GEOLOGICAL SURVEY OF NEW JERSEY.

ANNUAL REPORT

OF THE

STATE GEOLOGIST,

FOR THE YEAR

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MAP
OF
NEW JERSEY
1877.
Scale
Glacial Drift.
I.Rice, Lith.

Board of Managers.

His Excellency, Joseph D. Bedle, Governor, and *ex-officio* President of the Board.....Trenton.

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William W. Shippen, Esq.....Hoboken.

GEOLOGISTS.

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

To His Excellency Joseph D. Bedle, 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 to present my report on the work of the Geological Survey for the year 1877.

With high respect,

Your obedient servant,

GEO. H. COOK,

State Geologist.

REPORT.

INTRODUCTION.

The Geological Survey of New Jersey is carried on for the development of the natural resources of the State. In accordance with this view of its objects, geological investigations are working out the details of structure, composition, origin, age and location of the various rocks, earths and minerals found in the State; they are also showing the economic uses of our natural products, and presenting ways by which such products can be made most available for the State and its people.

Inquiries concerning marls, soils, ores, building stones, slates, limestones, &c., are pursued; also inquiries about water supply and drainage—as also those concerning agriculture and sanitary improvements. The making of accurate and detailed maps, which will show correct locations and distances, and also heights above the sea, is, in the absence of any maps of sufficient accuracy now in existence, a necessary part of the work, which has been satisfactorily begun. And collections of rocks, fossils, ores, minerals, building stones, limestones, slates, marls, clays, sands, peat and other useful products, are made and have been deposited in the Museum at Trenton, and in the cabinets of Princeton College, Rutgers College and Stevens Institute.

The work done during the year is described under the following heads, viz.:

1. The final report on the clay district of Middlesex county.
2. Exploration of the portion of the State covered by the glacial drift.
3. Examination of the deposits of shell marl, in Sussex and Warren counties.
4. Extension of the Coast Survey Triangulation over New Jersey.
5. Topographical survey of the country between First Mountain and the Hudson.

6. Drainage of the Great Meadows on the Pequest.

7. Laboratory work in the analysis of iron ores, limestones, marls, &c., &c.

8. Office work of Centennial Map, Museum of the Geological Survey, &c.

ASSISTANTS.

Prof. John C. Smock, Assistant Geologist, has been engaged in geological explorations of the glacial drift, the plastic clay and shell marl formations, and in office work connected with them, through the entire year.

Edwin H. Bogardus, Chemist, has been at work in the laboratory during the year.

Geo. W. Howell, C. E., has been occupied for a part of the year in the topographical survey of the country between First Mountain and the Hudson.

Prof. Ed. A. Bowser, C. E., has continued the coast survey triangulation in New Jersey during the summer and autumn.

EXPENSES.

The expenses have been kept strictly within the appropriation. The accounts have been regularly audited by a committee of the Board.

1. FINAL REPORT ON THE CLAY DISTRICT OF MIDDLESEX COUNTY.

This report, with the accompanying maps and sections, is now going through the press, and will be ready for distribution in a few weeks. It will make an 8vo. volume of 350 pages, and will be accompanied with a geological and topographical map, on a scale of 3 inches to a mile, which shows the location and elevation of all the clay pits that have been opened, and the outcrop of the different clay beds, as far as they are thought to be available; and by a general section, on a scale of 6 inches to a mile, which shows all the clay openings at their proper heights and in one plane. The explanations and illustrations of the work are such as to make them available for intelligent explorers and landowners, who are interested in the digging and sale of clay;

and the report will also help to make public the beds of rich fire and potters' clay of this district. In quality, for standing fire, there are no better clays in use, as is shown by the analyses and fire trials of these clays as given by comparison with the best of our own country and of England, Scotland, France, Germany, and Belgium.

Most of the pits opened are along the navigable waters of the Raritan river, Staten Island sound and Woodbridge creek, and none of them are more than two miles from docks and water carriage, and all are within 25 miles of New York. The amount to be obtained is enormously large. Ten thousand tons to the acre is not an uncommon yield, and single acres have yielded 40,000 tons, and there are hundreds of acres of such ground. For supplying material for fire bricks, gas retorts and other refractory wares, this district has advantages over any other in the whole country. It also supplies a large amount of clay for fine and common pottery. It is of the highest economic importance that the superior quality of these clays should be more generally known. Great quantities of excellent clay for making refractory wares have been and are still being wasted, from their valuable properties not being known. The manufacture of all kinds of articles from clay is just being fairly established in our country, and the most available materials to be used in carrying it on will all be in demand. There has been dug in a single year in the clay district described, 265,000 tons of fire clay and 20,000 tons of stoneware clay. There is no reason why this amount should not be quadrupled, and it is hoped that this report will help to make it profitable to begin this enlarged use.

2. EXPLORATION OF THE PORTION OF NEW JERSEY WHICH IS COVERED BY THE GLACIAL DRIFT.

The occurrence of loose and rounded rocks, stones and gravel on the surface, and of kinds of stones entirely different from the solid rock underneath, has been observed by every one who has traveled in the Northern States of our country. In the Southern States, gravel banks are occasionally met with, but the loose and rounded rocks and stones are very uncommon. So well marked is this difference that it is recognized as a fact that the diluvium or drift of the Northern Hemisphere did not extend

below about latitude 40° in our own country. The cause of this phenomenon has been variously ascribed to water, to floating ice and to glaciers. The study of glaciers in Switzerland and Norway, and in high northern and southern latitudes, has led most geologists of the present day to the conclusion that our great deposits of gravel, stones and loose rocks have been left in their present places by glaciers. That all the northern part of this continent has been covered by a thick body of ice, so thick, even in New Jersey, that it covered the tops of the highest mountains. That this immense mass of ice had a slow movement from the north towards the south, in which it scraped or tore off the earth and rocks from the rocky mass under it, grinding, grooving and smoothing down the rocky surface, and pushing forward, tumbling and rounding the fragments of stone and rock, and finally leaving them at the southern edge of the glacier, or wherever breaks in it may have allowed the loose materials to rest. This theory is consistent with observed facts. The terminal or southern edge of the drift is well and very plainly marked by a line of hillocks of mixed clay, sand, gravel, rounded stones and boulders of large size. The thickness of the ice is inferred from the fact that high hills and mountain tops are smoothed and grooved the same as the lower ground. The direction of the movement is proved by finding that the loose rocks and stones are always like the fast rocks which are north of them, and not like the rocks further south. The direction is further proved by observing the direction of the streaks, scratches and grooves in the worn rocks underneath, which are almost always in a southerly direction. The powerful scraping action of the moving glacier is further proved by our finding no disintegrated or decomposed rock in the country where the drift occurs, while it is very common and a marked feature of the country south of it. To those who are not yet prepared to accept this theory, as well as for those who do, it will be convenient to look at the details as they are arranged under these several heads.

Beginning on the eastern side of the State on the north side of the Raritan, at Perth Amboy, the line of Short Hills extending from that place to the First Mountain, and passing just north of Metuchen, Plainfield and Scotch Plains, marks the southern edge of the drift. Between the First and Second Mountains it fills the whole valley for less than a half mile south of the Morris

and Essex railroad. Between Second Mountain and Long Hill, the deposit of clay, gravel and boulders runs just south of Summit, and crosses the Passaic a little above Stanley. From Long Hill to Morristown the deposit of gravel and boulders forms a ridge which is just south of the Morris and Essex railroad, and has its southern foot marked by the Great Swamp and Loantika brook. From Morristown westward across the ridges of the Highland range of mountains, the terminal deposit is not so regular in its occurrence. It can, however, be seen at Dover, and is very plainly marked where it crosses the valley of the Musconetcog, about a mile northeast of Hackettstown. Thence it crosses the mountain in a very irregular but well marked line of hills to the valley of the Pequest at Townsbury. From there onward by the southwest end of the Jenny Jump mountain and Butzville, it extends on to the Delaware below Belvidere. The portion near the Delaware shows the gravel and boulders very plainly, but it appears to have been washed and otherwise modified by floods or great bodies of water descending in that valley. The whole line of this moraine is remarkable plain and well defined. It is not as distinctly marked across the Delaware in Pennsylvania, but on the east it shows very plainly across Staten Island, where its eastern end forms one side of the Narrows, and furnishes the location for Forts Tompkins and Wadsworth, and on Long Island its western end marks the other side of the Narrows, and is the site of Fort Hamilton. Thence it runs eastward, furnishing the sites for Greenwood Cemetery and Prospect Park, and extending along the north side of the island for 40 or 50 miles. Its course finally changes a little towards the south, and it reaches the south side of the island a few miles west of Southampton. This well marked line of hills of glacial drift is 150 miles long. The most southerly point reached in the whole distance is Perth Amboy, which is in latitude 40° 30′. Across New Jersey the line is not exactly east and west, but appears to deviate towards the north, the deviation being greater somewhat in proportion as the ground is more elevated.

The hillocks of stones, gravel and earth which together made this long chain, have every appearance of piles of debris which have been thrown down without order, and without the presence of water to sort or arrange the various materials. The hills join each other in such ways that basins without outlets are found so

frequently as to make lakes, ponds, and marshes a characteristic feature of countries covered by glacial drift, and whenever these hills are cut into, so as to show their structure, it is found that they are not stratified, but that the clay, sand and boulders are all mixed in a confused mass.

These hillocks, however, are not confined to the terminal moraine mentioned, but are irregularly scattered over all the country north of it, and to name them would require a long list. There is not a railroad crossing the district which does not cut them in many places. The Morris canal crosses from Montville to Hook Mountain on one. They can be seen all along the west foot of the Palisade Mountains and Bergen Hill. At Newark they make the bluff bank of the Passaic. They make the beautiful hill on which is the cemetery at Paterson. The Plains near Morristown are only drift hills which have been somewhat leveled on top by water. The remarkable bank across the valley of the Wallkill at Ogdensburg is only a mass of drift. A mass of glacial drift filling the valley of the Pequest has dammed the stream and made the marsh, which is known as the Great Meadows, and a similar dam of glacial drift across the Wallkill at Hampton, in Orange county, N. Y., has caused the water to set far back into Sussex county and made the Drowned Lands which cover a large tract of the very best land in those counties.

The top of the Blue Mountain, in Sussex and Warren counties, which is the highest land in New Jersey, being from 1500 to 1800 feet high, shows marks of glacial action everywhere. High Point which is 1799 feet high is smoothed as completely as the rocks in the valley, and a boulder 4 feet in diameter rests on its very highest point. The crests of the Highland ridges as well as their sides are all worn smooth, and boulders of the largest size are found resting on their tops. There is an immense mass of boulder clay at Stanhope, at an elevation of 950 feet, which has been cut through by the Morris and Essex Railroad.

The trap ridges known as the Palisades and the First and Second Mountains are all worn smooth to their tops as if the ice had thickly covered them.

It is only when near the southern border of this drift area that the thickness of the ice appears to have been insufficient to cover the crests of the mountain ridges. On all the ridges which

its terminal moraine crosses, the line has fallen back towards the north.

The following tabular statement of the elevation of various places, on the terminal line of the drift, and their distances north of the parallel of 40° 30' of N. L. may give some hint as to the probable thickness of the immense body of ice which brought down this mass of stones and earth:

	Elevation in feet above tide water.	Distance north in miles.	Rise per mile. Feet.
Perth Amboy	0	0	
Feltville, 1st Mountain	400	12	33
Second Mountain, 2 miles south of Summit	440	14	31
Morris Plains	700	22	32
Hills south of Dover	900	22	41
Hills west of Hackettstown	750	24	31
Townsbury	600	22	27
Mountain west of Townsbury	900	24	38
Mount No-More	750	21	36
Roxburgh	680	20	34
Average slope on rise per mile			34

If we assume, as facts appear to warrant, that the great glacier which covered this continent from 40° 30′ northward, had its upper surface nearly uniform, and rising towards the north at the rate of 34 feet per mile it would everywhere north of the terminal line have a thickness sufficient to overtop the highest land in the State, as its marks show that it did. The High Point on the Blue Mountain near the New York boundary is 1800 feet high, and has glacial marks and boulders on its top. It is 58 miles north of the parallel mentioned, and a rise of 34 feet per mile would make the thickness of ice there 1972 feet, which is 172 feet above the top of the mountain.

As this becomes the means of measuring the thickening of the ice from its southern and thin edge, towards the north, it is a matter of some theoretic interest. The total thickness, however, judging from the worn rocks on the higher mountains in New York and Pennsylvania, must have been at least 4,000 or 5,000 feet.

That the movement was from the north, is inferred from the

mineral composition and structure of the rocks and stones found loose in the drift, and by which a practiced eye can identify them and tell their parent rock. At Jersey City the boulders are mainly of trap rock, from Bergen Hill and Weehawken, altered red-shale from Weehawken, an occasional block of serpentine from Hoboken, and of gneiss from the country further north. Among the boulders at the Short Hills, near Metuchen, can be found masses of granite from the Highlands, 20 or 30 miles off, boulders of Green Pond mountain conglomerate from beyond Dover, and perhaps beyond the State line; occasionally, too, are found masses of sandstone containing fossils from the Oriskany rocks, either at Greenwood lake or beyond the Blue mountain, and all mixed in with an abundance of red sandstone from the underlying or adjacent rocks. Boulders of limestone, of great size and in large numbers, are found along the northwest slopes and on the tops of the Highland ridges, south and southeast of the limestones of the Kittatinny valley, while they are very uncommon in the country east of those mountains. Rounded masses of magnetic iron ore are found scattered sparingly over the country, to the south of the mountains in which the iron mines are found. In the valley of the Walkill, at Sparta, and even much further south, boulders of franklinite and zinc ore, some of them weighing many tons, are found lying on the surface or imbedded in the earth. They are evidently from the zinc veins at Stirling Hill or Mine Hill, six and eight miles away. At Ogdensburg, on the bank of a glacial drift, which is in the valley just east of Stirling Hill, boulders of the darker-colored franklinite and zinc ore, peculiar to the zinc vein at Mine Hill, are found among the stone and gravel that make up the bank. No such boulders are found north of these zinc veins. Like all the loose materials that can be identified anywhere in this whole area covered by glacial drift, they have been moved in a southerly direction. The parent rock, from which they were torn, is further north.

The scratches and grooves in the surface of the solid rock, mark the direction of the moving mass more accurately. They are to be found on masses of hard rock which have been covered with earth or soil, and are common on all the azoic, paleozoic and trap rocks of the district. They are not common on the

triassic red sandstone. Rocks, which have been long exposed to weathering agencies, do not show them.

These scratches, which are mostly parallel, have evidently been made by fragments of hard and tough stone, which have been driven over them while imbedded in some heavy and solid mass.

The following is a list of these scratches. They were mostly taken this year, the observations were made with a good pocket compass. They are arranged for the different ridges on which the observations were made; and as most of the ridges have a direction of northeast and southwest, and the scratches cross obliquely from the north to the south side, those on the north slopes are arranged separately from those on the south, so as to show whether the ridges have caused any change in the direction of these marks, and of the agency which produced them.

Directions of Glacial Markings, Magnetic Bearings.—Northwestern slope of Kittatinny, Blue or Shawangunk mountain, and valley west to the Delaware.

S. 35° W., half a mile east of Carpenters Point, near Greenville road, New York, on Cauda galli grit.

S. 80° E., Greenville turnpike, on Onedia conglomerate.

S. 75° E., Greenville turnpike, on Oneida conglomerate, farther east.

S. 65° E., Greenville turnpike, on Oneida conglomerate, still farther east.

S. 58° E., Greenville turnpike, on Oneida conglomerate, still farther east.

S. 60° E., Greenville turnpike, on conglomerate, summit of mountain.

S. 45° E., Port Jervis and Coleville turnpike, on conglomerate, one mile west of summit.

S. 65° E., Port Jervis and Coleville turnpike, back of road to High Point.

S. 75°–80° W., on High Point, conglomerate rock.

S. 70°–80° E., on Port Jervis and Coleville turnpike, one-quarter of a mile east of last station.

S. 85° W., on Port Jervis and Coleville turnpike, a few rods east of last point.

S. 80°–85° E., near Hornbeck's mills, Montague, on Cauda galli grit.

S. 45° W., on Peters Valley and Culvers Gap road, on Medina sandstone, one-quarter of a mile from road to Newton.

S. 50° W., near Big Flatbrook, on Peters Valley and Newton road, on Medina sandstone.

S. 48° W., on Peters Valley and Newton road, half a mile east of brook, on Medina sandstone.

S. 50° W., on Peters Valley and Newton road, still farther east, on Medina sandstone.

S. 45° W., on Peters Valley and Newton road, one-quarter of a mile west of road to Walpack, on Medina sandstone.

S. 18° W., Newton and Flatbrookville road, west of summit, on Medina sandstone.

S. 10° W. and S. 20° W., Newton and Flatbrookville road, on west slope of mountain, on Medina sandstone.

S. 16° W., mean, Newton and Flatbrookville road, on west slope of mountain, on Medina sandstone.

S. 18° W., Newton and Flatbrookville road, on west slope of mountain, near old school house, on Medina sandstone.

S. 20° W., Newton and Millbrook road, east of top of mountain, conglomerate.

S. 16° W., Newton and Millbrook road, on top of mountain, conglomerate.

S. 40° W., Flatbrookville and Millbrook road, down on slope, Medina sandstone.

S. 30° W., Flatbrookville and Millbrook road, down on slope, Medina sandstone.

S. 25° W., Flatbrookville and Millbrook road, Medina sandstone.

Southeastern slope of Kittatinny Mountain.

S. 30° W., on slate, one mile north of Coleville, on Port Jervis turnpike.

S. 80° E., on slate, southwest of Long pond, and near Newton and Walpack road.

In Kittatinny Valley and western foot of Highlands.

S. 30° W., on zinc vein, near Hamburgh road, at Franklin.

S. 10° W. and S. 20° W., on white limestone, along railroad, between Franklin and Ogdensburg.

S. 35°–40° W., on slate, in Fredon road, at Newton.

S. 35° W., on slate, Newton and Millbrook road, one mile west of Stillwater.

Southwest, top of slate ridge, Johnsonsburg and Marksboro road.

South, conglomerate at Alamuchy.

S. 20° W. and S. 30° W., on gneiss, east of Nelson Cummins, Great Meadows.

S. 5° 10° E., on sandstone, near Larason's bridge.

S. 30° E., on gneiss, eastern slope of Jenny Jump mountain, Danville and Hope road.

S. 15° W., on gneiss, on west slope of mountain, west of Warrenville.

S. 12° W., on gneiss, on Carrington and Longbridge road, west slope.

S. 30° E., on gneiss, on Carrington and Longbridge road, east slope.

On various ridges of the Highlands.

S. 5° W., on gneiss, Sparta mountain, half a mile northwest of Woodport.

S. 20° W., on gneiss, Stockholm, lower forge.

South, on gneiss, Green Pond road, west of Lyonsville.

S. 15° W., on gneiss, near Greenville school house.

S. 10° W., on conglomerate, summit of Copperas mountain.

S. 30° W., on conglomerate, western slope of Green Pond mountain, west of Green Pond.

On First, Second and Third Mountains (trap ridges.)

S. 30° W. and S. 40° W., in gap, west of High mountain, Second mountain range.

S. 80° W., Paterson and Pompton road, top of Second mountain.

S. 80° W., Paterson and Pompton road, just below and east of summit.

S. 70° W., 75° W. and 80° W., Paterson and Pompton road, on east slope of same mountain.

S. 80°–85° W., Paterson and Meads Basin road, Second mountain top.
S. 30° W., Paterson and Pompton road, on southern slope of Second mountain.
S. 25° W., Paterson and Pompton road, near foot of south slope.
S. 8° W., Paterson and Pompton road, foot of mountain, three-quarters of a mile from furnace.
S. 15°–20° W., Pompton furnace, near knife factory.
S. 75° W., Paterson, south of Garret rock, First mountain.
S. 75° W., Paterson, near Morris canal, on Little Falls road.
S. 40° W., Second mountain, northwest slope, near Passaic and Essex county line.
S. 48° W., on west slope of Second mountain, on Mt. Pleasant turnpike.
S. 48° W., on top of Second mountain, on Mt. Pleasant turnpike.
S. 50° W., on Second mountain, southeast slope, Centreville road.
S. 25° W., on Hook mountain, road crossing to Beavertown, northwest slope.
S. 40° W., on Hook mountain, near Beavertown.
S. 60° W., on Hook mountain, south of peat works, north slope.
S. 65° W., on Hook mountain, west slope.
S. 55° W., on Hook mountain, south end.
S. 60° W., on First mountain, near Eagle Rock.
S. 58° W., on First mountain, on west side of summit.
S. 72° W., on First mountain, on northwest slope, near foot, Centreville road.
S. 48° W., on First mountain, on rock cut half way up mountain, Centreville road.

Palisade Mountain.

S. 10° W., on High Torn, Haverstraw.
S. 20° W. and S. 30° W., in gap east of High Torn and south of Haverstraw.
S. 20° E., one-quarter of a mile northwest of Alpine, southeast of Closter.
S. 25° E., on summit, at Alpine.
S. 30° E., summit of mountain, on road from Cresskill to Huyler's Landing.
S. 15°–20° E., half a mile east of Cresskill, on west slope.
S. 18° E., on road from Englewood to Palisade Mountain House, near top.
S. 30°–40° E., on road from Englewood to Palisade, top of mountain.
S. 35°–40° E., in front of Palisade Mountain House.
S. 65° E., in front of Palisade Mountain House.
S. 25° E., Leonia and Fort Lee road, near Fort Lee.
S. 20° E., top of bluff, north of Fort Lee.
S. 40° E., on Palisade avenue, north of Guttenburg and English Neighborhood road.
S. 20° E., near Guttenberg brewery.
Southwest, one mile northeast of New Durham station, foot of mountain.
S. 10° W., one-quarter of a mile southeast of Homestead station, foot of hill.
S. 20° E., new reservoir on hill, at Hudson city.
S. 10° E., west end of Delaware, Lackawanna and Western tunnel.
S. 25° E., near east end of same tunnel.
S. 20° E., at east end of same tunnel.
S. 25° E., at point of rocks, Pennsylvania Railroad.
S. 25° E., south side of Montgomery avenue, Bergen Hill.
S. 42°–45° E., Montgomery avenue.
S. 20° E., west end of cut of Newark and New York Railroad.
S. 20° E., near Bergen avenue, Newark and New York Railroad.

S. 25° E., near Jackson avenue, Newark and New York Railroad.
S. 35° E., on railroad, 100 yards east of last station.
S. 35°–37° E., at the east end of cut for Newark and New York Railroad.
Southeast, at Avenue C, near Morris canal, Bayonne city.
S. 10° W. and S. 15° W., Newark bay shore, near Saltersville dock.
S. 15°–20° W., Newark bay shore, a little south of Saltersville dock.

The directions given in this table can be classified as follows:

1. Approximately East and West—

High Point, Blue, or Kittatiny, Mountain.
Blue Mountain, western slope, Greenville turnpike, New York.
Hornbeck's Mills, Montague, Sussex county.
Eastern slope of Blue Mountain (on slate) southwest of Branchville, Sussex county.
First Mountain, Paterson.
Second Mountain, west of Paterson, (road to Pompton).

2. Southwest—

Blue Mountain, western slope, Walpack township, Sussex county.
Blue Mountain, western slope, west of Culver's Gap, Sussex county.
Blue Mountain, western slope, Pahaquarry township, Warren county.
Blue Mountain, western slope, near Delaware Water Gap, Warren county.
On gneiss slope, east of Nelson Cummins, east of Great Meadows, Warren county.
On slate ridge, Newton, Sussex county.
On zinc vein, Mine Hill, Franklin, Sussex county.
In Walkill valley, Ogdensburg, Sussex county.
Near Marksboro (on slate ridge), Warren county.

Palisades Mountain (Bergen Hill), west slope, south of Pennsylvania railroad.
First and Second Mountains, west of Orange.
Second Mountain, near High Mountain, north of Paterson.
Torn Mountain range, Haverstraw, New York.

3. Approximately South, (S. S. E. and S. S. W.)

South. Allamuchy, Warren county.
South 15° west. West of Warrenville, Warren county.
South. Near Lyonsville, Morris county.
South 10° west. Copperas Mountain.
South. Temple's store, Stockholm, Passaic county.
South 10° west. Torn Mountain, Haverstraw, New York.

4. Southeast—

Carrington, Warren county.
Eastern slope of Jenny Jump Mountain, Hope road.
Palisades Mountain and Bergen Hill, excepting foot of ridge along Hackensack Meadows and Newark Bay (see 2).

A remarkable characteristic of the glacial drift district, is the absence of the original earth and disintegrated rock from the surface of the country. Wherever drift is found, the underlying rock is generally solid and unchanged, and if of sufficient firmness is worn smooth and marked with fine parallel streaks or coarser scratches, and covering it is the drift material of mixed clay, loam and sand, with stones and boulders of sandstone, conglomerate, limestone, slate, granite, gneiss, hornblende and quartz rocks, such as constitute the fast rock in a great expanse of the country northwards, and the soils are of the same mixed character.

South of the glacial drift, few boulders are found. There are a few places like that on the New Jersey Central Railroad, a mile above Annandale station, or like that at Kingston on the Delaware and Raritan Canal, where glacial drift with boulders is seen. These may have been formed by local glaciers of small extent; and there is a belt of country, a few miles wide, immediately south of the glacial drift, in which numerous cobble stones and some boulders of quartzose rock are found. These stones are of smooth and in many cases of shining surface, and so different in appearance and material from those of the glacial drift that they can be recognized at a glance. Their origin is not known at present. They must belong to some older drift deposit of which we have not yet sufficient facts to furnish any connected account. But, generally, the country south of the glacial drift is covered with soil made from the rock immediately under it,

and mostly from its decay and the removal from it of some of its more soluble constituents. On the mountains in Warren, Hunterdon and the southern part of Morris county, the gneiss rock is so decomposed as to make a good soil, free from boulders quite to their tops, and where railroad cuts are seen, as in the New Jersey Central near High Bridge, or the approaches to the Easton and Amboy railroad tunnel near Bethlehem, the rock is so soft as to be easily cut into by the steam excavator.

The limestone in the valleys of Morris, Warren and Hunterdon is only covered by a fine yellow soil without boulders, which appears to be composed of the impurities of the original limestone rock, and to be left in its original place as the lime has been slowly dissolved out in the course of ages. This soil is entirely different from that in the limestone valleys of Sussex where drift deposits cover the rock to a considerable extent.

Over much of Middlesex, Somerset, Hunterdon and Mercer counties, which are underlaid by red sandstone and shale, the soil is nothing but the rock disintegrated, and there is no well marked worn or smoothed surface where one ends and the other begins.

The trap rocks too, which on the Palisade range and the ranges west of Newark, are everywhere worn and scratched on their upper surfaces, are in Rocky Hill, Sourland Mountain, and the south end of the ranges west of Newark, entirely free from such marks of wear, and the soil on them is only the remains of the disintegrated trap rock.

As the marl and tertiary deposits further south are earth and not rock, the worn surfaces would not expected; but the soils on them are the same as the deposits themselves. To this may be excepted the superficial differences produced by rains, weather and other atmospheric agencies, and older diluvial deposits.

The influence which this peculiar distribution of the glacial drift has upon the State is both interesting and important. It is seen in the differences of surface, in the collection of water in ponds and lakes, in the size of farms, in the different objects of profitable farming, and in the distribution of mixed industries. The rolling ground and rounded hillocks which form so characteristic a feature of the drift region are unknown in the country further south. Ponds and lakes so common in all northern countries are not found where glacial drift does not exist. They

occupy the basins between the hillocks which have been formed by heaps of stone and earth which have been dropped pell mell from the ends, or sides or crevices of the glaciers. Such basins are found everywhere in the glacial drift area, and can be numbered by hundreds. Some are found which are too open in the bottom to hold water, but most are filled and form beautiful lakes and ponds.

The more even and uniform surface south of the drift area enables farmers to work with less of broken and waste ground and fewer irregular fields, so that tillage is carried on more rapidly and cheaply, and more of farm crops can be got from a given area. On the contrary, grass and grazing are best adapted to the drift soils, and the mixed industries of mechanics, manufacturers, &c., have been more generally engaged in on them than on other soils.

The map at the beginning of this report shows the extent of the glacial drift in New Jersey. To give the details of its distribution the location and shape of its numerous hillocks, ridges and basins, requires much further study and the construction of full and accurate topographical maps. It is hoped that another year will enable us to show some completed work in this interesting department of geology.

The beds of stratified drift, at various places in the valley of the Delaware, south of the line of glacial drift, bear marks of having originated from the action of water. The boulders and cobble stones are all water worn, and round, and are not scratched or streaked. They have all come from places farther north in the valley and have been moved and deposited by powerful currents. There are to be seen in the railroad cuts near Trenton, where the exposure of this kind of drift is very fine, boulders of gneiss, from the rock near; of red sandstone from the country just north; of trap from Lambertville; of altered shales from near the trap; of conglomerate from New Milford; of magnesian limestone from the valleys of Warren county; of conglomerates from the Blue Mountain, and of cherty and fossiliferous limestones from the Delaware valley north of the Water Gap. The gravel consists largely of quartz but it contains numerous fragments of red shale, and black slate.

In the edge of the bank of this bed of gravel and boulders, a mile or two below Trenton, Dr. C. C. Abbott has found rude

stone implements of a very ancient date. He has published an account of them, and is disposed to assign them to an age older than the glacial drift. The circumstances in which they are found on the edge of a gravel bank, where they might have fallen down from the top or near it, precludes that positive proof of their true position and age, which is needed before coming to a satisfactory conclusion.

It is very desirable that the subject to which Dr. Abbott has given so much time and attention, should be more thoroughly illustrated by specimens collected from all places where the Indians or other early inhabitants, have deposited them, and also that careful note should be made of the locations where found, the depth beneath the surface, the material in which they are buried, and all particulars which may help to a full understanding of them.

3. EXAMINATION OF THE DEPOSITS OF SHELL MARL IN SUSSEX AND WARREN COUNTIES.

Shell marl, or as it is sometimes termed "white marl," occurs at a large number of localities in Sussex and Warren counties. The deposits of this marl belong to the most recent of the geological formations, and some of them have been formed during the historic period. Consequently the deposits are found resting upon the most recent clays, gravels and sands of the modified drift. In fact nearly all of the localities are in marshes, or in and around ponds which are in these stratified drift beds. This is especially true of the numerous deposits between Newton and Hope along the valleys and waters of the Paulins Kill and Pequest and their tributaries. Generally, this marl occurs in limestone districts, but there are exceptional localities, as that of Roe pond, on Pochuck Mountain, and that on the Williams farm, south of Vernon, in Sussex county. Lime, or calcareous matter, may have been a favoring condition, and essential, but not necessarily so the limestone rock. Other rocks may have furnished a sufficient quantity of this element to the waters in which the fresh water mollusca lived and whose shells yielded the material for the marl.

All the deposits are in basins or small valleys, which were at first filled with water, or sufficiently wet to sustain these forms

of life. It seems probable that at first these were more open at the bottom and dry, though without any natural outlet. In the course of ages the wash from the slopes about them lined them with a clayey sheet, or puddling, which afterwards held the water. In this manner large and small sink holes gradually became pond holes and little pond basins, and these latter became the abodes of the several kinds of mollusca, whose remains make up the marl. The most common of these were the Limnea valvata, Planorbis and Cyclas. These lived in the shallow waters around the shores of these ponds. The succession of life left a multitude of little shells, which, through the action of waves and other accidents, were ground to pieces and formed the white, pulverulent, chalk-like mass. The marl, by the slow but steady accumulation of centuries, rose and extended itself until in some places the whole pond or basin was filled and there was no space left for the waters, or only for the drainage in very wet seasons. Following this filling in process, came the growth of grasses and plants suited to such wet grounds. These, by their decay, formed the peaty earth or muck so constantly found over these marl deposits, or around the borders of the ponds. And we now find every stage of the process going on, from the wet basin with these living shells and very little accumulation of calcareous matter, to deposits which are now dry during the greater part of the year and in which no living animals can be found and comparatively few well preserved shells. They are extinct in such localities and the work of accumulation is at an end. In still others the pond remains, but encircled by a bed of marl whose area greatly exceeds that of the water, and which occupies the site of the old pond. Such seems to be the order of progression and the origin of these deposits.

From the list given below, it will be observed that they are numerous in the valley of the Delaware, west of the Blue mountain, but mainly confined to a small part of Montague and to Sandyston townships. In the Kittatinny valley they are numerous along the Pequest and Paulinskill, particularly in the southeastern part of that valley, between Newton and Hope. In Green township, Sussex county, nearly every little basin is partly filled by this marl, and it is in most of the ponds. But it is not at all likely that these localities are all which can be found. Explorations will doubtless discover very many additional de-

posits about the many little ponds and lakes, and in the numerous peat bogs of that valley.

It will be observed that these deposits are all north of the limit of the moraine drift. This is to be expected. In a country perfectly drained, with no lakes, ponds or pond holes, these accumulations could not take place. Hence they are not to be sought for south of that line.

The composition of some of the best specimens, and such as represent large bodies of the marl, appear in the following partial analyses.

	Carbonate of Lime.	Carbonate of Magnesia.	Sand and Clay.	Water, Vegetable Matter, &c.	DESCRIPTION.	OWNER AND LOCATION.
1	98.33	.....	0.90	0.67	White, pulverulent; no vegetable matter.	Job J. Decker, Andover, Sussex county.
2	88.96	.....	9.98	2.16	Precipitate from water, white.	Benjamin Van Syckle, Peters Valley, Sussex county.
3	97.79	.....	0.60	1.59	White, dense and fine.	Abm. M. Cooke, Shiloh, Warren county.
4	95.34	2.18	.98	1.50	Surface marl, white, solid and fine.	Abm. M. Cooke, Shiloh, Warren county.
5	96.32	1.57	1.16	.90	Drab-white, fine and with shells.	Daniel M. Howell, Hunts Mill, Sussex county.
6	92.25	2.98	1.56	3.21	White, pure, some grass roots.	White pond, Marksboro, Warren county.
7	89.87	2.29	.97	6.87	Ash-colored, many shells, light.	Henry S. Cook, Hope, Warren county.
8	96.54	1.47	2.05	0.00	White, very fine, medium density.	Martin Drake, Newton, Sussex county.
9	84.52	1.76	8.46	5.26	Surface marl.	Martin Drake, Newton, Sussex county.
10	90.18	0.00	9.75	.....	White, very dense, thick shells.	Sink pond, near Lincoln, in Warren county.
11	99.04	0.00	.55	0.41	White, very light, pure.	Jacob Voss, near Lincoln, in Warren county.
12	68.73	0.00	23.99	7.28	Dark-colored shells and vegetable matter.	Isaac Bonnell, Montague, Sussex county.
13	94.75	0.00	.71	4.54	White, very light, pure.	White pond, Monroe Corners, Sussex county.
14	64.20	0.00	16.21	16.59	White shells and clay.	Francis Layton, Centreville, Sussex county.

These marls were tested for phosphoric acid, but not enough was found to weigh. Two specimens were analyzed for ammonia; one, which was a white one, in which none could be found, the other was No. 12, which contained only 15–100 of one per cent.

Shell marl has been found in the following places in Sussex and Warren counties:

1. Roe Pond. This deposit of shell marl is in Vernon township, Sussex county, and three-fourths of a mile south of North Vernon, or Glenwood P. O. The pond has an area of about 15 acres. The marl is found on all the shore line and is covered by a layer of

black muck one to two feet thick. By opening the gates in the dam at the outlet the water can be lowered and the marl easily reached. Some of it has been dug at the north end of the pond and used by J. S. Carpender. The *Parnassia Caroliniensis* was observed here growing in the marly soil.

2. Williams Farm, 4 miles south of Vernon, Vernon township, Sussex county. The extent of this deposit was not learned. The marl has not been dug, excepting as cut in ditching the meadow. The locality is quite exceptional, being in a gneiss rock district.

3. Black Creek Meadows, Vernon township, Sussex county.

4. Meadows east of North Church, Hardiston township, Sussex county.

5. Fowler Estate Farm and Mud Pond, Hardiston township, Sussex county.

6. Lane's Pond, Sparta township, Sussex county. The shells are seen about the shores of this pond, but no marl of any extent. It may be found deeper, or this may be a locality where the formation has just begun.

7. White Pond, Germany Flats, Sparta township, Sussex county. Marl occurs on the shores of this sheet of water and under much of the southern end of the pond. The area of the pond and marl shores is about 40 acres. The outlet is connected with Mud Pond and that with Lane's Pond. On account of the marl being mostly below the level of the water it is very wet and not so easily taken out, excepting in a very dry time.

8. Drake's Pond, near Newton, Sussex county. The pond in and around which this marl deposit occurs, has an area of 7 or 8 acres. It is in the magnesian limestone rocks. The maximum depth of the pond is 36 feet. The thickness of the marl is not known. It is, however, of workable extent and the outlet could be easily lowered 10 or 12 feet, so as to drain off much of the water and leave the shores dry. As it is only a few rods from the Sussex railroad, this marl locality has advantages of accessibility.

9. White or Davis Pond. Shell marl occurs in the meadows around and in White pond, near the Newton and Andover road and two miles north of Andover. The deposit is in a blue, magnesian limestone belt. It has an area of several acres. It is

very wet meadow, and drainage is not easily effected. The thickness of the marl was not ascertained.

10. DECKER'S POND.—This locality is one mile southwest of Andover, Sussex county. There is about ten acres of meadow south of the pond, in addition to the latter, in all of which the marl occurs. In the meadow it forms the surface over a considerable area. On the sides of the deposit there is some muck covering it. Some borings, made quite recently, found a thickness of twenty feet. This deposit is large and accessible at all seasons, although at times it is wet, and the drainage cannot be easily improved. Limestone rocks bound this deposit on the west; on the east there are gneiss and white limestone.

11. WILLIAM WOLF'S FARM, TROUT BROOK, Green township, Sussex county. Locality unexplored.

12. J. COLLINS DRAKE'S FARM, SOUTH OF REDING'S POND, Green township, Sussex county. The marl at this place is so deeply covered by muck that its extent has not been ascertained. There are several acres of the wet basin, all of which may be underlaid by it.

13. JOHN H. AYRES' MEADOWS, near Lincoln, Green township, Sussex county. This meadow occupies the site of an old pond. The marl is covered by muck to the depth of one to two feet. There are several acres in this meadow tract.

14. JACOB VASS' FARM, LONG POND, three-eighths of a mile south southeast of Lincoln, and near the county line. There is no visible outlet to this little basin. It dries up in hot, summer weather. The muck covering is one to two feet thick. There may be three acres of marl here.

15. SINK POND. This marl basin is near the line of Warren county, and southeast of Lincoln, Green township, Sussex county. It has no outlet. In the summer it dries up. The area is between five and seven acres. At the top there is black muck and loam 1 to 2 feet thick. Blue, magnesian limestone rocks crop out on all sides.

16. HAZEN'S POND, Frelinghuysen township, Warren county. Marl is reported as occurring in and about the shore of this pond, but deep under the water and muck. There is no known outlet to the pond and the shores are very wet and swampy.

17. COOK POND, northeast of Johnsonsburg, Warren county. This marl deposit is in a narrow and long valley one mile north-

east of Johnsonsburg, Warren county. The length of this deposit is nearly one mile, while its breadth does not exceed an eighth of a mile. The marl occurs in the meadow and also in the pond at the head of the narrow valley. It is covered by black muck and lies upon the gravelly beds of drift. On the northwest blue limestone outcrops line the border of this meadow. The thickness of the deposit of marl is not known. As the meadow is wet and swampy in part, the extraction of the marl is not altogether easy.

18. GLOVER'S POND. This pond is one mile south of Johnsonsburg, in Frelinghuysen township, Warren county. It is in a blue limestone district. It covers an area of 50 acres. The marl is seen on the shores and under the shallow waters near the shores. Its thickness is not known. Much of it is not accessible, unless the water be allowed to run out, by deepening the outlet, or by draining it into Bear Creek on the northeast.

19. LONG POND, of L. J. Howell and A. M. Cooke, northeast of Hope, Frelinghuysen township, Warren county. This little pond basin is another of those having no visible outlet and becoming dry in the late summer. Its area is not over three acres. A spit of muck is found covering the marl. This deposit is thick, and is easily worked in dry weather.

20. GEO. H. BEATTY'S MEADOWS, west of Hope, Warren county. A large area of meadow land near the village of Hope, and is said to be underlaid by marl.

21. RICE POND OR REID POND MARL. This little pond is 2½ miles north of Hope. Slate Hills bound it on the northwest and blue limestone ledges on the southeast. Its area is 3 or 4 acres, with a narrow fringe of marsh. The depth of the marl was not learned.

22. GEO. CARTER'S FARM, south of Blairstown, Blairstown township, Warren county. Here marl occurs near the surface and is cut in ditching. There are several acres of meadow, but how much is underlaid by marl is not known. The drainage is northward into the Paulinskill.

23. WHITE POND. One mile north of Marksboro, in Hardwick township, Warren county, is the celebrated White Pond, so named from its shores of white marl. Its area is estimated at 100 acres. Its outlet is southward into the Paulinskill. The marl occurs more or less all around on the shores, and on the southeast is at

least 100 yards wide outside of the water line. Its extent in the pond is not known. It has been found 10 feet thick, but is probably much thicker in the pond. There is here a large body of marl which is dry and workable for most of the year. By lowering the outlet it might be possible to increase the extent of marl accessible at all times.

24. Catfish Pond, near Stillwater, Sussex county. Another pond without outlet, and drying up in summer. Its area is about five acres. The depth of the marl is unknown.

25. Grass Pond. This locality is in Green township, Sussex county, one mile south of Hunt's mills. The water dries up in the summer, hence the name of Grass Pond. Its area is said to be thirty to forty acres, and the marl is covered by black muck, excepting the central portion. Some digging has found a thickness of at least five feet.

26. Isaac Bonnell's Farm, Montague township, Sussex county. This marl is in a meadow along Chamber's mill brook. It covers an area of seventy-five to one hundred acres. Borings made years ago found it to be fifteen feet thick. It is covered by the soil and muck, about two feet thick. The surface marl is somewhat mixed with the muck. This locality has been worked, and the marl from it has done good.

27. Isaac Cole's Farm, southeast of Brick House, Montague township, Sussex county. The marl occurs in a meadow near the Milford and Hainesville road, and is said to have an area of fifty acres.

28. James Bevans' Farm, north of Hainesville, Sandiston township, Sussex county. Extent unknown. In a meadow.

29. Francis Layton's Farm, west of Centreville, Sandiston township, Sussex county. This deposit is in a basin between the limestone and the Cauda Galli grit rocks, and has an area of ten or twelve acres. It is now wet meadow, and the outlet brook from it flows southeast to Centreville. The ditches show a covering of black muck, one to two feet thick. Its thickness is estimated at ten feet in the deeper portions. The outlet could be lowered by slight cutting and the deposit be dried, so as to be accessible at all times of the year.

30. James C. Bevans' Meadows, near Dingman's ferry, Sussex county. This deposit has an area of seven to eight acres, and lies in a hollow between the Corniferous limestone and the

Cauda galli grit. The overlying muck is said to be one to two feet thick, and the marl may be three or four feet. At present this deposit is very wet meadow. The lowering of the outlet brook, which runs southeast to Peters' Valley, would drain it effectually, and make the marl easy to be got at all the year.

Shell marls have not found any considerable use or favor among the farmers in Sussex and Warren where they are most common. Some farmers use them and say that they are very beneficial to growing crops. Others have not been able to satisfy themselves that the marls are of much, if any, benefit. In foreign countries wherever an improved agriculture prevails they are highly esteemed, and are largely used. There can scarcely be a doubt that like results would follow their general and judicious use here.

Their readiest use would be on pastures; applied in the autumn, or when the marl is so dry as to spread very finely. A dressing of 5 to 15 loads an acre is safe, and is sufficient. It may be put upon wheat ground, and thoroughly worked up with the soil, where it will be found to increase the crop, and will also promote the after growth of clover. It is much to be hoped that farmers will give it a more careful trial before giving up that it is useless. There is so much of it, that if it could be successfully used it would be a great saving to the many farmers who need more manure on their farms, and who have an abundance of shell marl within convenient distances. It cannot but be valuable for it has in it the same constituents that are in leached wood ashes, principally carbonate of lime, and there is no land I think upon which the ashes are not useful. They sell readily at from 10 to 20 cents a bushels. The shell marl can be got for very much less than half that price.

There is an inquiry for such shell marls among those who propose to manufacture Portland cement. This cement is an artificial composition made by mixing together clay and fine limestone, burning and grinding them. It is much more highly valued by engineers than the common hydraulic cements, which are made from natural stone burned and ground. The uses of these cements are very large, and important. Attempts have heretofore been made to establish this manufacture in the neighborhood of New York, but they were unsuccessful. Other enter-

prises of the same kind are in contemplation, and must finally succeed. These marls are almost absolutely pure carbonate of lime; they need no grinding, being already nearly as fine as flour, and they are so near New York that they can be delivered there at the very lowest paying rates.

4. THE CONTINUATION OF THE UNITED STATES COAST SURVEY TRIANGULATION OF THE STATE.

This work which is the necessary basis of all our accurate Geographical and Topographical Maps has been continued through this year. The United States Coast Survey had many years ago located and measured a chain of primary triangles, across the middle of the State, and parallel to the sea coast, from New York to Pennsylvania. It had also extended a series of tertiary triangles along the country bordering on the waters of the Atlantic, the whole length of New Jersey, and up Delaware bay and river, above Trenton; and up Hudson river above the State line. Within a few years past, the law of the United States has allowed the officers of the Coast Survey to aid States which are conducting Geological or Topographical Surveys, by ascertaining for them the latitudes and longitudes of fixed points proper to be used for locating accurately on maps, the geography and topography of the country.

In accordance with this authority, the Coast Survey determined for us the latitudes and longitudes of the established ends of the boundary between New Jersey and New York, and computed the bearing of the straight line between them. In 1875 and 1876 the seasons were spent in selecting points suitable for another chain of primary triangles across the State. The country embracing the series of mountain ridges, which cross the State from northeast to southwest, in the counties of Bergen, Passaic, Sussex, Morris, Somerset, Hunterdon and Warren, was chosen in which to begin the work. The system of triangles at present begun, contains twelve primary stations, with sides varying from eleven to twenty-eight miles long. They are well shaped, and several of them join to form quadrilaterals. Two of these have been occupied the past season; one is now completed, and the other is nearly done. Two stations of the old series, Mt. Rose and Newtown, have also been occupied for determining the new

stations and connecting them to the former Coast Survey work. Observations have also been made upon twenty-three tertiary points from the stations occupied.

From the nature of this work it proceeds with extreme slowness, as compared with ordinary surveying, but it is the best method known for getting accurate work done; such as is found necessary in all thickly settled countries. The results are needed in our State now, and they cannot be got too soon, for our topographical work is going forward.

The stations occupied are Goat Hill and Pickels mountain, in Hunterdon county, and the tertiary points are nearly all in the same county.

5. TOPOGRAPHICAL SURVEY.

Topographical maps, showing the outlines and inequalities of the surface, are absolutely essential to the proper explanation and exhibition of our geological work. They also find important uses in plans for drainage, for water supply, for locating roads and railroads, for making studies for rural improvements, &c., &c.

The map of the Middlesex county clay district, which has on it lines indicating the elevations of the surface, as well as the location of the different clay beds, has found important and acceptable uses. It has been used to locate new openings for clay and found accurate, it has been used in court for ascertaining the prospective value of clay lands, it is referred to as authority on questions about artesian wells, and it has furnished clear and satisfactory information on questions of water supply.

The map prepared last year to show the basin and water shed of the upper Passaic and its various branches, has been much sought after, and the edition printed was exhausted long ago. By the color and figures marking elevations, it conveyed information not accessible to most people in any other way. The usefulness of this map for so many purposes of public interest, as well as for the direct question of water supply, for which it was made, has induced us to begin the preparation of a topographical map of the country between First mountain and the Hudson river. The projection is prepared on a scale of three inches to a mile, and the tertiary points, of which the latitude and longitude is known, have been determined by the United States Coast

Survey. The territory, embraced in the map which is in progress, is bounded on the north by an east and west line, drawn through the northerly curve of the Passaic north of Paterson; on the east by the Hudson, New York bay and Staten Island sound; on the south by Raritan river, and west by First mountain. This comprises an area of 408 square miles, and is the home of 456,000 people, nearly half the population of the State, and is growing in population and wealth faster than any other part of the State. Much of the material for the location of roads and streams is already in existence. The main work required was in obtaining the heights of ridges, valleys, road crossings, &c., and in delineating correctly the outline of hills, slopes and other objects, which give variety to the surface.

The surveys have been in progress during a part of the summer, and the field work for the northern third of the map is done. The work is now going on, with the expectation that before the cold weather drives the surveyors from the field, all that portion from the northern end south, and including Newark and Orange, will be ready to put on the map.

6. DRAINAGE OF THE GREAT MEADOWS ON THE PEQUEST.

This work comes under the direction of the Board of Managers by the provisions of the law to provide for the drainage of lands. By this law the Board is authorized to prepare plans of drainage for tracts of wet land under specified conditions. The plans for the drainage of the Great Meadows were prepared by the Board in 1871, and commissioners to execute the plans were appointed by the Supreme Court in 1872. The work, however, was not fairly begun until 1874, and its progress has been somewhat delayed by difficulties incident to a large work of an unusual kind, and to the financial embarrassments of the times. It is now well advanced, and its good effects are already realized on the end of the tract nearest the outlet. All the obstructions in the Pequest from Larason's bridge, at the lower end of the meadows, down to Danville bridge, have been taken out. The reefs of tough clay and stones have been cut down so as to drop the bed of the stream five and a half feet at the former bridge, and to bring the channel to a uniform grade of descent of one foot per mile and to a full width of thirty feet. The water flows

through it with a strong and steady current of more than a hundred feet per minute, and all our recent freshets have not been sufficient to make the stream overflow its banks.

The channel of the Pequest in the meadows has been dredged out to the same grade and the same width as the outlet, from Larason's bridge up stream two miles and twenty-five chains. The channel of Hoagland's Mill brook is deepened and cleared in good condition from its junction with the Pequest, near Larason's bridge, up to Roe's island road, one mile and a quarter. The work of opening and clearing the channel of Schmuck's Mill brook has been carried along from its mouth at the Pequest river thirty-five chains, and is now in progress. The work of clearing the channel of Stinson's Mill brook has just been let out to a contractor. The outlet to Cummins's meadow ditch and the brook crossing the road to Post's island, is ready to be let out to contractors. These streams are all that cross the meadows and empty into the Pequest between Larason's bridge and the mouth of Bear creek.

The plan of drainage in the hands of the Commissioners requires for its completion the clearing of the channel of the Pequest to Long Bridge, and the bringing it to a uniform grade of descent. And the channel of Bear creek will need some clearing also.

The dredge will be taken out of the Pequest now, and all minor obstructions removed, so that the stream may have free flow, and the force of the current exert its scouring action upon the bottom and sides of the channel during the winter and spring freshets. It will be a matter of much interest to know whether the force of the water with the increased current will cut away the bottom of the channel, in that part of the stream immediately above where the dredging has just been stopped.

It was calculated that with a fall of one foot per mile, the current of the Pequest would be a foot and a half per second. By trials now, when the stream is little swollen, it is found to be over 150 feet a minute—several tests made showing 100 feet in 30, 33, 35, 37, 40 and 43 seconds respectively. This is much above what was calculated for.

The fall in Hoagland's mill brook is 8 feet per mile, and the current in it is rapid and proves to be ample for quickly carrying off all the water in times of heavy rain.

The fall in Schmuck's mill brook as improved is 10 feet for the lower mile next Pequest river, and 7 feet per mile for the second and upper mile.

The Stinsons' mill brook has a fall of 12 feet per mile.

The meadow ditch and brook on the southeast side of Post's Island will have a fall but little less than that from Schmuck's mill, *i. e.* 6 or 7 feet per mile. These are all obtained by the present improvement which lowers the Pequest five feet or more under its former surface level, and so enables these branches to discharge their water at the low or improved level.

For clearing out the Pequest up to Long Bridge, the Commissioners propose to have the dredging begin at the upper end and work down, so as to have the deepened channel in which to float the dredge. This would save the necessity for dams in the channel, which are needed when the dredge works up the stream, as in the latter case it drains the water away from itself.

The work is going on to completion, and as far as there has been opportunity to see its effects, it is a complete success. The streams from the mountains on both sides, which were formerly almost lost in the spongy earth of the meadows, are now being opened out to the Pequest, and as far as they have proceeded they carry the water without any overflow. The meadows, which were formerly overflowed for a large part of the year, are dry.

The Commissioners of the Pequest drainage, are Amos Hoagland, of Townsbury; James Boyd, of Vienna; and William L. Johnson, of Hackettstown; and their engineer is A. R. Day, of Hackettstown. They are making every effort to carry the work through to a successful completion. For their enthusiastic interest in their work, as well as for the patience and perseverance they show, in meeting and overcoming its difficulties as they arise, they merit the highest praise.

Improvements of this kind are so uncommon in our country, that their value to agriculture, their sanitary benefits, and their influence on the reputation and attractiveness of all the surrounding country are not appreciated or even understood. Distrust, discouragement, and even active opposition are shown to them by the very persons to whom, with good management, they will become a mine of wealth. And they scarcely receive from the public authorities that encouragement to which, as great economic and sanitary benefits, they are so richly entitled. This

comes, of course, from not having any visible exhibition of the effects of such drainage, and will all be corrected as the results of experience are known and seen. It is demonstrated by the results in the present case, that the cleared Pequest does carry off the water with the rapidity calculated for at the planning of the work, and that there is no accumulation of flood water in the meadows, as far up as the clearing extends. It is also demonstrated that the small streams which formerly discharged their flood waters upon the meadows and submerged them, do now, as they are cleared, carry the water in their channels without overflow, and empty it into the Pequest. And it is demonstrated this year, by the work of farmers on the lands drained, that where they were cleared before, good crops can be safely and profitably cultivated the first year; and that where the ground has never been cleared, it can now be worked on steadily without any loss of time or threat of injury from standing water or sudden floods.

For particulars in regard to the Great Meadows and its former and present condition, reference may be made to the statements farther on in this report; and for other examples of drained lands and their value, reference is made to the meadows at Oxford Furnace, or to the banked meadows of Salem and Cumberland counties, in New Jersey, any of which can be shown to be easier cultivated, to cost less for manures, and to yield larger profitable returns, than the best of our uplands. In foreign countries the polders of Holland and the fen-lands of England, all of which are lands reclaimed from the water, are universally regarded as the model lands for agricultural productiveness and clear profit.

The subject is one of so much present and future importance that it is thought best to give some particulars in regard to agricultural and sanitary drainage in foreign countries and in our own.

Drainage has been practiced longest and most extensively in Holland, and what is demonstrated by the Dutchmen there is well stated in Mr. Waring's book entitled a "Farmer's Vacation," written from notes made there in 1873. Of the difference between the undrained German province of East Friesland and the drained Dutch province of Groningen, as he passed from one country into the other, he says: "Instantly the aspect of the country

changed, and we recognized the presence of the transforming hand of the Dutch Wizard of Drainage.

"In East Friesland the ditches had been nearly full to the brink, vegetation showed the ill effect of a wet soil, and there was a general air of swamp and fog over the land and its people. Here, the water was three or four feet below the surface, the land was dry, the growth was magnificent, and, though the country was flat as the sea, there was no suspicion of wetness anywhere. The few people we met were hardy and red-cheeked. The farm houses and barns grew larger and hay and grain ricks multiplied. Perhaps nowhere else in the world is such a sudden change of condition, due entirely to art, to be seen in a country of precisely the same original character."

He also says: "Although Holland took its first impetus from commerce, this has sadly fallen away, and now agriculture has on all sides filled and overflowed the gap. The reclaiming of the overflowed lands and ancient harbors has given them another and firmer hold upon prosperity, a prosperity, too, which is much more general in its influence, reaching all classes of the community to a degree unknown during the old commercial days. * * * The Netherlands have gone silently and quietly forward, until they have become one of the most advanced agricultural nations of Europe, exporting more of the products of the soil than any other, * * * and their wealth accumulates to a much greater degree than with any other agricultural people."

So profitable has ditching and draining of wet grounds and lakes been found, that they are just now beginning to bank in a lake of 480,000 acres, so that they may pump out the water which is eleven feet deep, and make the bottom into farms.

But it is not necessary to go out of our own State, or even out of Warren county and the valley of the Pequest, to show that drainage of this kind is an achieved benefit. At Oxford Furnace, in the valley of the Pequest, there is a large tract of land, formerly marsh or swamp and liable to overflow, which has been drained and reclaimed, and is now in profitable cultivation. An account of this improvement and its results, prepared for this report by Mr. Charles Scranton, of Oxford, is here given. He says:

"I will briefly answer the most important of the questions

asked relative to the operations of draining the meadows at Oxford, among which are the following:

"1st. Where and how large was the tract reclaimed?

"2d. What was its condition when the work was begun?

"3d. What streams, main ditches and side ditches have been opened or deepened to effect the drainage?

"4th. What is the present condition of the tract? What crops are raised on it, and are they as good as on upland?

"5th. Does it cost as much for manuring and tillage as an equal area of upland?

"6th. Can you estimate approximately the cost of reclaiming this land?

"7th. Has the drainage had any effect on the salubrity of the tract? Are fogs any less common than before the drainage was done?

"This tract of land comprises about four hundred and twenty acres of land, subject to overflow at every heavy rainfall, and is located in the eastern part of Oxford township, Warren county, and has on its edges or surroundings somewhat over a hundred acres more of sour land. It was in 1857 bog meadows and low swamp timber land, the timber being chiefly soft maple and birch. The Furnace brook passing through it on its winding course to the Pequest river, with the large number of rivulets and springs, kept the whole tract soft, spongy or wet, for the greater portion of the year, so that the timber could not be cut and brought to the shore, and the pasture was of very little value except for a few weeks in the dryest part of the summer. A small portion of the parts lying near the uplands, was generally mown for hay, of which it yielded a poor quality.

"In the year 1858, I dug a canal, following straight courses eighteen feet wide, and six feet deep, for the distance of about one and three-fourths of a mile, with four main ditches, generally about five feet wide at the top, one and a half feet wide at the bottom, and from four to five feet deep. The upper three-fourths of a mile has a fall of about nine feet, and the lower mile has a fall of about six feet. The canal has been self-enlarged by the freshets since occurring, so that it is now about twenty feet wide at the top, and seven feet deep, and carries all the water of an ordinary freshet. The timber has been cut off, the stumps have been pulled out and burned, and the bogs were cut off, piled in

heaps, and burned, the ashes, in each case, spread over the land, and about one-third of the whole tract has been limed.

"The crops raised are principally corn and hay. Very little manure has been applied to any portion of the tract, as so far it has not seemed to require it. Corn has been planted on the same ground for three and four years in succession, when it would become too weedy, and would then be sown with timothy seed, to mow for hay for three or four years, always affording a fine fall pasture. The present condition of the tract is incomparably better than it was ten years since, and the crops, corn and hay, and the pasturage, superior to any upland that I know of in this State. The hay crop is best where the largest alluvial deposit has been left by the overflowing of the meadows, while very little difference is observed on the corn crops. Sixty acres were planted with corn the present year, and from one acre, covering a part of each kind of soil, was the following yield in ears, viz.:

"184 bushels sound corn.

"8 bushels soft corn.

"Total 192 bushels, or an equivalent of about 104 bushels of shelled corn per acre, 56 pounds to the bushel. The acre was at the suggestion of Mr. Hendershot, (who farms for Mr. S. T. Scranton), carefully measured by Messrs. Wm. H. Scranton and Warren Ward, and contained 4,096 hills of corn, averaging 3.28 feet apart in each direction.

"After this kind of land has been once thoroughly got under cultivation, I think it safe to say that an acre of it is more easily plowed or farmed than an acre of ordinary upland. I will omit the cost, or approximate cost of reclaiming this land further than to say, that the original cost of the canal and main ditches referred to was about five thousand dollars, or say, twelve dollars per acre.

"I do not notice any particular visible effect on the salubrity of the tract by reason of the drainage. The families living near have been unusually healthy the past few years, while those living at an altitude of from one to two hundred feet higher have suffered from fevers, diptheria, etc. I might have remarked that the families living near the outlet some twenty years ago were subject to fever and ague, but it has scarcely been known

in that vicinity since the stagnant water has been carried off by the canal.

"The wheat and oats raised on this tract has only been in small areas. The soil being black and rich, would produce a straw too rank and weak to well support itself. This will be probably overcome in future years by the application of lime and manure, and so the soil may become less rich. Lime is not particularly needed for the crops of corn and hay, though I have no doubt but each of these crops would be benefited by the use of lime on these lands in a greater degree than are the same crops grown on uplands. In conclusion, I may say, that I believe the results shown in the drainage of these lands, practically demonstrate the value of drainage of similar and larger tracts of the same kinds of land in New Jersey, and that the time is not far distant when it will be seen that for certain kinds of crops such lands are vastly superior to any others in the State, for the reasons that they will produce more with less cost for manures, as they have, under proper management, a soil practically inexhaustible in fertility."

The following statement of the past and present condition of the Great Meadows has been prepared by A. R. Day, C. E., of Warren county, who has known about them all his life, and is thoroughly conversant with the progress of the present improvement from its beginning up to this time.

"I have given all the attention in my power, so as to answer your inquiries respecting the Great Meadows, which I do *seriatim.*

" 1st. 'In regard to the early condition of the Great Meadows'.

"Since my earliest recollection this territory has been known as one vast swamp, much of it inaccessible to man or beast on account of water and sink holes, and in which numbers of cattle were annually lost by miring, in the earlier season and immediately after rains. There were some shallow ponds, or reservoirs of water, scattered over it; one of some size, known as the Goose pond, and as a water fowl resort and hatching ground during the summer. There being no outlet sufficiently low to carry off the spring or storm freshets, the whole territory of six thousand acres remained thoroughly permeated with water, thrown over it from the narrow and shallow channel of the Pequest river, through the whole length of the meadows, and the larger tributaries from the Johnsonburg mill stream, and the Hunt's mill

branch or Bear creek, from the Allamuchy mill stream, the Smoke's mill brook, the Stinson saw mill brook and the stream known as the Hoagland mill brook. These tributaries being all mountain streams in their source, rapidly threw upon the meadows after every rain-fall a large quantity of water, to remain in diffusion or overflow summer and winter; thus producing a most detrimental effect upon the health of the region, through which prevailed chills and fevers when prevalent nowhere else, thus leaving no doubt as to the *local* cause. No agricultural operations whatever were possible, even mowing small lots of grass upon the edges of the meadows being in some seasons interfered with.

2d. " 'The injurious effects of dams and fish weirs.'

" The want of a natural outlet for the Pequest, at the lower end of the meadows, was greatly aggravated by the erection of a three foot dam, one mile below the meadows and above Vienna, and the evils of this were increased greatly by several fish dams above the mill dam mentioned, all which retarded the current, choked up the stream, and constituted reservoirs for floating stumps, logs, brush and sedimentary deposits from the swamp above. But all these were only minor aggravations of the main and great evil—the want of a natural outlet and channel at the lower end of the meadows.

3d. " 'The former attempts to drain these meadows.'

" Of these, all were but local and partial; most of them merely private efforts, contemplating no general benefits, and little or no concert of action. There are on the statute books two different special acts, authorizing the drainage of these meadows, under which nothing effective was done. The Rutherfurd family, who owned and still own large tracts of these meadows in the Allamuchy district above Long Bridge, made some early efforts for drainage. In the Bear creek and Pine Run district still more extensive efforts, leading to some legal measures and resulting lawsuits, to drain have been made, dating back some seventy or eighty years ago, which appears to have been an energetic and determined effort. The natural outlet of Pine run into Bear creek, to the north of the old Warbasse property, was discarded, and a *wholly new artificial* outlet, much of it through dry and hard land, was made, to a point of discharge about half a mile farther down Bear creek. This was done to increase the fall,

but it is still insufficient to effect the drainage, and the water still stands all summer in the swamps along Pine run, in what is now spoken of as the "Harris district." This must always be the case till Bear creek outlet and channel are both widened and deepened.

"About sixty years ago, two enterprising gentlemen (one of them from Princeton, N. J.,) by the name of Addis and Wadsworth, attempted the drainage of the east side of the meadows, and constructed for Smoke's mill brook what they called the 'Main ditch,' over two miles long, and discharging into Pequest, north of what is now known as Post's island. This, too, after a few years, was neglected, giving no results equivalent to the expense; neither current nor discharge being possible, so as to relieve the great body of water to be provided for, which only can be secured by lowering and widening the channel of the Pequest.

"The late Christian Cummins, Esq., one of the most energetic and resolute of the property owners along the Great Meadows for half a century, also engaged in quite expensive operations for drainage, and made a ditch through his extensive property, long enough and large enough to be a reservoir of itself to hold the water ordinarily. But it was too level, no flow or outlet, and at this day is but a monument of the uselessness of attempted drainage *without* an outlet.

"The district fronting the Presbyterian Church at Danville, being the lower end of the Great Meadows, and often covered with water up to a stone's throw of the church steps, presented so hopeless a case that but little was ever attempted except a few short shore drains.

"The district on the northwest side of the Meadows, above and below Stinson's sawmill, is quite often covered with water except during the latter part of summer. But here are several old extensive ditches, which do not seem to have effected much, for the bogs are as large as a barrel, and sour, wet land, still close right on to the rocky hard-pan soil which skirts this shore of the Great Meadows. Considerable of this portion of the meadows is now held by the Crane Iron Company, the Scranton iron interests, the Philadelphia Marble Quarry Association and others, who have purchased the farms adjoining for their mineral products. They

are utterly unmanageable for any agricultural purpose in their present situation.

"The most extensive, intelligent and persistent effort ever made for drainage of the Great Meadows was made about twenty years since by Dr. J. Marshall Paul of Belvidere. Like his predecessors, he at first confined his plans to local ditches, but following the results of experience, he at last recognized the fact that he had no outlet. He then, in co-operation with some other enterprising citizens, bought out the mill dam near Vienna and removed it, also some fish dams; took out from the channel of Pequest river large numbers of stumps, logs and drift wood, which had some effect, but the enterprise soon came to a stand still, for want of co-operation among the owners, want of faith in final results, without a lowering of the bed of Pequest river. Since then no efforts have been made, till the requisite number of land owners, in 1872, petitioned for the appointment of commissioners under the General Drainage Act, which led to the work now being done for the drainage of the Great Meadows. This enterprise has been the hope of the neighborhood for three generations past. Our best and most prominent citizens have always advocated it, not only those in the immediate neighborhood, but throughout the country. Among them all I name but one. Dr. George Green of Belvidere stood high in our county, as one of our most pure and public spirited citizens in his day, and as a man of sound judgment whose opinion, on almost any practical subject of the time, all were glad to obtain. In the Annual Geological Report of New Jersey for 1855 will be found (page 120) his letter saying that 'the drainage could be suggested or recommended on public grounds that would be incontrovertible. I should think that the State, county, township and the community in this vicinity would all be benefited by the bringing into profitable cultivation so large a tract of comparatively worthless land, and making it one of the most valuable and productive in the State.'

"The actual cost of all these efforts to drain the Great Meadows it would be hard to state. That many thousands of dollars have been spent, and then abandoned without result, there can be no question. Much has been learned since that day, and there are now available the teachings of science and experience, and less likelihood of failure in any well considered system of drainage.

Unless it is denied that there is any benefit in relieving land of its surplus water, there can be no question as to the benefits of this enterprise. That it is certainly drying the Great Meadows is a fact patent and apparent to all. And this brings me to your next inquiry.

4th. "'The benefits which have been accomplished by the present work.'

"Among the most immediate of these, is the relief from those annual inundations so sure to come formerly with every spring. Now, with the outlet to the Meadows at the steam mill bridge (formerly Larason's), lowered five and a half feet, and the channel widened to thirty feet and lowered and graded to one foot per mile, the flow of water is free and unobstructed, it commences with the first rainfall, and there is no accumulation.

"All along the Pequest, below the dredge operations, are tracts of land which were under water not only in the spring of 1875, but in the summer of that year had to be passed over in boats in August, and are now dry, hard, fit for the plow and cultivation of corn. Hundreds of acres are already thus improved as to dryness, and other hundreds are relieved from all surplus water, but not yet so far advanced. The character of the grass and pasturage is also changing for the better, and there are now sweet, rich grasses where formerly water, weeds and wild aquatic grasses prevailed. In one tract owned by Simon A. Cummins, Esq., our county collector, he has this season laid over a mile of drain tile, and says he expects to raise next season, a crop of corn sufficient to pay his whole assessment. In former years I have seen this tract all under water, by back-water from the Pequest.

"His brother, Andrew J. Cummins, who carried around the original petition for signers to drain the Great Meadows, has also this year raised a large crop of corn on land formerly subject to overflow. You may be personally acquainted with this tract as it lies immediately in front of the Vienna Hotel, and and has never been plowed before.

"Rev. Ephraim Simonton, a retired clergyman, has also this year raised corn very successfully on land never before broken, and unavailable till this improvement. But perhaps the most remarkable crop has been a timothy crop near Danville, on newly drained land, formerly not only wet but submerged, raised by William Vreeland. Some of his neighbors are now plowing

and grass-seeding lands where the plow never ran before. There are other instances but these are sufficient. The Goose Pond, around which the sportsmen formerly waded in their long-legged boots, can now be passed over in low shoes. It has completely run off dry and no water fowl have been there this summer.

"5th. As to the prices of land in the Great Meadows, it is difficult to give definite figures. Most of the land is held in connection with adjoining farms, and taxed in the gross in that connection. I can recall but a single actual sale separately, and that some years ago, which brought three dollars an acre for one hundred and eighty acres. I know of another tract offered at five dollars an acre and no purchaser. Some lots where wholly or partially in timber have brought ten, fifteen or twenty dollars an acre. Their inaccessibility except in winter very much depreciates their market value as we have many winters when they cannot be reached at all."

The Great Meadows have always been noted for the prevalence of malarial diseases in their vicinity. The former sanitary condition of the country around them is best shown from the testimony of the practitioners of medicine, who have attended the sick there. The gentlemen whose letters follow here are all practitioners who have had a wide experience and for a long period of time. In the country where they are known it would be needless to say that their statements and opinions are entitled to the fullest credence.

From Dr. John S. Cook, of Hackettstown:

"In my conversation with you at our last meeting I mentioned that the Pequest valley, during the last thirty years, had been visited by several epidemics, which assumed a malarial type, while our Musconetcong valley had been comparatively exempt from such visitations. We have malarial diseases, but they never assume an epidemic form. I have no data from which to give you definite information, and, therefore, can only write in a general way from my own knowledge.

"The valley of the Pequest comprises an area of country where malaria is endemic and where it prevails every year to a greater or less extent. The topography of the district is such as to favor its production. We have a plain situated between mountains, into which the heavy rains and inundations of cen-

turies have deposited great masses of vegetable matter, and this with the varying seasons of each succeeding year, has been permitted to decay until we have a soil composed of this vegetable mold of several feet in depth, and this being deposited upon a deeper floor of clay and other impenetrable soil, presents conditions the most favorable for its development, especially when we have a large amount of surface water loaded with vegetable ingredients percolating through the loose upper earth and held on the surface of the lower stratum. The drainage of this district must make it one of the most fertile in this portion of the State, and it must also affect most favorably the health of its inhabitants. This will be brought about not only from the removal of the surface water, but from the absorption of decomposing organic matter by the growing crops.

"I can recall an epidemic of dysentery which prevailed throughout the valley, and especially in the neighborhood of Vienna, during the fall of 1857. This assumed a decided malarial type and was fatal in many cases. Scarlet as well as typho-malarial fevers where they have prevailed, have assumed a malignant type. In the fall of 1874, an acute laringytis prevailed in the neighborhood of Schmuck's, which was of an unmanageable form and a number of deaths occurred, adults as well as children being among its victims. Dr. Wm. I. Roe who has been located at Vienna for a number of years says that disease at almost every stage of its progress has a tendency to assume a malarial type, and this tendency is no more than one might expect to meet with, when we take into consideration the sanitary conditions by which his patients are environed.

"I have given you in this general way, some information gathered in the course of my experience during several years of active practice in both valleys, and in conclusion, I have to say, that we meet with few, if any, such cases of malarial diseases in the Musconetcong valley, as are frequently to be found in the valley of the Pequest.

From Dr. Wm. I. Roe, of Vienna, Warren county:

"Yours inquiring in regard to malarial diseases of the Pequest valley in the vicinity of the Great Meadows is at hand.

"Nearly thirty years ago, I was in practice for two years at Danville on the lower border of the Great Meadows. At that time the prevailing diseases were, for the most part, malarial in

character. The intermittents were very severe, and many of the residents expected the usual attack of "chills," as surely as they looked for the coming of spring, while a family moving in the neighborhood from a non-malarial district seldom escaped the ravages of miasma in one form or another.

"In 1872, after an absence of twenty-five years, I again commenced practice in this vicinity. While I find a proportion of diseases of malarial type, they have not occurred to nearly the extent that they did during my previous residence here, nor have they been of so severe a form. During the past six years there has been a gradual diminution in the number of miasmatic cases, more particularly during the past two summers. I have attributed this to the drainage of the lower portion of the Great Meadows.

The malarial diseases which prevail here are the usual varieties, viz.: Intermittent and remittent fevers, neuralgia, typho-malarial and congestive fevers. The intermittent or common "chills and fever" is the most frequent. For two years past neuralgia of a severe and intractable form has been more prevalent than in former years. Remittent fever has not been frequent or severe. I have noted an occasional case of typho-malarial and two of congestive fever. The greatest number of cases have usually occurred during the summer months. The present year however is an exception, the greater number occurring during the months of September and October.

"These diseases seem to prevail to a greater extent along the southern border of the meadows than along either the eastern or western. It may be of interest in this connection to state that during the past six years there has been but one case (and that a very mild intermittent) on either of the three so-called islands, situated in the very center of the Great Meadows. More than sixty different persons have been residents of these islands during that period. Comparing the extent of malarial disorders in the Pequest valley, with those of the Musconetcong, I think that for two years past there have been a greater number of cases in the latter, particularly in that tract situated between Waterloo and Hackettstown, popularly known as 'Guinea Hollow.' I have seen quite a number of obstinate remittent and intermittent fevers in that vicinity, and have been informed that they prevailed very extensively, scarcely a family escaping. They

have been of a much graver nature and more intractable than the same affections occurring in the valley of the Pequest.

From Dr. N. M. Hartpence, of Oxford, Warren county:

"My practice has not been extensive in the country bordering on the Great Meadows, yet from the experience I have had I am convinced that malarial diseases are very prevalent there, and that you are correct in believing that such a body of land overflowed with water at times, is a fruitful source of such diseases, more particularly intermittent fever, and as observation has fully demonstrated that malaria is generated more especially in marshy situations, and that it affects by preference low and marshy localities, and in proportion as countries previously malarious are cleared up, periodical fevers disappear, I feel warranted in saying that a thorough drainage and cultivation of those lands, will finally be of great public benefit viewed even from a sanitary point."

From Dr. E. T. Blackwell, Hackettstown, N. J.:

"It was my fortune to pass the year 1849 at Townsbury, Warren county, two miles below the lower limit of the Great Meadows, but quite near enough to be strongly within the influence of its unwholesome emanations. The health of the community was good until the beginning of August; when malarial diseases, in great variety, and of all grades of intensity became extremely prevalent. Until winter this outbreak continued, prostrating in some instances three or four members of the same family. The year 1850 I passed at Danville, immediately on the edge of the Great Meadows. My experiences with the malaria were here repeated in an intensified form. During the preceding endemic, by shunning exposure in the night time, and when this was impossible, by wearing a handkerchief, arranged as a respirator, I was able to avoid its worst effects upon myself. Here all devices failed; and I experienced in my own person its poisonous results in an attack of fever.

"It appeared to me while sojourning in this neighborhood, and marking the effect of these blighting influences upon the health of the people, that I could perceive, in the lessened vigor and robustness of many of the residents, the results of this insidious and baleful poison. According to my observation, this is by far the most malarious district in this part of the State. The outbreak of malaria always occurs when the overflow of the

Pequest, drying up, leaves its sedimentary matter, as well as the earth saturated with deadly gases, to the full influence of the fierce autumn sun.

"No lover of his species can fail to hail with satisfaction every attempt by legislative means to improve the public health, by the prevention of all diseases, resulting from causes of a public nature; and I recognize in the drainage of the Great Meadows, an undertaking destined to exert a controlling influence in improving the healthfulness of this portion of our State."

7. MISCELLANEOUS LABORATORY WORK.

In addition to the regular work of the Laboratory in analyzing clays, ores, and soils which are the regular work of investigation in the Survey, some other work has been done. The miscellaneous inquiries in regard to natural products of the State have been answered as far as time would permit. There are a number still awaiting examination, which will be attended to as soon as the work in hand can be laid aside.

The following are among the substances examined:

Nickel Ore.—Two samples of rock containing pyrite, taken from a shaft sunk by William Davis, between Chester and Peapack, have been examined for nickel, but none was found. A sample taken from the southeast slope of Jenny Jump Mountain, and on land of A. Davis, was also examined for nickel, but none was detected. Numerous other specimens have been sent from different places in the northern part of the State, but none have been found which contained any nickel. The price of this metal has diminished so much, and the demand for it has fallen off so greatly, that it is probable less interest will be felt in searching for it.

Gold.—It is very generally reported that the iron pyrites which is found in the conglomerate of the Blue Mountain contains gold. A number of specimens from different places in the mountain have been examined at various times, but none of any value has ever been found. A sample brought by F. La Bar, from a few miles above the Water Gap, has been assayed this year, but no gold was found in it. One or two samples sent by other parties, and from different places along the mountain, are in the laboratory now. From the trials already made, it is safe

to say that there is no encouragement to work in the mountain with the expectation of finding gold, even if the iron pyrites is very abundant in it.

Iron Ore.—Bog iron ores are frequently brought in to be examined. Generally they are not rich enough to be used for making iron; besides that, those in the middle and southern part of the State have generally been found to contain so much phosphorus as to spoil the quality of the iron. A sample brought in by T. F. Carman, from Menlo Park, Middlesex county, contained only 12.15 per cent. of iron. A sample sent by Henry Bingler, of Hainesburgh, Warren county, contained 32 per cent. of iron.

Magnetic iron ore, sent by Mr. Cramer, from his mine east of Hackettstown, on Schooley's Mountain, Sample No. 1, a rich ore, contained of

Metallic iron	62.23
Titanic acid	9.80
Phosphorus	.14
Sulphur	none
Manganese	a trace

Sample No. 2, a lean ore, contained of

Metallic iron	40.25
Titanic acid	4.20
Phosphorus	.39
Sulphur	.?
Manganese	a trace

Analysis of iron ore from Fisher mine, on Fox Hill, sent by John D. Mills, of Rockaway, Morris county, for Mills, Willison & Co. The vein is said to be 10 or 12 feet thick, and the average sample was made from pieces taken entirely across the whole thickness.

ANALYSIS.

Magnetic oxide of iron	79.40
Phosphorus	.04
Sulphur	.59
Lime	2.70
Magnesia	.94

Manganese	0.00
Silica	11.90
Titanic acid	a trace
Metallic iron	57.50

This is a fine looking ore, and contains so small an amount of phosphorus that it ought to be available for making the very best kinds of iron.

A. J. SWAYZE'S HEMATITE.—This hematite locality is in Hope township, three and a half miles south of Blairstown, Warren county. The first work done on this farm was four or five years ago, by Ziba Osman, who, at that time, owned it. Ore was then found, but not in sufficient quantity to encourage the continuation of the work of exploring, or lead to mining.

In January, 1877, Mr. Swayze began the work of testing the property, by sinking a number of trial pits. The ground explored is northeast of Rice pond and southeast of the farm house. It slopes towards the west. The top of the ridge east of the pits shows slate outcrops; west of them, and west of the road, alluvial and diluvial beds conceal the strata. The pits dug by Mr. Swayze are between 20 and 50 feet deep, and 2½ feet wide. They showed, in general, a bed of unsorted boulder drift, of varying thickness, and consisting of blue, clayey earth and gravel, cobble stones and boulders of all sizes. Many of the latter are beautifully striated. In some of the pits this bed of drift was only a few feet thick. The maximum thickness, 28 feet, was found in a pit (unfinished at time of visit), near the foot of the hill. Under the drift the yellow, ochrey clay and ore is found. The hematite occurs in small fragments, and in "bomb"-like masses in the clay. In two of the trial pits, and in the working shaft, the *ore bed* rests upon a yellowish, earthy slate, apparently a slate which has been very much altered, and has become soft and crumbling. It is supposed that deeper pits would soon get through this soft rock, and reach the hard, unchanged blue slate of the hill.

The working shaft is southeast of the farm house, about an eighth of a mile, and half-way up the hill side and near the Osman openings. In it the strata are: drift earth, 8–9 feet; then the ore bed, 8 feet; and at the bottom, the yellow slate. From

this shaft a drift, 20 feet long, was cut, going eastward and ascending in the ore bearing clay. Another, 30 feet long, followed the same bed towards the west. These drifts indicated considerable variation in the thickness of the ore body. Most of the ore was *wash ore.* South southeast of the shaft, and higher up the hill side, a pit, 20 feet deep, struck the ore near the surface, and found it 2 to 4 feet thick. A pit south of the shaft was 50 feet deep, and the drift covering was 20 feet. In it there was 1 to 5 feet of ore in one body, with two lower *veins* or deposits. These test pits show somewhat of variation, but they indicate the existence of ore throughout an area of several acres, and in workable thickness.

About 100 tons have been raised at the main working shaft Mr. Swayze reports making some iron from it, using charcoal in a forge. It was soft and tough.

An average sample, obtained at the shaft, was analyzed in the State laboratory, and found to contain:

Matters insoluble in acid	12.40
Oxide of iron	67.92
Water	13.20
Oxide of manganese	1.10
Phosphoric acid	0.45

Or, of

Metallic iron	47.44
Phosphorus	0.19
Manganese	0.79
Sulphur	none

These results indicate a moderately rich ore, with comparatively little phosphorus, no sulphur and manganese enough to have a beneficial effect in smelting. It ought to answer for Bessemer steel making.

This locality is interesting as it shows the slate rock covered by the ore-bearing clay, and that in turn by the boulder drift.

Northeast of the farm house the blue limestone crops out, the end apparently of a belt or tract which extends thence southwest along Rice's pond and west of Hope. Near this point there is an outcrop, a few yards square, of micaceous gneiss in which pyrite is a common mineral. A little digging has been done

here in search of valuable ore. There appears to have been a great deal of erosion here which has worn down the limestone, making it the bottom of the valley and leaving the slate in ridges enclosing it. And originally this limestone may have extended eastward and joined the slate where the hematite now appears. The drift is a later formation which has covered both ores and rocks alike.

Franklinite iron ore.—Explorations made this year for franklinite and zinc ore, at the southwest end of the zinc vein in Stirling Hill, Sussex county, have exposed a large body of ore, of peculiar composition. It is in the ore vein, associated with the zinc minerals and calcite, and to the eye presents the appearance of massive franklinite. A specimen analysed in August was found to contain of:

Metallic iron	51.98 per cent.
Metallic manganese	7.40 per cent.
Metallic zinc	3.15 per cent.
Earths insoluble in hydrochloric acid	7.70 per cent.

Another sample taken from farther in the mine, in September, was analysed with the following result:

Metallic iron	51.21 per cent.
Metallic manganese	7.40 per cent.
Metallic zinc	6.24 per cent.
Silicic acid and insoluble earths	9.80 per cent.

This mine is opened by Messrs. Silsby and Martin, of Ogdensburgh, Sussex county. A tunnel has been driven in from the road near the foot of the hill so as to cut across the vein at a depth of more than 100 feet below its outcrop on the hill above. An enormous mass of this ore has been uncovered by this means, and it is mined at the smallest possible expense. The ore is met in the tunnel for over a hundred feet in length, but the vein is so much broken that it offers no safe basis upon which to calculate the amount of ore the mine will yield. There are thousands of tons of it, in sight, as the vein is opened to the top, so that the ore can be seen all the way from the tunnel upwards.

It is a valuable ore for working into Bessemer metal; and has found a ready sale to the iron manufacturers.

Limestones.—Five samples of limestone, collected by M. G. Smith, from his land, near Polkville, Warren county, were examined to determine whether they were *pure* or *magnesian* limestones, and the amount of earthy impurity in them.

No. 1 is a magnesian limestone, and contains 10 9 per cent. of earthy impurities.
No. 2 is a magnesian limestone, and contains 9.2 per cent. of impurities.
No. 3 is a pure limestone, and contains only 6.1 per cent. of impurities.
No. 4 is a magnesian limestone, and contains 20.7 per cent. of impurities.
No. 5 is a magnesian limestone, and contains 21.6 per cent. of impurities.

Lime made from No. 3 would be worth fully fifty per cent. more per bushel, in the stone, than that made from either of the others. If the magnesian limestones must be used, Nos. 1 and 2 are the best. The magnesia is about two-fifths of the weight of the magnesian lime, and as it is commonly burned now with coal, it probably has no value as a fertilizer. Formerly, when burned with wood, with which the heat is not so intense, the magnesian lime was best liked for making mortar, because it set quicker than pure lime; but when burned with coal it is not as good as the pure lime, even for that use.

Henry Bingler sent seven samples of limestone from his farm on the north side of the Paulinskill near Hainsburgh, Warren county. They were examined in the same way as those just mentioned.

No.	Earthy impurities.
1. Limestone	15.5 per cent.
2. Magnesian limestone	6.9 per cent.
3. Magnesian limestone	5.1 per cent.
4. Limestone	18.1 per cent.
5. Limestone	2.5 per cent.
6. Part limestone and the rest magnesian limestone	11.8 per cent.
6. Limestone with some magnesia	13.4 per cent.

Of these specimens number five is the best of the limestone, but all the limestones are more valuable for farmers use than the magnesian limestones. The latter are very good of their kind.

It would be much to the advantage of farmers if they would take pains to get pure limestones from which to burn lime for agricultural use. There are good localities for it near Manunkachunk on the Delaware; also, near Johnsonsburg, on the road to

Hope; on the same road near Howard; also on the same road a half mile northeast of Hope, all in Warren county. Near Stillwater, in Sussex county; near Fredon, west of Newton; at Newton; and, in fact, it can be found almost everywhere between the blue limestone and the slate, and it can be distinguished by its dark or almost black color, its fine grain, its somewhat slaty structure, and some of it contains fossils. It may be mistaken for slate, but an experiment by burning and slaking will show the difference. Or by testing with strong vinegar, when the limestone will effervesce, while slate will not.

Mineral Water.—J. W. Sutterly, in digging his well at Point Pleasant, obtained water charged with mineral substances, and brought it for examination. It contained 7.85 grains of solid matter in one gallon of the water, of which 4.14 grains are carbonates of iron, magnesia and lime, 3.65 grains of chlorides of sodium and potassium, and a little sulphate of potash. It is a pleasant chalybeate water.

8. CENTENNIAL MAP OF NEW JERSEY.

This map has been prepared by the survey first for the Centennial Commissioners' report, but it is the property of the survey and will be useful for many purposes of our work. It is believed that it has on it all the townships of the State, and all the canals and railroads, and nearly all the country roads. It is on a scale of 6 miles to an inch. In the centennial report it is accompanied by a copy of a map of New Jersey on nearly the same scale, which was made by British officers before the revolution, and engraved and printed in London in 1777. The two show something of the changes which have been made in the civil geography of New Jersey in one hundred years.

9. MUSEUM OF THE GEOLOGICAL SURVEY.

This museum occupies all the front of the third story of the State House. It is open every week day. The specimens of the Geological Exhibit at the Centennial, and most of those of the Agricultural Exhibit, are arranged here. It is visited by our own citizens from all parts of the State, and by strangers who come to see the State House, and its various departments and

offices. In this way our various mineral and other natural products are brought to the notice of large numbers of people. It is desirable to add to the collection any specimens from the State which will improve it, in variety or quality, and donations for this purpose will be gladly received and placed on exhibition with the name of the donor.

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