bottom a yellow sand is found.

Further on, and at the township line, some digging has been done on the west of the road and a few rods only from it. The sand at this place is much like that nearer the village, excepting that the bed appears to be thinner—from one to two feet thick.

The next locality is west of High Bank Landing, and one and a half miles from Mays Landing. It is east of the Estellville road. The white sand knolls hereabouts look somewhat like the dunes of the shore beaches. And there are two, if not more, lines of these hillocks. One of them is close along the river and the second is 300 yards west of the first and parallel to it. In both of them many holes have been dug and sand taken out for the works at Estellville. The thickness of the white sand varies from one to three feet. It is underlaid by yellow sand. The grains appear quite uniform in size and more rounded than those of the Maurice river and South Vineland sands. All of these localities are alike in the superficial nature of the bed and its comparative thinness. It constitutes the surface formation. And it is quite probable that the knolls, or hillocks, are dunes heaped up by the wind, and that the white sand and the underlying yellow sand are one and the same bed, the top of which has been bleached in some way by agents acting on the surface.

THOMAS RICHARDS' SAND PITS, JACKSON.

Richards' glass-sand pits are one mile west of Jackson and one mile north-northeast of Atco, and near the Berlin and Jackson road. The vertical section, as observed on a former visit, is as follows:

(1) Yellow, gravelly loam and irregular, alternating layers of white sand, varying from..... 5 to 8 feet.
(2) Glass-sand (average)..... 5 "
(3) Sandy earth—at bottom.

The above section was obtained from the southernmost pits. The older diggings were nearer the road. In the sand bed there

are layers, from half an inch to six inches thick, of reddish-yellow, sandy earth. This earth is removed in the digging and separated carefully from the sand. The sand is white and rather fine-grained, and is used at Richards' works at Jackson for window glass.

WATERFORD.

Glass-sand for the supply of the works at this place is obtained from pits near a small stream west of the place.

HAMMONTON.

Glass-sand was formerly dug on a small farm at the head of the Hammonton lake. This locality was worked for the glass-house at Hammonton and for those at Waterford and Winslow, previous to the discoveries of sand deposits at these places.

WINSLOW GLASS-SAND.

Sand for the glass works of A. K. Hay & Co., at Winslow, is dug near them and in the village. The top dirt is sandy loam soil with some gravel and yellow, sandy earth and coarse gravel varying from two to five feet in thickness. The sand bed is said to be six to seven feet thick. This sand is yellowish and fine-grained. Near the top of the bed there are some thin layers of loam The whole bed is dug together. It is clean enough for common hollow ware, and is not washed.

WILLIAMSTOWN GLASS-SAND.

In the vicinity of Williamstown there are several localities of glass-sand and extensive pits. They supply the works at Williamstown, Glassboro, Clayton and Malaga.

J. A. SICKLER'S PITS.

These pits are about one mile northeast of Williamstown, at the side of the Sicklertown road and south of Four Mile Branch. The bearing on the sand averages three to five feet, but is as much as seven feet thick in places. It is reddish-yellow, gravelly earth, with some sandy loam. The sand is washed and sifted,

and it is very white and even grained. It is sold, in the ground, to the works at Malaga, Glassboro and Clayton, to which points it is carted in wagons.

PITS OF HURF & BRO.

These are three-quarters of a mile north-northeast of Williamstown and near a small tributary of the Four Mile Branch. The top dirt, or *bearing*, varies in thickness up to a maximum of ten feet. But the average is four to five feet. The sand bed also varies from a maximum thickness of ten feet and averages about six feet. Under it, next the sand there is a yellow, sandy clay, and under that alternating, thin layers of sand and clay, in which there is a great deal of water. Water and quicksand hinder deeper digging. The glass-sand has some loam in it, in places, and generally it is coarser grained near the bottom of the bed. Some of it could be used without washing, as it is almost pure quartz. But it is all washed by water of the brook near the pits. This flowing over sieves carries away the earth and removes the coarser grains and any pebbles which may get into it in digging. The sand is sold in the ground, or washed and delivered at the glass works. It goes to Williamstown, Clayton and Glassboro. These pits have been opened and worked about forty years, and they have yielded many thousands of tons of glass-sand. Several acres have been dug over.

CHAS. H. STEWART'S PITS

Are not more than a quarter of a mile west of those of Hurf & Bro. The general character of the sand, as to its stratigraphical relations, is very similar to those given above in the description of the pits of Hurf & Bro. North, northwest of Stewart's pits glass sand has been dug on lands of S. Jennings and others. The localities have not been visited. According to report the amounts dug are comparatively small.

ARTHUR DOWNER'S GLASS SAND.

A specimen of glass sand has been received from Arthur Downer, Monroe township, Gloucester county. The locality is west of Williamstown and near Scotland Run. The top dirt is

reported by Mr. Downer to be clayey gravel and dirty sand and on an average eleven feet thick. The sand bed is also eleven feet thick. The specimen was taken from a depth of sixteen feet. It is white and fine-grained, and looks like good material for glass.

VINELAND.

Some of the wells in the town are said to get through the gravelly loam bed and to reach the glass sand. West of the town this surface formation is wanting and the sand forms the soil and subsoil. And sand for glass-making has been dug near Landis avenue and on the east of Maurice river. The sand is at the surface and the pits are only a few feet deep.

SOUTH VINELAND GLASS-SAND PITS.

These pits are south of Butler avenue and a few rods east of the Millville road, on Main avenue and on the lands of Speer Brothers and of Osborn Bidwell. The surface here is gently rolling and about eighty feet above tide-level. The vertical section at the more northern diggings is as follows:

(1) Soil and reddish clay gravel	4 feet.
(2) Red sand (used as moulding sand) wanting in places	3 "
(3) Glass sand	8 to 10 "
(4) *Hardpan*—reddish, cemented sand (in places)	4 "
(5) Glass-sand.	

Towards the southeast the bearing on the sand is thicker, up to 10 feet. The thickness of the lower sand is unknown. The well at the pits is forty-two feet deep, and that did not get through the glass-sand bed. Near the top of the bed the sand is mixed with some thin loam layers. These are between one-sixteenth and one-quarter inches thick, and appear, in general, horizontal in the sand. They are not seen in the lower part of the bed. The sand of these pits is rather finer-grained than that of the Maurice river banks, and it is very clean and white—nearly pure quartz. Much of it is clean enough without washing, but all of it is washed at the pits.

These pits have been worked many years for the supply of the works of Whitall, Tatum & Co., at Millville. The sand is carted

thither by teams. As the distance is three miles only and the road a gravel turnpike, the expense of hauling cannot be large.

MILLVILLE, PETTICOAT RUN SAND.

A little sand has been dug at the pits east of Millville, near the Manumuskin road, and also near the Petticoat run, a branch of the Maurice river. The pits are not deep as the sand is at the surface. The sand is washed at the brook and taken to the works in Millville.

BRONSON'S SAND PITS.

These are on the east of the Port Elizabeth road, and a mile and a half south of Millville. The sand is the surface bed and is covered by the thin layer of turf. It is two to three feet thick and rests upon a dark-colored sand. The grains are somewhat rounded and of varying sizes. Localities, as this, having little, or no top dirt to be removed, are worked cheaply, and their number can be greatly increased.

SAMUEL HILLIARD'S SAND PITS.

These pits are four miles south of Millville and between the Buckshutem creek and the Buckshutem road. The present working is in the upland level, which is at least twenty-five feet above tide-level. At the northern end of the opening, or bank, the vertical section consists of the following beds:

(1) Sandy loam soil and subsoil, containing some gravel	2½ to 3 feet.
(2) Clay, greyish-white, with reddish streaks	4 to 5 "
(3) Yellow sand and fine gravel	1 foot.
(4) Glass-sand (to bottom of pits)	12 to 16 feet.

There is so much water when the bottom is reached that the work stops there, although the sand runs deeper.

In the southernmost pits

The Clay No. (2) is	2 to 3 feet.
(3) Yellow sand and gravel	2 "
(4) Glass-sand, to bottom of pits	8 "

The clay immediately over the glass-sand would do for red brick, but as it is needed to fill the pits, it is thrown with the other top-dirt, back into them. The sand bed exhibits very finely oblique lamination in its structure. Its uniform thickness is quite remarkable. The sand varies in purity according to the size and number of the loamy sand streaks in it. These occur as spheroidal, lenticular and irregular shaped masses in the clean white sand. The separation of these is not practicable while digging, and, consequently, all of the sand is washed. It is carted to the washing works, at the dock on the river bank, about a quarter of a mile east of the pits. The water for washing is pumped out of the river. Sifted and washed it is loaded on vessels and shipped to the desired points. These works can clean about forty tons a day.

These pits were opened in 1842 by Anthony Sharp. They were worked for many years so as to supply 1,000 to 2,000 tons a year, and about an acre of land was dug over. Hilliard's digging has been more towards the north, and a large area has been worked out. The product is said to amount to 10,000 to 12,000 tons annually. It goes to glass works in New England, New York, Brooklyn, Jersey City, Philadelphia and elsewhere. The supply appears to be very large, and the location is so convenlent for cheap transportation that this sand can be furnished in quantity large enough to meet all demands, and at low prices.

Glass-sand was formerly dug on the *Taylor farm*, three miles south of Millville and about one mile north of Hilliard's bank. The bank was a few rods west of the river. The *stripping*, or top dirt, at this place varied from ten to seventeen feet in thickness, and consisted of yellow, loamy sand with thin layers of gravel and gravelly clay. The sand was worked to a depth of sixteen to seventeen feet, down to the water. Portions of the bed contained some loam which gave it a reddish color. But the greater thickness consisted of almost pure quartz sand. And the lower part of the sand, as here dug, was considered the best. The sand was all washed previous to loading. This bank was largely worked for several years. And the sales in a single year amounted to 5,000 tons. Of late years the sand business on the Maurice river has been transferred from the old Sharp farm to Hilliard's bank.

THE HOLLINGSHEAD SAND BANK.

Was also worked extensively. It was south of the Taylor bank. The product of this bank along the river in 1867 was estimated at 10,000 tons by persons thoroughly conversant with the business. Then there were three banks worked, now there is one only.

RAMMEL'S MILLS GLASS-SAND.

Glass-sand occurs near the Cohansey creek, at Rammel's Mills, four miles north of Bridgeton. The supply of sand for the Bridgeton glass houses for one year came from this locality. The sand was found under a *bearing* fifteen feet thick.

B. F. LUPTON'S GLASS-SAND BANK.

This locality is one and a half miles south of Bridgeton and on the west of the Cohansey creek. The top of the bank, or upland bluff, is about thirty feet above the level of high tide. There is at the top earth and gravel three to six feet thick, then the bed of glass-sand, which is eighteen feet thick. Near the top of this bed there are thin layers of yellow loam in the sand. Lower these diminish and the sand is almost pure quartz, and it is finer grained. Under the glass-sand there is a coarse grained yellow sand. As the bank is only two hundred yards from the navigable water of the Cohansey, it is conveniently located for shipment. It was opened about twelve years ago. But comparatively small amount has been dug, and nearly all of it has been used in the Bridgeton glass houses. Mr. Lupton is about starting glass works near the bank and he intends to use his sand altogether, instead of selling as heretofore. But there is no reason for any reduction in sales where a locality has such advantages.

BARRENS GLASS-SAND.

This locality is in Salem county, west of Shiloh and south of the Bridgeton and Salem turnpike. The district is known as the Barrens on account of its white sand soil and its poverty as compared with the rich farming lands on each side of it. The

diggings are shallow pits which are not over four feet deep. After removing the turfy surface layer the sand is found and it is from two to three and a half feet thick. Under it there is a yellow sand. A small stream furnishes both the power and the water for washing the sand. It is carted to the Quinton and Salem glass works.

5. UNITED STATES COAST SURVEY TRIANGULATION IN NEW JERSEY.

The coast survey work of determining the exact latitudes and longitudes of conspicuous and well marked points in different parts of the State has been continued during the year under the charge of Prof. Edward A. Bowser. The importance of this work, in preparing an accurate basis for all our general and topographical maps cannot be over estimated, and it finds immediate use in the maps of the State Geological Survey. The expenses of this survey are paid by the general government, and the results obtained are part of the data for the Geodetic Survey of the whole United States. The order in which the surveys in New Jersey shall first be prosecuted is somewhat under the control of the State Geologist, and is intended to suit the progress of the geological surveys. It is of much importance for our work to have the United States Geodetic work continued steadily every year.

The following report on the triangulation work for the past year was prepared by Prof. Bowser:

"REPORT ON THE PROGRESS OF THE GEODETIC SURVEY OF NEW JERSEY.

"NEW BRUNSWICK, December 7, 1878.

"Four primary stations have been occupied and completed, viz., Mt. Rose, Newtown, Goat Hill and Pickles. The fifth station, Mt. Horeb, is about half completed.

"Ten tertiary points have been observed upon from two primary stations and their latitudes and longitudes computed. Fourteen other tertiary points have been observed upon from one primary station. As soon as they are observed upon from a second, their positions will be computed.

"Several of the tertiary points are marked with stone posts; in addition to this the position of each station is secured by measurements and magnetic bearings from the centre of the station to large rocks, trees, or stumps; also a written description and topographical plan of the ground, its surroundings, &c., is made. When the signal observed upon is a church steeple, no marks have been made. It would be well in this case to secure the position of the station against accident from fire or whatever else might destroy the building, by measurements and magnetic bearings to rocks, stumps, &c., as in the former case where stone posts are put to mark the centre of the station; and when there are no natural reference marks, posts about three (3) feet long and six (6) inches square of the most durable stone should be set leaving about four (4) inches out of the ground.

"E. A. BOWSER."

6. TOPOGRAPHICAL SURVEY OF THE COUNTRY BETWEEN WATCHUNG MOUNTAINS (KNOWN AS ORANGE MOUNTAINS) AND THE HUDSON RIVER.

The outlines of this work were given in last year's report. The survey covers the whole country which is bounded on the north by an east and west line drawn through the northerly curve of the Passaic river north of Paterson; on the east by the Hudson river, New York bay and Staten Island sound; on the south by Raritan river, and west by First Mountain. It comprises an area of 408 square miles, and nearly half the population of the State is on it. Improvements in drainage, water-supply, road making, and everything tending to provide for a dense population, are in progress within it. Elaborate topographical maps are essential for carrying on these works judiciously and economically. And they are absolutely necessary for strictly geological purposes, to locate and define the outlines of soils, and rock outcrops, and to show where deposits of clay, sand and gravel are to be found, and where quarries for building stone, road material, or other purposes may be properly looked for.

This survey will be completed in a few days—less than a week's field work was to be done when the cold weather came on. The principal work has been in leveling, which has been done with the engineer's level. Every hill and even knoll in the whole district has been surveyed and its height above tide-water determined.

The map will be drawn as fast as possible, but it will take some months to finish it. The northern half is well advanced, however, and it will be ready for inspection by the middle of January. It is on a scale of three inches to a mile, and the contour lines or lines of level, are drawn on it for every twenty feet of elevation, and in some cases every ten feet.

7. PROGRESS OF THE DRAINAGE WORKS.

The plan for the drainage of the Great Meadows, on the Pequest river, in Warren county, has been carried out; the work is mainly done, and is a complete success. The need for the drainage of these meadows was reported to this Board at the annual meeting in 1870, and a survey and plan for the accomplishment of the work was given at the same time. The report was accepted and approved at that time, and the proper steps taken for placing the execution of the plan in the hands of commissioners, as required by the general law "To provide for the drainage of lands." The commissioners and their engineer have been engaged in preparing for the work, and in carrying it out till the present time. The difficulties from opposition, delays and hard times have been vexatious and embarrassing, and nothing but the consciousness that they were doing a great and useful public work could have enabled them to go on with the perseverance and enthusiasm which they have shown.

Their work is in the highest degree successful. On the 19th a committee of this Board visited the Great Meadows and walked along the deepened channel for five or six miles. The water in the stream, notwithstanding the recent and very heavy rains did not more than half fill the channel, and the swamps on either side were quite dry. These swamps were formerly inaccessible, except when frozen in winter. Now they can be reached at any time, and the valuable timber in them can be marketed at a reasonable cost. As soon as the lands are cleared they can be put in pasture or meadow, or can be tilled—and experience everywhere else has shown that such drained lands are worth much more than good upland.

The advantages of the drainage were well shown when, at our late visit, we came in sight of the flat lands on the Pequest above where the channel is cleared. The whole flat land was covered with water and must remain so some time longer, or perhaps all the season. The following is the engineer's report of the work:

"VIENNA, WARREN COUNTY, NEW JERSEY,
"December 17th, 1878.

"DEAR SIRS:—I submit the following history and description of the drainage operations on the Great Meadows, along the Pequest river in this county, up to date.

"Under the general act of 1871, seventeen (17) landowners on these Meadows made petition to the Board of Managers of the Geological Survey, asking for the drainage of the Great Meadows by public authority. The Board of Managers directed the State Geologist to examine and report. Thereupon the Managers laid their plans before the Supreme Court, and recommended the appointment of commissioners for the execution of the work. After the usual legal notice given, by handbill and newspaper advertisments, calling for objections to the plan proposed, and appointment of commissioners, and no objections being made, the Supreme Court appointed three commissioners, not owners, and wholly disinterested, as required by law, in November, 1872, and put in their hands the profiles, maps and descriptions of the drainage proposed, and they were duly sworn to the faithful performance of the work in January, 1873.

"The tract to be drained is described in the appointment as 'situate on both sides of the Pequest river, from Vienna to Danville, at the westerly end, to a point in Green township, Sussex county, about one-eighth of a mile from the line between the counties of Sussex and Warren, and embracing an area of drowned and wet lands of five thousand seven hundred and fifty-six (5,756) acres. The boundary of said tract is plainly marked upon the surface at the meeting of the flat and boggy meadow or swamp with the upland.'

"The said system or plan of drainage is to cut a channel thirty (30) feet wide, and lower the reef at Vienna bridge three and a half ($3\frac{1}{2}$) feet, at Steam Mill bridge, five and a half ($5\frac{1}{2}$) feet, and at Long bridge, three (3) feet, reducing the bottom between these points to the grade line represented on the profile, and, to make the work complete, the streams through the Great Meadows must be cleared of obstructions and given capacity enough to carry the streams within their banks.

"The work was commenced and prosecuted in the summer and autumn of 1873, and has been continued since, as rapidly

as the season, the character of the work, and the means in hand would allow. The work now accomplished to this date is as follows:

"The main channel of Pequest river is cleared and opened complete, for a distance of nine and three-quarter (9¾) miles, being widened to thirty (30) feet, five and a half (5½) miles; to twenty-seven (27) fee', one (1) mile; and to twenty-four (24) feet, three and a quarter (3¼) miles.

"The bottom of the river has been graded to a uniform surface, with a fall of one (1) foot to the mile, for four (4) miles; to two (2) feet per mile, for a distance of one (1) mile; three (3) feet per mile, for two (2) miles, and one and a half (1½) feet per mile for two and three-quarter (2¾) miles.

"The excavation has averaged about three and a half (3½) feet in depth, for the whole length of channel, being at or near grade, about five (5) per cent. of the whole distance, and ninety-five (95) per cent. in depths varying down to eight (8) feet, this last being on the sides of the natural channel, and is now the depth of the river bottom, below the general surface of the meadows.

"The bottom of the stream nearly throughout, is hard and cohesive, very little being miry or soft. The work has been almost wholly among solid material, some boulder rock and hardpan, but no ledge rock, although the newly excavated channel, appears now in several places, to be close upon the bed rock of the valley. Through the Great Meadows proper, a distance of six and a half miles, the channel was found to be through a sandy clay, so close and dense as to task, to its full capacity, the dredge machinery, driven by a forty-horse power steam engine.

"The amount of excavated material in the whole nine and three-quarter miles, is one hundred and eighty-two thousand (182,000) cubic yards. Much other work, besides the excavation, has also been necessary, to make the drainage abiding and successful. The outlet proper was first opened for the spring freshets of 1877, and then and since, the action of the stream, upon its new banks and bottom, both at high and low water, dissipates all apprehension as to the enduring character of the work, and its beneficial results.

"The heavy rain-fall of the 9th and 10th inst. (said to have been the greatest since 1841), did not bring the river up to its former high water mark, by three feet nine inches, and, contrary

to all former precedent, the water began to fall almost immediately upon the cessation of the storm, heretofore continuing to rise for several days thereafter. Actual observations at different stages of water show the current to be from 100 to 220 feet per minute. Any bars or deposits formed under high water are taken away, as the stream settles again to its ordinary size and channel, and all indications are that the stream will keep for itself a clear and open channel.

"The other 'streams' on the Great Meadows, tributary to the Pequest, and required by the 'Plan' to be cleared and opened, are Hoagland's mill brook, Stinson's brook, Smoke's mill brook, and Trout brook from Allamuchy pond. Heretofore the water from the streams have spread over the meadows for want of a fall and a channel. Channels have now been cleared and excavated for them, so as to carry the water directly off, for an aggregate distance of five and a quarter (5¼) miles, with excavations averaging three and a half (3½) feet in depth, and amounting to nine thousand two hundred (9,200) cubic yards.

"The lands relieved of water two years ago, by this drainage, are, to some exent, being already put under cultivation, and most satisfactory crops of corn, potatoes, oats and especially of corn fodder, have been reaped the present season from lands standing under water in August, 1875. Preparations for an increased area of culture of these lands next year, are now progressing. Over two and a half (2½) miles of private ditches have already been opened into the main outlets.

"The cost of the enterprise so far, has been kept within the estimates originally made, and its friends see no hindrance to the complete success of the work, unless it be litigation. The expense of the whole has been increased very considerably by this litigation, and has added much to the labors and cares of the commissioners appointed by the supreme court to superintend the work, and who, in every step taken, have only endeavored to perform their *sworn* duty according to law.

"The undertaking has been entered upon, with the facts and figures all before, or accessible to the landholders. It was by law, made wholly within the control of a majority of the ownership, whether to begin, to stop, or to go on. Once commenced, and thus far so successfully prosecuted,—benefits to some extent already realized,—and third parties, in the shape of

bondholders, contractors, and other innocent and outside parties involved, there should now be no hesitation or waver in sustaining so beneficent a work, to the full completion

"The commissioners appointed by the Supreme Court to execute this drainage are

"Amos Hoagland, Townsbury, Warren county;

"James Boyd, Vienna, Warren county;

"Wm. L. Johnson, Hackettstown, Warren county.

"Respectfully yours,

"ABM. R. DAY,

"*Engineer.*"

The lands on the Passaic river and its branches, the Whippany and Rockaway rivers, above Little Falls are subject to overflow in times of freshet. There are more than 11,000 acres of these flowed lands, which cannot now be used for any purpose except meadow and poor pasturage. A heavy rain at any time in July or August is sufficient to flood these meadows, to spoil the grass, and leave the water to stagnate on the surface and become the fruitful source of malarial disorders of all kinds, and to bring not only the lands themselves, but a much larger area of the surrounding country into discredit, and make its lands unsaleable. The tract of country thus damaged is one of the most beautiful, and but for this insufficient drainage one of the most desirable portions of the State. The primary cause of the defective drainage, is a reef of rocks across the stream at Little Falls, and a bar of boulder earth across the Passaic at Two Bridges just above the mouth of the Pompton river. There is also a dam across the river at Little Falls, which has been made to *improve* the water power there. This dam is about a foot and a half higher than either the reef or the bar.

Attempts for the removal of these obstructions, have been made at various times for the last hundred years, and legislative action was had in regard to it in 1788. In 1790 an act was passed "to enable the owners and possessors of the meadows, swamps and low lands on the river Passaic and its several branches between the Little Falls and the mill dam at Chatham to break up the reefs near said falls and to dig canals for the more effectual drainage of said lands and to raise money for that purpose." And in 1812 this act was reiterated as far as breaking

up the reef was concerned. In 1815 an act was passed repealing that part of the law of 1812 which authorized the assessment of the lands flowed for the expenses of breaking up the reef. Several acts for clearing the river have been since passed, but nothing effectual has been done, and since the completion of the stone dam a few years ago the obstruction to the flow of water and drainage of the land is worse than it ever was before that time.

From the bed of the river at Lower Chatham to the top of the dam at Little Falls, a distance of twenty-one and three-quarter miles, there is a fall of only six and three-tenths feet, or less than three and a half inches per mile. The dam can be lowered seven feet, and the bar and reef cut down to the same level with the lowered dam without much other work, as the bed of the stream everywhere else is now deep enough. When this is done, the stream from Chatham to Little Falls will have a fall of thirteen and three-tenths feet, or about seven and a half inches per mile, which would give the current a velocity of from ninety to one hundred and twenty feet per second, and enable all the water of the stream to run within the banks, and prevent overflow.

This work was reported on to this Board in 1869, and in 1871 on the petition of land owners, commissioners were appointed, under the general drainage law, to do the work. The difficulty of raising money to pay the mill owners' damages, before they begin to clear out the obstructions, has prevented the beginning of the work up to this time.

It is greatly to be desired that this drainage should be done. It would bring a large area of excellent land into profitable use, and thus increase the wealth of the State. It would be a public benefit in removing a fruitful source of disease. The damage done by the overflow this year is nearly, if not quite enough, to pay the cost of removing the obstructions. And the lands drained, which are liable to be assessed to pay the expenses, are worth far more than the assessments would amount to. If townships, counties, or State could endorse the improvement bonds, so that money could be raised, the work could go on immediately, and the bonds be paid, gradually by the proceeds from taxes on the lands benefited.

8. WATER SUPPLY.

The question of water supply is growing in interest every year. Many applications come to the office of the Survey for information regarding the quality of different waters, the probabilities of getting water by artesian wells, &c. All these questions are of interest to the persons inquiring and some are of public importance.

The State Reform School for Boys, at Jamesburg, has heretofore obtained all its supply of water from wells and springs on the grounds and not far from the dwellings. The past summer a large number of the boys have been sick from fever or other disorders, and two or three died. There was much alarm at the sickness, and after thorough examination, the cause was traced to impure drinking water. The buildings are located on a knoll or low hill. The top earth of this knoll is open, gravelly sand and loam for from twelve to fifteen feet down. Underneath this is a very solid black clay, nearly flat on the upper surface but sloping to the southeast. All the water here comes from the rain, which falling on this gravelly soil, sinks in it till it reaches the clay, when it soaks off towards the southeast outcrop of the clay, where it appears in the form of springs. The water of these springs has been collected into two large reservoirs, and from these the principal supply is drawn. A few wells have been sunk down to and a little in the clay, but the water is of the same character and comes in the same way, from the drainage through the gravel and surface earth. Water collected in this way where a large number of persons are living together is always liable to dangerous contamination. In this case the supply was abandoned and water for drinking brought from a distance.

The geological materials at the school are alternating beds of clay and sand, and good water is usually found in the sand, though it sometimes contains a little sulphate of iron or copperas. It is probable that a bed of sand sufficiently thick and open to

carry a good supply of water will be met at not much over a hundred feet from the surface; and as the clay effectually shuts out all surface water from those lower layers of sand, the water will be free from surface filth or any organic impurities.

The plan proposed is to bore an eight-inch well, and the work is in progress.

At the State Prison in Trenton a large amount of water is needed, and a well has been dug to help out their supply.

The prison is located on flat ground not far from the Delaware and south of the city. The surface of the ground is forty-five feet above low water in the river. The material on the surface is a modified drift, consisting of boulders, cobblestones, gravel, sand and loam mixed, but it was presumed that the granitic rock of the vicinity would be found at the depth of thirty or forty feet. The well was dug of a clear inside diameter of twelve feet eight inches, besides the brick lining, nine inches thick, and the heavy plank curb outside the bricks.

The materials passed through were—

(1) Gravel, &c	33 feet.
(2) Yellow clay (decomposed gneiss)	5 feet.
(3) Blue clay (rotten gneiss)	7 feet.
(4) Partially rotten rock	7 feet.
(5) Solid gneiss rock.	

Water was first met in the gravel at twenty-one feet down,—in large quantity but somewhat hard. The quantity did not increase much until the clay was passed and the rock reached. There was then a considerable addition, apparently about as much as there was in the gravel,—and the water quite soft.

An analysis of the water from the gravel showed it to contain about fifty grains of solid matter to the gallon, most of which was sulphates of lime and magnesia, and only a trace of chlorine, and no organic matter.

Analysis showed the water from the rock to contain less than two grains of solid matter, mostly carbonate of lime, to the gallon, and a very little carbonate of iron.

Several holes, of two and three inches diameter and from four

to seven feet deep, were bored in the rock at the bottom of the well, and much of the rock water comes from these holes.

The temperature of the water from the gravel on the 4th of October was 59° Fahrenheit, and that of the water taken directly from the rock was 56° Fahrenheit.

To ascertain the quantity of water the well would supply,—all the water was pumped out, and then the time of filling up of each foot was recorded.

1st	was filled at beginning.		
2d	was filled in	9	minutes.
3d	" " "	11	"
4th	" " "	15	"
5th	" " "	17	"
6th	" " "	18	"
7th	" " "	18	"
8th	" " "	17	"
9th	" " "	20	"
10th	" " "	20	"
11th	" " "	20	"
12th	" " "	20	"
13th	" " "	20	"
14th	" " "	20	"
15th	" " "	21	"
16th	was filled in	22	minutes.
17th	" " "	23	"
18th	" " "	23	"
19th	" " "	29	"
20th	" " "	32	"
21st	" " "	35	"
22d	" " "	43	"
23d	" " "	48	"
24th	" " "	58	"
25th	" " "	76	"
26th	" " "	101	"
27th	" " "	162	"
28th	" " "	251	"
28¾	stopped rising.		

One foot in depth of water in the well is 943 gallons. Now if we take the time of filling this to be twenty minutes, which is the time required when about half the water is out, the well will supply 68,000 gallons in twenty-four hours, or if it is pumped down till the water is only two and a half feet deep and kept at that it will supply 135,000 gallons a day.

It is probable that the amount from the gravel is all a well of this size can furnish; but it may be that a much larger quantity can be got from the rock, by sinking the well deeper into it. The rock is gneiss, stratified, not very solid, nor uniform in quality, but open and with the strata almost perpendicular, so that a deepening of the well, in rock which would need no lining, would expose a much greater surface of rock and length of seams from which water could escape.

There is a slight taste to the water which is unpleasant; it probably comes from the wood of the curb, as it is well known such wood used in water pails gives a disagreeable flavor to the water, and continues to do so for a long time; and in this well

all the water from the gravel comes down behind the wood in contact with it.

The water supply for the cities of Newark, Jersey City and Hoboken, from the Passaic river at Belleville, is not quite satisfactory in quality, and the supply for Orange, Montclair, Bloomfield, Bayonne and other places, from wells is insufficient and unsafe. The question of an ample supply of pure and wholesome water for these different places which are in the same district of country, and can best be supplied from a common source, is an interesting one. And it is engaging the attention of leading citizens in all those places. The country to be supplied covers an area of seventy square miles. Its population in 1875, was:

Belleville	2,795
Bloomfield	5,425
East Orange	6,497
Montclair	4,034
Orange	10,813
Newark	123,310
Hoboken	24,766
West Hoboken	5,219
Union	4,676
Harrison	4,765
Bayonne	5,836
Jersey City	109,227
	307,363

There is an abundance of water in the Passaic river at Belleville which can be used without interfering with any rights of water-power. At Passaic and at Paterson, manufacturers claim the right to use all the water flowing in the stream, when it is low, and they use it for driving machinery. At Belleville, the sewage from Newark and salt water from the bay are liable to come up with the flood tide and pollute the water, and at all times, the sewage and manufacturers' waste from Paterson and Dundee run into and mix with the pure river water. On account of these sources of impurity, uneasiness and distrust are continually expressed in regard to the quality of water from this part of the river. And this has led to many inquiries for an available supply of water of unquestioned purity.

At the head of Little Falls, on the Passaic, the whole of the water from the watershed of that river, which has an area of 750 square miles, is collected in one stream.

The Passaic water shed is made up of that of the

Ramapo, which drains	148	square	miles.
Ringwood, which drains	108	"	"
Pequannock, which drains	82	"	"
Rockaway, which drains	165	"	"
Whippany, which drains	59	"	"
Passaic, which drains	188	"	"
Total	750	"	"

The rain which falls upon this area, furnishes all the water which runs off in its streams. The depth of the rain falling per year, upon several parts of this water shed has been carefully observed and recorded. The average yearly rainfall in New Jersey is forty-four and a half inches, and the smallest which has been observed was a little over thirty inches in depth. The latter is, of course, the only safe one to use in calculating for water supply. A great many measurements have been made to ascertain what portion of the rainfall is lost by evaporation, and what runs off in the streams. As would be expected the amounts differ, according as the surface is rocky or earthy, hilly or flat, &c., but all of them agree that at least 40 per cent. of the rainfall runs off in the streams. That is, if there is an annual rainfall of thirty inches, twelve inches of that can with certainty be depended upon for water supply, and in ordinary seasons the quantity is much greater than that.

A square mile being 27,878,400 square feet, and the available annual rainfall on it being one foot deep, can be depended on to supply that number of cubic feet of water yearly. And as a cubic foot of water is about seven and a half gallons, the square mile will supply daily 581,063 gallons, which is more than enough to provide a population of 5,000 with 100 gallons of water each, every day. And at this rate the several streams above mentioned would furnish daily as follows, viz:

The	Ramapo	85,997,324 gallons.
"	Ringwood	62,754,804 "
"	Pequannock	47,647,166 "
"	Rockaway	95,875,395 "
"	Whippany	34,282,717 "
"	Passaic	109,239,844 "
	Total daily supply	435,797,250 "

This is water enough for a population of five millions. But probably two-thirds of it runs off in freshets, and the streams at their lowest do not carry one-third of this quantity daily. It would be comparatively inexpensive to collect these surplus waters in times of freshet in ponds, lakes and reservoirs in the mountains, and then let them out to swell the streams when they are at their lowest in autumn.

At Little Falls, then, there is an abundance of pure soft water, coming mostly from a mountainous region. It has an elevation of one hundred and fifty feet above tide-water, and it is only seven and a half miles from the Newark reservoir, and only nine miles from that of Jersey City.

The Morris canal is supplied with water from the upper branches of the Passaic, and brings the water on a level one hundred and seventy-two feet above tide, by Little Falls, Paterson, and to Bloomfield, only two and a half miles from the Newark reservoir, and four miles from that of Jersey City. It has been proposed to abandon the canal as a means of transportation and use it and its reservoirs, Lake Hopatcong and Greenwood Lake, for supplying water. The quality of the water is good.

In addition to these projects for taking the water from Little Falls, and from the Morris canal, several others have been proposed by which water from some of the branches of the Passaic can be taken from seven to ten miles above Little Falls, and at elevations more than two hundred feet above tide, so as to furnish the supply for most of the district, by gravity alone. From any of them the quality of the water is unexceptionable. The quantity depends on circumstances to be mentioned farther on.

The large investments already made in pumping apparatus, buildings, fuel, &c., connected with the present arrangements, together with the depressed condition of business, make prudent

men dislike to consider any changes which may involve increased debts or expenses. The expenses of the Newark Aqueduct Board for the pump works, for the fuel, engineers, &c., at Belleville, in 1877, were $21,471, and they consumed 3,221½ tons of coal. The expenses of the Jersey City works for the same objects were not found in the published report for 1877, but it gives the amount of coal consumed as 5,518 tons. If the other expenses are in the same proportion, the cost of pumping water at Belleville for Jersey City must have been $34,920. This aggregate sum of $56,391 yearly expense could nearly, or quite all, be saved, if a supply could be got from some elevated ground, and drawn down by its own gravity. This sum is the interest on nearly a million dollars, and if the change could be made for that sum, there would be no increase on the present yearly expenses for water, and there could be no cause of complaint, besides there would really be a great public benefit now, and the value of it would be increasing every year.

The water taken from the Passaic river for water-supply in times of drought, or when the stream is low, will diminish the amount going to Paterson and Dundee to drive their machinery, and would have to be paid for, or else an equal quantity provided by storing surplus waters in reservoirs. Such reservoirs can be prepared of sufficient capacity and at a moderate expense.

Most of the water used in Newark is drawn from the large reservoir, which is 175 feet above tide, and most of that used in Jersey City is drawn from the reservoir, which is 161 feet high. But there are parts of both these cities which need water much higher than that in the reservoirs mentioned, and which have to be supplied by extra pumping engines. A considerable part of Orange is more than 200 feet above tide level, and there is much of the thickly settled parts of Montclair which is from 250 to 300 feet high.

If the Little Falls water-power were purchased the whole of the water could be controlled. Water-power could be used to pump supplies of water into reservoirs on the mountain near the Great Notch, at any elevations needed for supplying the population on the lower or on the higher grounds. This plan is feasible and has some advantages in regard to short distances to all the places interested.

The Morris canal is nearer at hand, and is most quickly available.

The more distant supplies have the merit of being at greater elevations, and so delivering water by gravity at places where the others would need to have it pumped up.

The economical merits of the different projects must be determined by engineers. The expense needs to be carefully considered and provided for. The water is ample in quantity and excellent in quality.

To secure these advantages for all the places interested, united action is needed. This might be accomplished by the municipal governments now existing, or it could be done by the organization of a water company or commission, made up of representative men from all places desiring the water, who would undertake the management and hold the property as a public trust, to be used for the general good.

The plan if undertaken will require some years for its proper execution, it is altogether feasible and economical and it cannot be begun too soon.

9. MISCELLANEOUS LABORATORY WORK.

IRON ORES.

Iron ores, both magnetites and hematites, continue to be sent in for examination. The inquiries are directed generally to their value for making Bessemer steel. The ores, which have been examined in the laboratory, are here reported, as they illustrate the character of some of our best ores and, also, the interest manifested in the discovery of such as can be used in these times of low prices.

1. MAGNETIC IRON ORES FROM CHARLOTTENBURGH, MORRIS COUNTY.

Four specimens were received from Martin J. Ryerson, of Bloomingdale.

The analyses showed that these ores contained of

	1	2	3	4
Metallic iron	61.420	61.470	67.420	64.940
Sulphur	0.274	3.360	0.550	0.390
Phosphorus	0.021	0.028	0.014	traces
Manganese	.....	.....	.....	.....
Titanic acid	.....	.....	.....	1.000

Specimen No. 1 is from the opening made by the Bethlehem Iron Company. Opening is 80 feet deep, 160 feet long and on a vein 9 feet wide.

No. 2, is from an opening about 25 feet deep and 18 feet wide.

No. 3, is from a depth of 20 feet and where the vein is 8 feet wide.

Nos. 2 and 3 are from recent openings, close to one another, and near the Green Pond Mine Railroad.

No. 4 is a black compact, lamellar ore mass from the hill east of the old Charlottenburg mine.

The laboratory determinations show that these are all rich ores and all are low in phosphrus. No. 2 contains considerable sulphur. This exists in the ore as sulphide of iron, or pyrite, a mineral occurring to some extent in all the ores of that neighborhood. No. 4 differs from the others in the very small amount, traces only, of phosphorus, and in the presence of titanium. This latter constituent is not sufficient to make it difficult to work, and such ore should command the attention of manufacturers. Its richness and comparative freedom from impurities make it a desirable ore.

The location of these openings, so near railroad communication, favors working to profit.

2. MAGNETIC IRON ORE FROM LANDS OF JOHN H. BEERS, NEAR MORRIS PLAINS, MORRIS COUNTY.

Several holes have been dug, ranging between three and twenty-two feet in depth in search of a vein. The specimen came from what was considered to be a regular vein, or ore bed. The analysis indicated the following percentages:

Metallic iron	54.46
Sulphur	0.31
Phosphorus	0.04
Manganese	0.00
Titanic acid	7.70
Matters insoluble in acid (rock)	22.50

The ore is remarkable for the titanic acid, which is larger than in any of the iron ores here examined, save that of the Church mine in Hunterdon county. And it is sufficient to render the working of the ore somewhat difficult and expensive. It is quite probable that the samples analyzed may not represent all the ore of the locality. Excepting the titanic acid the ore is fairly rich and of good quality. Some of the pieces are rich, but the average is lowered by lean lumps.

3. MAGNETIC IRON ORE FROM THE NAUGHTRIGHT MINE, NEAR NAUGHTRIGHTVILLE, MORRIS COUNTY.

Two samples were received from Theo. B. Naughtright. They are reported as averages from the mine. The chemical determinations are as follows:

	1	2
Magnetic oxide of iron	89.39	82.78
Sulphur	0.27	0.041
Phosphoric acid	0.16	2.56
Titanic acid	7.50	6.40
Lime	.....	2.70
Magnesia	.....	0 91
Matters insoluble in acid	2.20	2.40
	99.52	97.791

	1	2
Or; Metallic iron	64.77	59.32
Sulphur	0.27	0.41
Phosphorus	0.07	1.11

Sample No. 1 is a compact, lustrous blue ore with lamellar cleavage—and as the analysis indicates—a rich ore. It represents a vein twenty feet wide.

No. 2 has a greyish aspect, due to the grains of apatite in the ore mass. The analysis shows the lime and phosphoric acid in quantity—amounting to 5 per cent. It comes from a vein four to five feet wide. Both ores contain considerable titanic acid. Were it not for this constituent both would be very desirable ores. The location of the mine is very convenient for the transportation of the ore—on the Schooley's Mountain table land near the High Bridge Railroad. It was opened in 1870.

4. MAGNETIC IRON ORE, FROM AN OPENING TWO MILES WEST OF PATTENBURGH ALEXANDRIA TOWNSHIP, HUNTERDON COUNTY.

One specimen of ore sent by J. J. Martin was analyzed, and the following results obtained:

Metallic iron	49.25
Phosphorus	0.25
Manganese	0.00
Titanic acid	1.00

The ore is lean, and includes some hornblenic mineral with the magnetite.

5. MAGNETIC IRON ORES FROM HOWELL FARM MINES, NORTH END OF JENNY JUMP MOUNTAIN, WARREN COUNTY.

From Chas. Scranton, Oxford Furnace:

	1	2	3
Magnetic oxide of iron	78.96	73.27	70.06
Sulphur	traces	1.24	0.18
Phosphoric acid	0.06	0.85	0.43
Titanic acid	0.00	0.00	0.00
Oxide of manganese	2.70	1.80	2.60
Lime	.....	3.71	6.49
Magnesia	.....	.....	1.30
Insoluble in acid	11.70	10.20	10.10
Metallic iron	57.17	53.05	50.72
Sulphur	traces	1.24	0.18
Phosphorus	00.26	0.37	0.19

Sample No. 1 is a brownish-black, earthy mass, containing some scales of graphite. It is from the western side of the vein in shaft No. 4.

No. 2 is a hard, bluish-black ore, containing some graphite and feldspar. It is from the middle of the vein, shaft No. 4.

No. 3 is a hard, brownish-black ore, fine-grained, and from the eastern side of vein, shaft No. 4.

The analyses are not complete as appears on summing up the figures in the columns. This is due to the carbonic acid not having been determined, and the lime and magnesia in part only. Most of these bases, if not all, are combined in the form of a dolomitic limestone. The ore from the hanging-wall side of the vein (No. 3) contains the largest percentage of limestone. The phosphorus is very slight in No. 1 and is not excessive in the others. All are characterized by considerable percentages of oxide of manganese. They are excellent ores, easily worked, and adapted to the manufacture of superior grades of iron and Bessemer steel. With easier transportation the locality will develope into a mining district noted for the richness and high grade of its ores. The mines of the locality were described in the annual report for 1873. Distance from railroad communication has prevented regular mining operations.

6. HEMATITE, FROM THE FARM OF JOHN P. WENE, ONE MILE EAST OF BETHLEHEM, HUNTERDON COUNTY.

A specimen of this ore was received from Brewer, Melick & Co., who are working the mine and selling ore to the Crane Iron Company. They have mined as much as three hundred and ten tons a month. They are now getting ninety tons, besides a large amount of ochre. The analysis of the iron ore yielded the following results:

Metallic iron	55.42
Sulphur	0.10
Phosphorus	0.10
Matters insoluble in acid	6.90
Water	11.80

The analysis indicates a rich ore and of good quality.

ORES OF NICKEL, ZINC, &C.

1. FROM F. M. HARTPENCE, LITTLE YORK, HUNTERDON COUNTY.

Three specimens supposed to contain zinc.

No. 1 was a light yellow quartz ore rock, with crystals of quartz in cavities therein.

No. 2. A jaspery rock containing fine quartz crystals.

No. 3. A black slaty rock traversed by small veins of white quartz.

No zinc was found in any of them.

2. PYRITIFEROUS LIMESTONE (BLUE), FROM F. M. SHINMON'S, LAFAYETTE, SUSSEX COUNTY.

The specimens were taken from a pit about ten feet deep, dug in searching for *ore*. The pyrite occurs disseminated through the limestone.

The specimens were tested for zinc and nickel, and assayed for gold and silver, but none of these metals were found.

3. LEWIS BARNES, PORTLAND, PA.,

Sent a sample of pyrite, said to contain nickel. An assay was made, as also tests, for nickel. Traces of the last named metal

were found. The specimen was reported as coming from near Washington, Warren county.

4. JOHN D. VAN GORDER, MILL BROOK, WARREN COUNTY.

Sent samples of a pyritiferous slate, taken from a prospecting shaft on the Kittatinny, or Blue Mountain, near Mill Brook. This shaft was twenty-five feet deep and passed through several feet of the conglomerate and then *bottomed* in the slate rock. The specimens were from the slate near its junction with the quartzose conglomerate and from the bottom of the shaft. Another lot came from another locality, but from the same geological horizon—the slate near the conglomerate. The specimens were tested for nickel and zinc, and assayed for gold and silver. None of these metals were found.

Some stress is put upon these negative determinations, particularly upon the last named, as the laboratory is receiving from time to time specimens such as these, all containing pyrite, and all reported as containing gold or silver. And these emanate not from the land owners, who naturally refer to the Geological Survey for their better information, but from prospecting miners and speculators, aided by untrustworthy and erroneous assays made by careless or unreliable chemists. And the pyrite-bearing conglomerate and slate rocks of the Kittatinny and Shawangunk mountain range has been the source whence many such specimens have come.

5. PYRITE FROM SPARTA, SUSSEX COUNTY, SENT BY CLARKSON BIRD, OF HAMBURGH.

This was supposed to contain copper. None was found in it.

6. PYRITIFEROUS SLATE ROCKS FROM HOPE, WARREN COUNTY, SENT BY A. J. SWAYZE.

The specimens were sent as zinc ores. No zinc could be detected in them.

7. TWO SPECIMENS FROM JENNY JUMP MOUNTAIN, ALSO FROM A. J. SWAYZE.

These were tested for zinc. One of them was quartz; the other hydrous silicate of zinc. There was, probably, a mistake about

the latter, although there is no geological evidence against the existence of zinc ores in the Jenny Jump mountain range. Some quartz specimens look so much like the silicate of the Ogdensburg mines that it is well for those who search for this ore to be on their guard. And this resemblance may also serve as a basis for deception, which can be practiced upon experts unless they are cautious and painstaking in their examinations of localities and of specimens.

8. SPECIMENS FROM ENOS G. BUDD, BUDD'S LAKE, MORRIS COUNTY.

These were sent on the supposition that they contained valuable metals. Examinations showed the absence of these metals.

LIMESTONES.

1. CRYSTALLINE LIMESTONE FROM SAUNDERS' QUARRY, NEAR MENDHAM, MORRIS COUNTY.

Analysis of this stone was made:

Lime	33.95
Magnesia	18.21
Carbonic acid	27.66
Alumina and oxide of iron	1.60
Matters insoluble in acid	16.40
Total determined	97.82

This limestone is a mixture of calcite, or carbonate of lime, and serpentine, and in places there is some mica and other foreign minerals. The sample sent to the laboratory was said to be an average of the stone as it is quarried for burning into lime. From the percentage of carbonic acid it would appear as if the magnesia comes from the serpentine and that the carbonate of lime constitutes about 60 per cent., by weight, of the stone. The quarry is quite largely worked for the local supply and the lime is used by farmers for the improvement of soils, for which it is highly appreciated.

2. BLUE, MAGNESIAN, LIMESTONE FROM PENNWELL, HUNTERDON COUNTY

Four specimens were received from John Warner, of Port Murray, Warren county. They were examined for the percent-

ages of lime and rock (or insoluble matters). The results of the examinations were as follows:

	1	2	3	4
Lime	29.87	29.64	25.75	26.65
Matters insoluble in acid	2.00	2.80	1.90	4.10

Nos. 1 and 2 represent: (1) first quality, or grade, and (2) second quality. No. 4 also represents second-grade stone. According to these figures all these stone are magnesian, and in none of them is the foreign matter (insoluble) above the average of limestones as quarried for lime-making. In Nos. 1, 2 and 3, it is a little below the average of blue limestones.

CLAYS.

Several clays have been received and partially examined, so as to answer inquiries.

1. CLAY FROM GEORGE SUCH, SOUTH AMBOY.

A specimen of fine, white clay was received from Mr. Such, and was analyzed. It was obtained from the Ridgway tract, near the road leading to Amboy and near the Kearney line. The results of the analysis are as follows:

Alumina and titanic acid	40.33
Silicic acid (combined)	43.75
Water (combined and hygroscopic)	14.20
Quartz sand	0.55
Potash	0.21
Soda	.....
Lime	.....
Magnesia	0.11
Sesqui-oxide of iron	0.97
Total	100.12

The analysis shows that this clay is remarkably free from sand and compares favorably with the very best clays of this clay district. (See report on clays, 1877.)

2. CLAY FROM THE FARM OF JOHN LONGCOR, TRANQUILITY, SUSSEX COUNTY.

This clay was drab-colored, sandy, but the sand in it was fine-grained. It is not adapted to any of the more valuable uses in pottery. For common red ware it might answer.

3. CLAY FROM SUCCASUNNA PLAINS, MORRIS COUNTY.

Sent by E. A. Quayle, of Morristown. This specimen is buff-colored and a little sandy. Analysis was not made, but a microscopic examination shows the quartz grains and irregular plates, characteristic of the kaolin clays. Its color is evidently due to oxide of iron, and that would spoil it for white pottery. It is possible that washing might prepare a paper clay out of the crude mass. It is not a fire-clay.

4. CLAYS FROM NEAR CROSSWICKS, BURLINGTON COUNTY.

From Rev. N. Pettit, of Bordentown. Two lots from this locality. Both are very sandy and unfit for pottery, but good for red-brick. The beds whence they were taken have not been opened.

5. CLAYS FROM BRICKSBURG, OCEAN COUNTY.

From H. Severance. See page 50.

MARLS.

FROM WELLS' MILLS, OCEAN COUNTY, FROM CHRISTOPHER ESTLOW.

Two samples of astringent clays, locally known as *marls*, were analyzed. (For comparison with these an analysis of a third specimen, obtained from Wheatland, Ocean county, is included in this table.)

	1	2	3
Lignite	43.690	12.380	26.150
Water (moisture)	7.900	3.900	5.200
Insoluble in acid (sand)	27.800	66.100	59.400
Alumina Oxide of iron*	13.062	14.361	6.456
Lime	traces	traces	traces
Magnesia	0.090	0.144	0.108
Potash	0.120	0.115	0.140
Phosphoric acid	0.038	0.039	0.044
Carbonic acid	traces	traces	0.028
Chlorine	none	traces	traces
Sulphuric acid	5.419	2.984	2.161
Sulphur	2.044	0.591	0.590
Total	100.163	100.614	100.277
Nitrogen			0.349

No. 1 is the average of the upper portion of the marl as opened in Estlow's pits.

No. 2 is from the bottom of the same pits, and it is an average.

The pits showed the following order of materials from the surface downwards:

(1) Soil and sand and gravelly earth..... 7 feet.
(2) "Marl"..... 7 "
(3) White, sandy clay at bottom.....

The marl as freshly exposed, has a laminated structure and is largely a mass of white, quartz sand and chocolate-colored clay, containing more or less pyrite and woody matter. The latter occurs in the form of bark, leaves and wood fragments. It has a very strong smell and acid taste, and it resembles the so-called "rotten stone" of the Squankum marl pits, and the marl dug near Toms River.

Mr. Estlow has found this *marl* to be beneficial when applied some time after digging, as weathering appears to improve it. Freshly dug it is poisonous to vegetation. He thinks that it does good on clover sod.

The analyses show that it contains considerable organic matter and somewhat of sulphur and sulphuric acid. Exposure to

*A part of the iron is in combination with the sulphur as sulphide of iron—or pyrite. And the determination of the iron as oxide, instead of a part as metallic iron, makes the sums a little too high.

rains leaches these out and removes the poisonous constituent. Mixing lime with such marl ought to do good, as that would turn the sulphuric acid into sulphate of lime, or plaster. And they are deficient in this constituent. They are not, in any sense, *marls*. However, they are valuable in the sandy districts of South Jersey, where they can be used on light soils to make them heavier and more compact. The analyses show more potash and phosphoric acid than the average of soils of that part of the State, and hence their addition must improve the quality of the soils whereon they are used. But such materials cannot be transported far as they are not sufficiently rich in fertilizing elements to pay for the expenses of carrying. But they should be used on the farms and lands near the pits, or localities where they may be got.

No. 3, from Wheatland, is found overlying the clay pits of Daniel Townsend, and others. The bed there cut is thin—from a few inches to three feet thick. Over it there is the clayey soil and gravelly earth, in all, five to seven feet thick. It is full of pieces of wood (lignite) bark, leaves, &c. It is very poisonous as thrown out of the pits upon the surrounding soil. The analyses show that it resembles that of Estlow's pits. From the reports of Mr. Estlow and others, it would seem that this layer, or bed of astringent, woody earth was quite extensive and that it is to be found under the gravelly strata throughout Ocean and eastern Burlington counties. And it will have its influence in the development of the agriculture of that part of the State.

SIX SPECIMENS OF GREENSAND MARLS FROM THE FARM OF E. TOMLINSON, KIRKWOOD, CAMDEN COUNTY,

Were examined for lime and phosphoric acid, and the following results were obtained:

	Phosphoric acid.	Lime.	Carbonic acid.
Pit No. 1, A	0.83	3.34	1.67
" " " B	0.97	11.25	7.74
" " " C	2.94	4.69	.....
Pit No. 3, A	2.32	3.73	.....
" " " B	3.91	5.64	.....
" " " C	0.90	1.30	.....

Pit No. 1, A, represents a vertical section four and one-half feet overlying the shell layer. This marl is greyish, fine grained, with an occasional fragment of a shell in it. The carbonic acid combined as carbonate of lime is derived from that source.

Pit No. 1, B, represents a section of four and a half feet of the bed—the shell layer. It is quite full of fragments of Terebratula Harlani shells. The carbonic acid in it is equivalent to nearly 18 per cent. of carbonate of lime.

C, of Pit No. 1 is an average of a section six feet thick, below the shell layer.

This specimen is of dark green color, granular and shows the grains of phosphate in it. The analysis indicates a good percentage of phosphate.

Pit No. 3, north of barn.

A, from section four and a half feet thick. Greyish in color. Granular. Analysis shows phosphate.

B, also from a section four and a half feet thick. Dark bluish-green in color. Granular. Granules of phosphate of lime abound in it. High percentage of lime and phosphoric acid in it—the richest of the lot. Carbonic acid was not weighed.

C, of Pit 3, represents six feet. A green marl, inferior to the other specimens from this pit.

Taking A and B together, there is nine feet of marl whose average for phosphate of lime is about 6 per cent.—*i. e.*, one hundred and twenty pounds in one ton—which is above the average of marls in West Jersey.

Several additional specimens of marls have been received, but owing to the lateness of their reception, they have not yet been analyzed. They will appear in the next annual report.

PAINTS

FROM HENRY HANN, OF SCHOOLEY'S MOUNTAIN, MORRIS COUNTY.

The specimen was submitted to Messrs. Bush & Hollingsworth, 39 Dey street, New York, manufacturers and dealers in paints and pigments, and pronounced to be "too muddy and slate-like" and of no value for paint.

COAL

FROM WM. SCOTT DECAMP, OF POWERVILLE, MORRIS COUNTY.

The specimen was got at Old Boonton, Morris county, and it came from a seam, or layer, about a quarter of an inch thick. Similar layers of coal are found at Newark, in Hoehnle's brown stone quarry. The occurrence of bituminous coals in our red-shale and sandstone formation is well known, but thus far no workable beds have been discovered. Inasmuch as none have been found in the many exposures of these rocks it is not worth while to explore for them, excepting along ravines or other natural sections.

In the miscellaneous work of the Survey questions are submitted for examination, which are somewhat aside from the regular subjects of a Geological Survey—yet they are of importance in the development of our natural resources and on this account they have received some attention, though not as much as is desirable.

A question of this class, is regarding the *ground rot* in sweet potatoes. These potatoes are raised with remarkable success in most parts of Southern New Jersey. Immense crops are grown, and they have the reputation of being the best in our country. Gloucester county produces 700,000 or 800,000 bushels a year. Within a few years past the farmers in some parts of that county have suffered greatly from the loss of their potatoes by what they call *ground rot.* The disease attacks whole fields at once, and after failing in this way, no soils have yet been known to regain their fertility and power of growing this crop. A large area is affected by it, and it threatens to become of importance to the whole community.

The question is fairly within the domain of scientific inquiry, and should be capable of solution, though it may need much patient investigation, and most of the experiments tried will necessarily be entire failures. But with intelligent perseverance success is certain.

Another question of the same kind, is in relation to the grape rot, which has nearly destroyed the grape crop for two or three years past. This crop is a large one now, and from our climate,

soil and advantageous position near the best markets, is capable of indefinite enlargement, the demand being constantly and rapidly increasing. But the rot is discouraging vine growers. The loss of grapes cannot be less than from *2,000* to *3,000* tons a year, and almost the whole falls on labor or on persons of small means. It is a legitimate subject of investigation, and can undoubtedly be overcome.

The disease shows itself in the fruit, and those who have examined grapes in different stages of the disease, say that it is caused by a minute fungus which falls upon the fruit, and by its growth there destroys the grape. To counteract it, the grapes have been dusted with lime, road dust and other fine powders, but so far without decided success. Some have acted on the assumption that the disease is only a consequence of weak or incompletely developed vines, owing to exhaustion of the fertility of the soil or the insufficiency in it of some essential elements which should be supplied in manures. It is certain that this is the case with some other fruits, the apple in particular; apple trees respond to generous fertilizing as surely as corn or wheat do, and those apples which are apt to rot on the tree, by the liberal use of special manures are changed to sound, good keeping fruit. This subject is one of present importance and of sufficient magnitude to call for aid from the State.

The cranberry rot is another source of heavy losses to some of our citizens. It is a special crop grown on boggy or swampy grounds. But the cranberry has become of more importance in New Jersey than in any other State; and utilizes profitably, lands that for any other purpose have been nearly worthless. Crops of cranberries, when successfully grown, are enormously large and very profitable, and the supply about equals the demand. But if growing them could be made certain, prices would be lower, more consumers could enjoy the fruit, and a branch of staple industry would be improved.

The disease which affects the cabbage and turnip crops, which is known as anbury, fingers and toes, or club root, is in some of our soils very damaging. In some soils not a crop can be grown without considerable losses from this disease, and in many cases an interval of several years must pass before a second crop can be grown on the same ground. In other soils this difficulty does

not occur. It is a proper subject for scientific inquiry, and there is reasonable ground to believe that both cause and cure can be found.

These are by no means all the inquiries put to us, but they are prominent specimens of what is needed for New Jersey lands.

10. STATISTICS.

MINING STATISTICS.

IRON ORE.

The product of the iron mines in the State during the year 1878, according to the tonnage of the Morris Canal, the Central and the Delaware, Lackawanna and Western Railroads, and the returns from the Oxford Furnace mines, amounts to 409,674 tons.

The zinc mines yielded, according to the data from the same sources, 14,467 tons. These figures correspond closely with those for 1875, when the estimate for iron ore was 390,000 tons. They are lower than those for 1871, 1872, 1873 and 1874. From these and from *estimates* for the years 1876 and 1877, there is reason to hope that iron mining in New Jersey has reached its lowest point, and is now increasing its annual product. The future for our rich mines of iron and zinc ores, with their unequalled advantages of contiguity to our greatest markets, remains more promising than ever before.

GREENSAND MARL.—TRADE AND STATISTICS.

Greensand marl, the well known natural fertilizer of the southern part of the State, continues to be used extensively throughout the marl district. The liberal use of marl has made this district one of the most fertile in our country. In some places it has been used to such an extent as to modify very materially the texture and composition of the soil. It is applied in smaller quantities, but with satisfactory results, outside of the limits of the marl belt. The country southeast of this belt needs such a fertilizer both as an amendment to the soil and as contributing the inorganic constituents necessary for the plant food. All of the railroads traversing this part of the State carry marl. Its

use is, however, much less than the needs of this district, and various causes are given for the comparatively small aggregate which is carried by them. The low priees of farm products, the scarcity of money and the cost of the marl have affected the marl trade and reduced the tonnage of the marl carriers. The cost ought to be lessened and the price be lowered so as to bring it within the means of all thrifty farmers. Such a reduction would induce experiments and increase and extend the use of marl. And such a policy would surely react to the profit of the transportation companies in the additional freights coming from larger areas un ler cultivation and the increased fertility of the lands now in farms. The country southeast of the marl belt is capable of producing as large an aggregate as that of the latter, provided it be improved by the liberal use of this marl and be farmed judiciously. In order to ascertain the present condition of the marl trade and, especially as it bears upon the clearing up and improvement of the southeastern and southern parts of the State, inquiries were addressed to the several marl companies and the following letters in answer were received. It has been thought proper and advisable to print the letters, as they not only state the condition of the marl trade, but also account for its depression and suggest points for improvement. And it is hoped that they may lead to such changes as will advance their interests as well as those of the carriers and the farmers:

O. C. HERBERT, MARLBOROUGH, MONMOUTH COUNTY,

Writes: "I have looked over my marl account and I find that I have sold from January 1st, 1878 to December 25th, 1878, two hundred and eighty cars of marl, each containing three hundred bushels, making eighty-four thousand bushels. Sold to farmers (who dig and cart their own marl) by the foot, over eight thousand feet, which we estimate to be about one hundred and sixty thousand bushels, thus making about two hundred and forty-four thousand bushels of marl sold during the past year.

"Marlborough, December 24th, 1878."

As to prices Mr. Herbert writes:

"Your question in relation to the marl I answer as follows:

Marl delivered at		Freehold	4½	cents	per bushel.
"	"	Tracey's	6½	"	"
"	"	Jamesburg	6¾	"	"
"	"	Cook's	4	"	"
"	"	Morganville	4	"	"
"	"	Mount Pleasant	4¾	"	"
"	"	Matawan	4¾	"	"
"	"	Van Wickle's Woods	4¾	"	"
"	"	on cars, Marlborough	3	"	"

"Marlborough, January 3d, 1879."

W. E. BARRETT, SUPERINTENDENT OF THE SQUANKUM MARL COMPANY.

"Our sales of marl the present year have been very light, amounting to 150,000 bushels. The falling off is due almost entirely to the "hard times" and scarcity of money among farmers in our section and not in any degree to want of confidence in marl as a fertilizer. Our price for marl at the pits is two and a half cents per bushel, and from five to ten cents on the railroad according to distance. I do not give prices at the different stations because there is some prospect of a reorganization of this company by new parties, and a list of prices furnished now might not be correct by the time your report is published.

"Farmingdale, December 24th, 1878."

A. A. YARD, SUPERINTENDENT OF THE SQUANKUM AND FREEHOLD MARL COMPANY

Declined to comply with the request regarding amount sold, but stated that their "sales this year have been very light." He enclosed circular of prices from which the following is taken:

SQUANKUM AND FREEHOLD MARL COMPANY,

Will deliver marl at the following prices per ton of twenty bushels, including freight in not less than one hundred tons:

On the Freehold and Jamesburg Agricultural Railroad.

Squan	$1 20	Tracey's	$1 30
Allenwood	1 20	Hoffman's	1 30
Howell	1 20	Jamesburg	1 30
Freehold	1 20	Rhode Hall	1 40
Manalapan	1 20	Dayton	1 40
Englishtown	1 25	Monmouth Junction	1 45

On the United Railroads of New Jersey.

South Amboy	$1 55	Princeton Junction	$1 55
Old Bridge	1 45	Penns Neck	1 60
Spotswood	1 40	Princeton	1 60
Prospect Plains	1 35	Plainsboro	1 50
Cranbury	1 40	Monmouth Junction	1 45
Hightstown	1 45	Deans Station	1 50
Windsor	1 50	Van Nortwick's	1 60
Newtown	1 50	Four Mile Tank	1 60
Yardville	1 55	Kingston	1 50
Bordentown	1 60	Rocky Hill	1 55
White Hill	1 65	New Brunswick	1 60
Florence	1 70	Piscataway	1 65
Burlington	1 75	Metuchen	1 70
Edgewater	1 75	Union Town	1 70
Beverly	1 80	Rahway	1 70
Delanco	1 85	Linden	1 70
Riverton	1 90	Elizabeth	1 75
Palmyra	1 95	Waverly	1 75
Camden	2 00	Newark	1 80
Trenton	1 70	West End	1 90
Lawrence	1 60	Jersey City	2 00

Perth Amboy Branch.

Avenel	$1 70	Benton's	$1 70
Woodbridge	1 70	Perth Amboy	1 75

Millstone Branch.

Millstone Junction	$1 60	Middlebush	$1 65
Voorhees	1 60	East Millstone	1 70
Harlingen	1 80	Hopewell	1 85
Blawenburg	1 80	Pennington	1 90

Pemberton and Hightstown Railroad.

Hightstown	$1 45	New Egypt (North)	$1 60
Woodsheds	1 50	New Egypt (South)	1 60
Sharon	1 50	Cookstown	1 65
Imlaystown Station	1 55	Wrightstown	1 70
Davis	1 55	Lewistown	1 75
Cream Ridge	1 55	Shreve's Road	1 75
Hornerstown	1 60	Pemberton	1 75

Central Railroad of New Jersey.

Spring Lake	$1 35	Red Bank	$1 40
Sea Plain	1 35	Middletown	1 65
Ocean Beach	1 35	Holmdel	1 65
Asbury Park	1 35	Matawan	1 70
Deal Beach	1 40	Cliffwood	1 80
Elberon	1 40	Morgan	1 85
Long Branch	1 40	South Amboy	1 90
Branchport	1 40	Perth Amboy	1 95
Shrewsbury	1 40		

Belvidere Delaware Railroad.

Coal Port Junction	$1 70	Titusville	$1 85
Asylum	1 75	Moore's	1 85
Ewing	1 80	Lambertville	1 90
Washington's Crossing	1 80	Flemington Railroad Junction	1 90

Flemington Railroad Branch.

Mount Airy	$1 90	Murheid's	$1 95
Barber's	1 90	Copper Hill	2 00
Ringoes	1 95	Flemington	2 05

At points on the Central, Morris and Essex and Belvidere Delaware Railroads more distant from Farmingdale the price ranges from $1.90 upwards.

GENERAL G. MOTT, OF THE CREAM RIDGE MARL COMPANY,

Writes: "The Cream Ridge Marl Company sold last year 6,460 tons of marl.

"The present price at the following points is as follows:

Imlaystown	5 miles.	$1 05	per ton.
Prospect Plains	17 "	1 30	"
Spotswood	24 "	1 40	"
South Amboy	34 "	1 55	"
Newtown	17 "	1 25	"
Trenton	30 "	1 50	"
Princeton Junction	31 "	1 50	"
New Brunswick	35 "	1 55	"
Hightstown	13 "	1 20	"
Jamesburg	20 "	1 35	"
Old Bridge	25 "	1 45	"
Windsor	14 "	1 20	"
Bordentown	24 "	1 40	"
Lawrence	35 "	1 55	"
Monmouth Junction	25 "	1 40	"

"Trenton, Dec. 23d, 1878."

Did not respond to the letter of inquiry, respecting sales and prices.

JOHN S. COOK, SUPERINTENDENT OF THE VINCENTOWN MARL COMPANY

Writes: "Owing to the hard times with farmers and the high rates of the railroads the sales have been very much reduced. But now the railroad has reduced the freights and our sales since December 1st have been increased considerably. Our average sales since opening the pits have been about 10,000 tons per annum.

"Our prices for marl are at

Trenton, 29 miles	$1 50	per ton.
Princeton Junction, 39 miles	1 60	"
New Brunswick, 55 miles	1 65	"
Hightstown, 30 miles	1 50	"

"Vincentown, December 23d, 1878."

No report was received from the

FOSTERTOWN AND SOUTH BRANCH MARL AND TRANSPORTATION COMPANY.

Of the sales along the *Camden and Atlantic* and the *Philadelphia and Atlantic City Railroads* during the year 1878, no accounts have been received.

FROM I. C. VOORHIES, SUPERINTENDENT OF THE WEST JERSEY MARL AND TRANSPORTATION COMPANY

The following letter was received:

"DEAR SIR:—Our business has been small for the year 1878, and I feel very much ashamed of it. I could not do any better. Our farmers are very much discouraged. The price of grain, &c., is very low. Very few farmers have made both ends meet. We have done a considerable business in lime this year, having sold and delivered 46,668 bushels of stone and gas lime—nearly all stone lime. Farmers complain very much of the price of marl, and think it ought to be lower.

"Enclosed you will find a price list for the different railroads, which will, I hope, prove what you wish.

Statement.

AMOUNT OF MARL SOLD AND DELIVERED BY THE WEST JERSEY MARL AND TRANSPORTATION COMPANY IN THE YEAR 1878.

January	560 tons.
February	none
March	160 "
April	2,192 "
May	864 "
June	none
July	456 "
August	476 "
September	794 "
October	164 "
November	none
December	592 "
	6,258 "

Price List.

THE WEST JERSEY MARL AND TRANSPORTATION COMPANY

Will deliver marl on and after January 1st, 1873, on the *West Jersey Railroad and branches*, at the following prices per ton:

West Jersey Railroad.

Camden	16	miles,	$1 55
Gloucester	13	"	1 50
Westville	11	"	1 45
Woodbury	8	"	1 30
Mantua	4	"	1 20
Barnsboro	3	"	1 10
Marlboro	1	"	.....
Glassboro	4	"	1 20
Union	6	"	1 30
Harding	8	"	1 35
Monroe	9	"	1 40
Elmer	12	"	1 45
Palatine	15	"	1 50
Husted's	17	"	1 55
Finley's	20	"	1 65

Bridgeton	24	miles,	$1 70
Cook's Crossing	14	"	1 50
Newkirk's	15	"	1 50
Daretown	17	"	1 55
Paulding's	18	"	1 60
Yorketown	19	"	1 60
Oakland	22	"	1 65
Alloway's	24	"	1 70
Middletown	25	"	1 75
Acton's	26	"	1 80
Salem	29	"	1 85
Clayton	7	"	1 30
Franklinville	10	"	1 40
Iona	13	"	1 45
Malaga	14	"	1 50
Newfield	16	"	1 55
North Vineland	17	"	1 55
Vineland	21	"	1 65
Millville	23	"	1 80
Manumuskin	33	"	1 85
Belleplain	39	"	1 95
Woodbine	43	"	2 00
Mount Pleasant	45	"	2 05
Seaville	48	"	2 10
Swain's	53	"	2 20
Cape May Court House	...	"	2 25
Millertown	59	"	2 35
Rio Grand	62	"	2 35
Bennett's	64	"	2 45
Cold Springs	...	"	2 45
Cape May	68	"	2 55

Swedesboro' Railroad.

Mullica Hill Road	9	miles,	$1 33
Tatum's	10	"	1 35
Parkville	10	"	1 37
Ogden's	11	"	1 39
Berkley	12	"	1 40
Clarksboro	13	"	1 43
Gibbstown	14	"	1 45
Wolfert's	15	"	1 50
Tomlin's	16	"	1 52
Asbury	17	"	1 55
Rulon's Road	18	"	1 55
Swedesboro	19	"	1 60

Bridgeton and Port Norris Railroad.

Brickville	25	miles,	$1 73
Bellevue	27	"	1 76
Fairton	28	"	1 78
Westcott's Station	29	"	1 82
North Cedarville	30	"	1 84
Cedarville	32	"	1 86
Newport	34	"	1 90
Dividing Creek	37	"	1 97
Buckshutem	39	"	2 02
Mauricetown	40	"	2 03
Port Norris	44	"	2 10

"The company do not furnish less than four tons. Marl delivered between stations at the price of station beyond. Marl must be removed within fifteen days after delivery or agents may re-sell it.

"*Terms.*—Three months' credit will be given by giving note, payable in bank. If cash is paid on delivery, interest will be allowed for three months; if a longer credit is desired, interest will be charged after three months.

"Woodbury, Dec., 1878."

Summary.

O. C. Herbert, (per railroad)	4,200 tons.
O. C. Herbert, (per teams)	8,000 "
Squankum Marl Company	7,500 "
Squankum and Freehold Marl Company	(no report.)
Cream Ridge Marl Company	6,460 tons.
Pemberton Marl Company	(no report.)
Vincentown Marl Company	5,000 tons.
Fostertown and South Branch Marl and Transportation Company	(no report.)
West Jersey Marl and Transportation Company	6,258 "
Woodstown, (Dickinson Pits)	2,500 "
Total (reported)	39,918 tons.

As compared with the sales which were reported for 1873, there is a falling off of about 70 per cent., or, in other words, the marl carried by the railroads of the State in 1878 did not amount to much over one-third of the tonnage of 1873.

11. 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 about the time the Board met last year, 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 very large number of copies has been distributed.

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 a very large number has been distributed.

The proper method of distributing 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 some of 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, till now no copies are sold nor have been for two or three years past. 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 as long as we continue to thrive in using it.

The Pennsylvania reports are sold at 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. At the meeting of the British Association in Dublin, in August last, a memorial and resolution was passed stating that the prices at which maps and books were held were so high, as to keep them entirely from the public, and requesting the Board having the matter in charge to revise their list of prices, so as to give the reports free circulation among those desiring to use them.

The French Geological maps too, are held at high prices, and I think, few of them are sold.

12. EXPENSES.

The expenses of the Survey are kept strictly within the appropriation. The bills have been regularly presented to the Auditing Committee and approved every quarter, and there are no outstanding accounts.

13. PERSONS EMPLOYED IN THE SURVEY.

Prof. John C. Smock, Assistant Geologist, has been steadily employed during the year in geological work, surveying the deposits of glacial drift, the soils of southern New Jersey, and in miscellaneous work.

Edwin H. Bogardus, Chemist of the Survey, has been engaged in the laboratory, analyzing soils and ores, and in other work answering questions which are submitted to the survey.

Geo. W. Howell, C. E., has been for a part of the year leveling and surveying for the topographical map of the country between Orange Mountain and the Hudson river. In this work he has been assisted by Mr. C. C. Vermeule, a graduate of Rutgers Scientific School.

Prof. Edward A. Bowser has been engaged in determining geographical positions at various places in the State in connection with the United States Coast Survey.

My own time has been occupied with office work, miscellaneous inquiries submitted to the survey, work connected with water supply, drainage, agriculture, &c., and in a special study of the resemblances of our glacial drift unstratified and partly stratified, to glacial deposits now accumulating in the Alps.

APPENDIX.

INDIAN AND OTHER PREHISTORIC REMAINS OF MAN.

In last year's report allusion was made to the interesting questions raised in regard to the remains of the people who formerly occupied our country. It is much to be desired that all remains of this kind should be secured and described. They are fast being destroyed or lost. It is earnestly requested that all implements, such as arrows, spears, knives, axes, mortars, pestles, &c., should be placed in some public collections in the State where they will be preserved, and that notes be made public of the location of habitations, burial places, &c., or any other facts which may be curious or interesting in regard to these early inhabitants. At Greenwich, in Cumberland county, there are marks of the foundations of their houses, which appear as if they were made partly or wholly underground, and not like ordinary wigwams. The same marks have been seen in other parts of the county; and in one instance something like a wooden floor has been found a few feet beneath the level of the ground.

Prof. Samuel Lockwood, of Freehold; Dr. Charles C. Abbott, of Trenton; Luke W. Brodhead, Esq., of Water Gap, Pa.; Dr. Brakeley, of Belvidere; Drs. E. J. Fithian, George B. Wood and Ephraim Holmes, of Greenwich, Cumberland county; Dr. Theodore T. Price, of Tuckerton, and Dr. Maurice Beasley, of Dennisville, have given a great deal of intelligent attention to this subject; and there are many other collectors in the State who may find interest in communicating with any of these gentlemen or with this Survey.

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Longitude West 75°00' from Greenwich.

GEOLOGICAL SURVEY OF NEW JERSEY.

GEORGE H. COOK, STATE GEOLOGIST

JOHN C. SMOCK, ASST GEOLOGIST.

THE STATE OF NEW JERSEY

SURFACE GEOLOGY

MAP SHOWING SOILS OF THE GLACIAL DRIFT OF NORTHERN NEW JERSEY AND APPROXIMATE BOUNDS OF THE PINE AND OAK LANDS OF SOUTHERN NEW JERSEY.

1878.

Scale: 6 Miles to 1 Inch.

Statute Miles.

Terminal Moraine

Glacial Drift

Oak Lands

Pine Lands

JULIUS BIEN LITH.