GEOLOGICAL SURVEY OF NEW JERSEY.

ANNUAL REPORT

OF THE

STATE GEOLOGIST,

FOR THE YEAR

1886.

TRENTON, N. J.:
THE JOHN L. MURPHY PUBLISHING CO.
1887.

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NEW BRUNSWICK, December 22d, 1886.

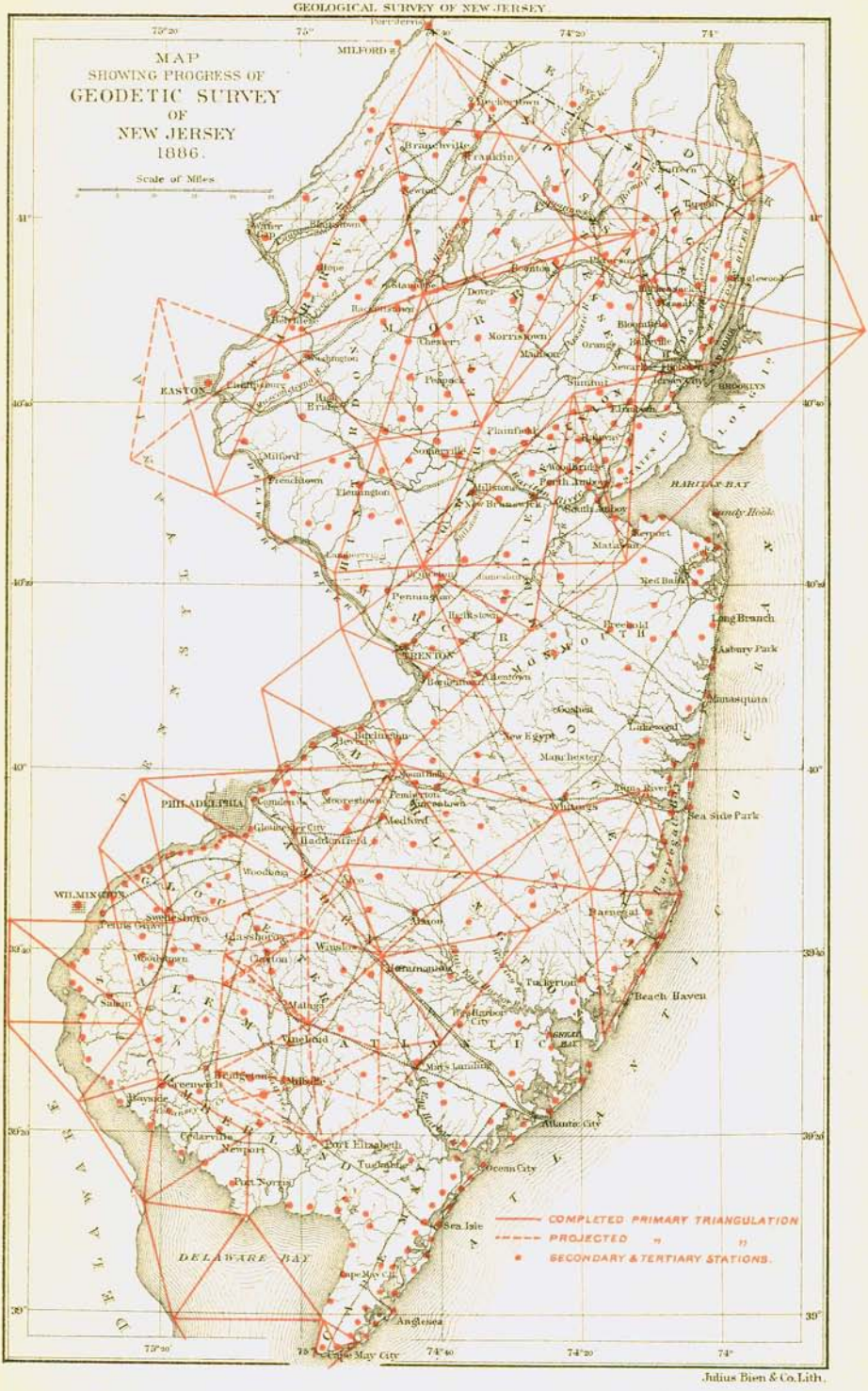
To His Excellency Leon Abbett, Governor of the State of New Jersey, and ex-officio President of the Board of Managers of the State Geological Survey:

SIR—I have the honor herewith to submit my annual report, as State Geologist, for the year 1886.

With high respect,

Your obedient servant,

GEO. H. COOK,
State Geologist.


GEOLOGICAL SURVEY OF NEW JERSEY
MAP
SHOWING PROGRESS OF
GEODETIC SURVEY
OF
NEW JERSEY
1886.
Scale of Miles
COMPLETED PRIMARY TRIANGULATION
PROJECTED " "
SECONDARY & TERTIARY STATIONS.
DELAWARE BAY
ATLANTIC OCEAN
RARITAN BAY
PHILADELPHIA
WILMINGTON
TRENTON
EASTON
Julius Bien & Co. Lith.

REPORT.

The report upon the progress of the Geological Survey for the year 1886, is arranged under the following heads:

- I. Geographic Surveys.
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    - Mapping and Engraving.
    - Work to be Done.
    - Plan of Publication.
    - Bench-Marks.
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      - I. Massive.
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    - Clay Marls.
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    - Red Sand.
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    - Yellow Sand.
    - Upper Marl Bed.
  - *Water-Supply.*
  - *Drainage.*
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  - *Museum of the Geological Survey.*
  - *Publications.*
  - *Expenses.*
  - *Assistants.*
  - *Statistics of Iron and Zinc Ores.*

I.

GEOGRAPHIC SURVEYS—GEODETIC AND TOPOGRAPHIC.

The work included in this part of the survey has all been done under the direction of the State Geologist, though the chief part of its cost has been paid by the United States: the geodetic portion by the United States Coast and Geodetic Survey, and the topographic by the United States Geological Survey. The large expense required for carrying on such work is far beyond the moderate appropriation made by our State, and we are fortunate in getting the benefit of these government surveys, at a time when they can be so well combined with our own.

GEODETIC SURVEYS.

The United States Geodetic Survey has been conducted in New Jersey, for several years past, by Prof. Edward A. Bowser, assistant in United States Coast and Geodetic Survey. The work to be accomplished is that of determining with precision the latitudes and longitudes of points in all parts of the State, so that surveys made may be adjusted around them in their true geographical position. These points are established on mountain or hill-tops, or on other elevated ground, so that there may be unobstructed vision from one to another. The lines joining these points constitute a net-work of triangles which, when completed, will cover the whole State. The points are at distances of from ten to thirty miles apart, and in the same triangle are located so as to make the sides as nearly of the same length as possible. The reconnaissance for ascertaining and selecting these points is excessively tedious and laborious, on account of the great uniformity of the surface and the large tracts of wooded country. It requires the climbing of trees, the erection of signals, and finally the construction of high and substantial platforms. And when the reconnaissance is

satisfactorily done, the angles of all the triangles have to be measured, and the measurements repeated till extreme accuracy is attained. The angles can only be measured when the air is clear and of nearly uniform temperature. Days are frequently spent without a single satisfactory observation, sometimes whole weeks together. It will then be understood that such surveys are conducted with extreme slowness. This of New Jersey has now been going on, in a rather limited way, for 12 years, and it will yet require 2 years more for its completion. The work still to be done is in the counties of Gloucester, Atlantic, Salem, Cumberland and Cape May.

The money appropriated for this survey, for the present year, being much less than usual, but a small amount of work has been accomplished. The small map of the State accompanying this report shows the primary triangulation, as far as executed, in full red lines; and that portion laid out and not yet completed in broken red lines. Secondary and tertiary points are shown by red dots. A portion of these have been determined by the Topographic Survey.

During the year scaffolds have been erected at the stations Richland and Newfield; the station Hammonton has been occupied and the observations completed for that point, and the reconnaissance has been continued in Cumberland county with a view to making a connection with the older triangulation work on Delaware bay.

LIST OF GEOGRAPHICAL POSITIONS.

The following table has been prepared from published reports of the United States Coast and Geodetic Survey, from manuscript furnished by that organization, and from work done by Acting Assistant Prof. E. A. Bowser, for that survey, since 1875.

The points given are indicated on the small map facing page 8. The primary stations, printed in small capitals in the table, are connected by red lines on the map, and all others are indicated by small red dots. So far as it can be done without interfering with other details, the points are shown on the sheets of the Topographical Atlas, and parties wishing to find them should consult these maps first.

Many of the points are prominent spires, chimneys or other structures which may be readily found by any one; many others are marked by conspicuous stone monuments; some only by buried marks; while still others were never permanently marked, being

only intended for immediate use by topographical parties. Many of the older points have not been found during the prosecution of the Topographical Survey; these are followed by an interrogation point (?). Some of these were located near enough for topographical purposes by witness-marks, etc., without the actual station-mark being recovered, while others were utilized through the medium of United States Coast and Geodetic Survey plane-table sheets. As a rule the stations will be found upon the highest or most commanding ground in the vicinity.

The name by which the station is known to the survey is first given; this is followed by a short description as full as space permits; and, as the description will often be unintelligible without, it is followed by the date of selecting or determining the point. When this is not exactly known, the date of the report in which it first appeared is given; thus (a. 1851) signifies that the point antedates 1851, etc. Those determined since 1875, by Prof. Bowser, are indicated by (B.)

The stations are arranged by counties geographically. Under each county the older points, computed on the Bessel spheroid, are given first. Following these, under the heading *Clarke's Spheroid*, are the later points computed from the latest and best data as to shape and size of the earth, and with corrected telegraphic longitudes. Many of the stations in the first list are repeated in the second. At the head of the second list under each county, in the columns of seconds, are given the average differences of latitude and longitude between the two lists. Any one desiring the latest and most accurate locations, correct to one-tenth of a second, should add these quantities to the figures in the list preceding. This should always be done when the stations are to be used for constructing maps.

Following this table is a supplementary table of latitudes and longitudes determined by the Topographical Survey, which will be found to include many prominent spires and buildings not given in the first.

The total number of points utilized in making the Topographical Survey of the State thus far is 452, and a few more remain to be determined before the work is closed. Excluding the close tertiary triangulation along the Hudson and Delaware rivers and the sea-coast, they average one to each 25 square miles. In one or two cases where unusually large intervals occur between stations, the topography has been laid down by means of transit traverses.

Table of Geographical Positions.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
SUSSEX COUNTY.						
	Deg.	Min.	Sec.	Deg.	Min.	Sec.
HIGH POINT. Copper bolt in ledge on summit of Blue Mountain, 1¼ miles from New York line. (B.)	41	19	12.74	74	39	23.38
Centerville. On hill, ¾ mile W. of village. (B.)	41	12	51.57	74	50	09.99
CULVER'S GAP. Copper bolt, first summit, S. W. of Gap. (B.)	41	10	18.49	74	47	22.43
Deckertown. Presb. Church spire. (B.)	41	12	36.60	74	36	03.87
Decker Pond. Blazed spruce on hill, E. side of pond. (B.)	41	12	11.84	74	31	42.65
Glenwood. Blazed spruce on hill, 1 mile N. W. of village. (B.)	41	15	24.81	74	29	57.91
Hamburgh. Church spire. (B.)	41	09	06.48	74	34	13.69
Beaver Run. Blazed hickory on hill, 1½ miles W. of village. (B.)	41	09	18.50	74	38	27.17
East and West Jersey Line (on Blue Mountain). (B.)	41	08	44.15	74	50	40.08
Smith's Hill. Blazed chestnut on summit, 1½ miles N. of Newton. (B.)	41	04	55.05	74	44	30.17
Lafayette. A summit, 2 miles N. of village. (B.)	41	07	51.01	74	41	07.16
HAMBURGH. Copper bolt in ledge on summit, 2½ miles E. of village. (B.)	41	08	50.85	74	31	30.18
Franklin Furnace. Stack. (B.)	41	06	29.72	74	35	01.74
Catfish Pond. Summit, E. of pond. (B.)	41	01	54.92	74	59	30.59
Newton. Presbyterian Church spire. (B.)	41	03	24.80	74	44	59.00
Woodport. Cross on boulder on summit, ½ mile W. of Dodge mine. (B.)	41	00	37.55	74	35	10.36
Sparta. Cross on rock on summit, 1½ miles S. of Sparta. (B.)	41	00	55.96	74	37	56.04
Clarke's Spheroid. Difference			*+02.5*			*+19.6*
WARREN COUNTY.						
Delaware Water Gap. Brow of Mount Tammany. (B.)	40	58	05.12	75	06	23.27
Danville. Blazed white-oak on summit, 1 mile W. of village. (B.)	40	52	09.43	74	55	53.36
Hackettstown. Blazed rock-oak on summit, 2 miles W. of town. (B.)	40	51	05.48	74	51	59.91
MONTANA. Stone monument, ½ mile S. E. of village. (B.)	40	45	50.08	75	03	17.38
Clarke's Spheroid. Difference			*+02.6*			*+19.5*

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
MORRIS COUNTY.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
East and West Jersey Line. 1½ miles N. of Budd's lake. (B.)	40	53	46.46	74	44	34.43
Green Pond. Blazed pine on summit, 1 mile N. of Denmark. (B.)	40	58	31.04	74	31	41.93
Sheep Hill. Cross cut on large rock on summit, 1 mile N. of Boonton. (B.)	40	55	06.58	74	24	04.35
Boonton. Presb. Church spire. (B.)	40	54	20.92	74	24	17.68
Parsippany. Presb. Church spire. (B.)	40	51	50.17	74	24	04.17
Schooley's Mountain. Cross on center one of 3 stones on summit, 1½ miles S. W. of Drakestown. (B.)	40	49	44.93	74	47	13.45
Watnong. Bar of iron, projecting 6 inches, on summit, 1½ miles N. W. of Morris Plains. (B.)	40	50	52.88	74	29	20.23
Morristown. Presb. Church spire. (B.)	40	47	47.83	74	28	30.19
MT. OLIVE. Stone monument on summit, 1½ miles E. of Budd's Lake. (B.)	40	51	59.88	74	42	32.80
BALD HILL. Stone monument, 1 mile S. E. of Brook Valley. (B.)	40	57	37.21	74	20	43.91
Clarke's Spheroid. Difference			*+02.6*			*+19.7*
PASSAIC COUNTY.						
Van Riper. Summit, S. edge of Paterson (?)	40	53	34.04	74	08	04.34
Weasel. Copper bolt in ledge, First Mountain N. of Great Notch	40	52	34.18	74	10	52.41
Aquackanonk. Summit of hill, Passaic City (?)	40	51	01.13	74	07	25.80
Beach Mountain. Summit near State Line, E. of Greenwood Lake. (B.)	41	09	57.56	74	17	20.29
Dunker Pond. Blazed oak on summit, ¼ mile S. W. of pond. (B.)	41	04	55.90	74	28	37.23
BEAR FORT. Copper bolt in ledge on summit, 1½ miles N. W. of West Milford. (B.)	41	08	23.55	74	23	11.70
Macopin. Blazed chestnut on summit, ¼ mile E. of pond outlet. (B.)	41	02	53.61	74	23	43.79
HIGH MOUNTAIN. Copper bolt in ledge on summit, 4 miles N. W. of Paterson. (B.)	40	58	11.52	74	11	35.58
Powder Mills. Machine shop chimney. (B.)	40	55	27.51	74	16	13.59
Greenwood Lake, N. Y. Bearfort Mountain, N. of State Line. (B.)	41	11	38.07	74	20	02.88
Clarke's Spheroid. Difference			*+02.6*			*+19.8*
WEASEL. (Same as Weasel above)	40	52	36.81	74	11	12.21

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
BERGEN COUNTY.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Cherry Hill. N. of Highland, on hill (?)	40	54	43.31	73	57	52.37
Banta. Summit of Hackensack and Tea Neck road (?)	40	53	09.94	74	00	39.66
Terhune. Hill W. of Corona (?)	40	51	38.11	74	04	36.76
Bury. Hill N. of Carlstadt	40	50	26.17	74	05	02.57
Vreeland. At Ridgefield cross-roads (?)	40	49	58.12	74	00	19.67
Kingsland. On ridge, ½ mile S. of village (?)	40	47	45.16	74	07	12.75
DIDERY. Yonkers, N. Y.	40	57	59.98	73	50	13.95
Bald Mountain. Summit Ramapo Mountain, ½ mile S. of State Line. (B.)	41	07	11.94	74	11	43.11
Ramsey's. Church tower. (B.)	41	03	31.01	74	08	12.30
Wykoff. Church cupola. (B.)	41	00	25.13	74	10	06.18
Allendale. Church spire. (B.)	41	01	46.96	74	07	14.94
Paramus. Church spire. (B.)	40	59	04.52	74	05	13.48
Hackensack. Church spire. (B.)	40	53	15.95	74	02	12.85
Palisade. (B.)	40	59	50.33	73	53	57.69
Englewood. (B.)	40	53	25.56	73	57	56.25
Bergen Fields. Church spire	40	55	43.04	73	59	53.38
Coytesville	40	51	34.99	73	58	25.47
Schraalenburg. Church spire	40	56	22.48	73	59	20.53
HIGH TORNE. Summit, 1 mile N. of Ramapo, N. Y.	41	09	02.79	74	09	27.53
Clarke's Spheroid. Difference			*+02.6*			*+19.8*
PIERMONT. N. Y.	41	02	57.26	73	55	38.52
DIDERY. Yonkers, N. Y.	40	58	02.57	73	50	33.88
BUTTERMILK. N. Y.	41	06	36.44	73	48	38.90
Bury. Hill N. of Carlstadt	40	50	28.80	74	05	22.41
Fort Lee flag-staff	40	50	49.00	73	57	53.76
State Line, New York and New Jersey. Stone on bank of Hudson river	40	54	50.10	73	55	28.95
Duer. N. Y.	40	59	53.46	73	54	10.37
HUDSON COUNTY.						
Schuyler. On ridge E. of Bellville (?) (a. 1851)	40	46	46.28	74	08	10.17
Bergen Neck (?) On ridge in W. Hoboken (?) (1818)	40	45	49.40	74	02	16.62
Stevens. In front of Stevens residence, Hoboken (a. 1851)	40	44	38.49	74	01	06.54
Bergen spire. Old Dutch Reformed Church. (a. 1851)	40	43	39.51	74	03	43.22
Caven Point (?) (a. 1851)	40	41	31.36	74	03	59.07
Palmerpaw (?) (a. 1851)	40	40	38.24	74	05	39.32
Constable's Point (?) (a. 1851)	40	39	23.52	74	05	25.61
Vanhorne (?) (2) (a. 1851)	40	39	05.63	74	08	06.80
Shooter's Island (?) (a. 1851)	40	38	34.24	74	09	20.04
Rowan (?) (a. 1851)	40	38	51.54	74	07	13.72

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Bedloe's Island. (flag-staff,) New York Bay. (a. 1851)	40	41	17.48	74	02	20.85
Gibbet Island, (tree). Now Ellis Island, New York Bay. (a. 1851)	40	41	55.72	74	02	05.49
Jersey City. (flag-staff). (a. 1851)	40	42	52.43	74	01	57.20
Passionate Fathers' Monastery. West Hoboken. (B.)	40	45	54.38	74	01	52.28
Brooklyn Bridge. New York pier. (B.)	40	42	23.57	73	59	35.51
Bergen Point spire. (a. 1859)	40	38	49.58	74	07	19.24
Centerville. Church spire. (a. 1859)	40	40	03.23	74	06	33.26
Kill's Light. Bergen Point. (a. 1859)	40	38	32.23	74	08	35.84
Robin's Reef Light. New York Bay. (a. 1859)	40	39	23.85	74	03	36.78
New York City Hall, N. Y. (a. 1851)	40	42	43.16	74	00	03.09
New York, Trinity Church spire. (a. 1851)	40	42	25.71	74	00	24.29
Brooklyn, Trinity Church spire	40	40	56.33	73	57	43.06
Clarke's Spheroid. Difference			*+02.6*			*+19.9*
Highwood (2). Brick pillar, marble cap in miniature redoubt, near residence of Mrs. James G. King (1867), 2 miles N. of Hoboken	40	46	12.70	74	01	02.06
Bergen Neck (?) 1818)	40	45	52.06	74	02	36.50
Stevens. (a. 1851)	40	44	41.14	74	01	26.44
Bergen Dutch Reformed Church (same as above). (1885)	40	43	37.14	74	04	04.35
Jersey City. Spire. (a. 1851)	40	42	53.18	74	02	16.75
Oil Co.'s Chimney. N. side of Kill van Kull. (1885)	40	39	18.82	74	06	33.40
Shooter's Island. Chimney. (1885)	40	38	32.58	74	09	39.74
ESSEX COUNTY.						
Crane (2). Summit, First Mountain N. of Montclair (?) (a. 1851)	40	50	05.42	74	12	48.86
Wallace. In Newark city (?) (a. 1851)	40	44	30.41	74	10	56.09
Newark Neck (?) (a. 1851)	40	42	44.97	74	08	00.00
Fairfield. Reformed Church spire. (B.)	40	53	01.94	74	16	38.13
Caldwell. Church spire. (B.)	40	50	18.38	74	16	14.02
Caldwell. Iron bar, projecting 3 inches, 1 mile E. of village, near top of hill. (B.)	40	50	21.69	74	15	04.77
Newark. First Presbyterian Church spire. (a. 1859)	40	44	01.18	74	10	02.26
Newark. Methodist Church spire. Broad street. (a. 1859)	40	44	03.58	74	09	52.60
Newark Bay light, or Passaic light (a. 1859)	40	41	43.69	74	07	19.23
Newark Bay beacon (a. 1859)	40	42	05.60	74	07	07.97
Clarke's Spheroid. Difference			*+02.6.*			*+19.9*
Newark. Episcopal Church spire	40	44	25.42	74	10	10.35

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
UNION COUNTY.						
	Deg.	Min.	Sec.	Deg.	Min.	Sec.
SPRINGFIELD. Pile of stones just E. of old fence line, Roll's Hill, 2 miles S. of Summit. (1817)	40	41	19.44	74	21	05.44
Sayre. Hill, 2 miles N. E. of Cranford (?) (a. 1851)	40	40	43.56	74	16	57.58
Elizabethtown. Spire of First Presbyterian Church (a. 1851)	40	39	42.84	74	12	36.97
Randolph. On drift hill, E. of Plainfield (?) (a. 1851)	40	36	41.81	74	23	20.32
Rahway. Spire of First Presbyterian Church. (a. 1851)	40	36	51.04	74	16	32.11
Wynant. (a. 1859)	40	32	55.28	74	13	58.89
Bird (?) (a. 1851)	40	39	03.13	74	10	08.69
Elizabethport. Presbyterian Church, white spire. (a. 1859)	40	38	49.75	74	11	08.24
Clarke's Spheroid. Difference			*+02.7*			*+19.7*
SPRINGFIELD. Roll's Hill, as above, (1817)	40	41	22.15	74	21	25.19
Sayre. (a. 1851)	40	40	46.27	74	17	17.35
Elizabethtown. Presb. Church. Same as above. (1885)	40	39	45.55	74	12	56.77
Oil Cloth Co.'s Chimney. Southern part of Elizabethport. (1885)	40	38	45.96	74	11	45.84
Staten Chemical Co.'s Chimney. Near Bay Way, west bank of Arthur Kill. (1885)	40	37	55.90	74	12	15.47
Standard Chemical Chimney. West bank of Arthur Kill. (1885)	40	36	54.00	74	12	21.73
Wynant (2). Hickory stub and buried bottle, Wynant's land, near Tremley R. R. station. (1885)	40	36	27.11	74	13	11.48
HUNTERDON COUNTY.						
Fox Hill. Stone monument, on summit, 2 miles N. E. of Califon. (B.)	40	43	56.31	74	47	59.45
Bethlehem. Masonry monument over Lehigh Valley R. R. tunnel. (B.)	40	38	49.95	75	01	18.99
Gravel Hill. Cross cut on rock on summit, 3 miles N. W. of Milford. (B.)	40	35	18.87	75	08	06.80
PICKLES. Stone monument, most southerly summit of mountain. (B.)	40	35	38.26	74	49	06.57
Readington. Reformed Church spire. (B.)	40	34	02.46	74	43	49.59
Cherryville. Stone monument, ¼ mile W. of village. (B.)	40	33	42.45	74	54	11.41
Croton. Stone monument on summit, 2 miles S. E. of village. (B.)	40	29	01.42	74	54	25.95
Three Bridges. Church spire. (B.)	40	31	20.53	74	47	29.89
Flemington. Methodist Church spire. (B.)	40	30	17.53	74	51	10.62
Pleasant Corner. Church spire. (B.)	40	26	25.98	74	51	04.55
Sand Ridge. Baptist Church spire. (B.)	40	25	20.45	74	56	54.99

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Sourland. White-oak stump, ½ mile W. of Amwell village. (B.)	40	25	48.96	74	45	19.50
GOAT HILL. Stone monument on summit, 1½ miles S. of Lambertville. (B.)	40	20	42.05	74	55	57.45
HAYCOCK, Pa. Summit, 2 miles S. of Bucksville. (B.)	40	29	16.09	75	12	50.97
Clarke's Spheroid. Difference			*+02.7*			*+19.6*
SOMERSET COUNTY.						
Bound Brook. Pile of stones on brow of First Mountain. (a. 1851)	40	34	56.66	74	31	37.57
Mine Mount. Bar of iron projecting 3 inches on summit, 2 miles W. of Bernardsville. (B.)	40	43	16.35	74	36	00.58
North Branch (?) (B.)	40	35	52.65	74	40	33.58
MT. HOREB. Copper bolt in ledge on summit, ½ mile S. W. of church. (B.)	40	36	39.37	74	33	56.57
Raritan. Woolen mill chimney. (B.)	40	33	52.02	74	37	37.32
Somerville. First Reformed Church spire. (B.)	40	34	03.78	74	36	21.72
Middlebush. Church spire. (B)	40	29	47.17	74	31	23.11
East Millstone. Reformed Church cupola. (B.)	40	30	07.44	74	34	27.65
Clarke's Spheroid. Difference			*+02.7*			*+19.7*
MIDDLESEX COUNTY.						
Williams (2) (?) (a. 1851)	40	34	51.18	74	12	31.94
Woodbridge (?) (a. 1851)	40	33	22.51	74	14	20.83
Woodbridge. Spire of Presbyterian Church. (a. 1859)	40	33	39.82	74	16	05.95
Zellis (2.) On hill, ½ mile S. of Woodbridge (?) (a. 1851)	40	32	43.02	74	16	17.64
Shotwell (?) (a. 1851)	40	32	45.43	74	15	01.06
BLOOMFIELD. Summit of Bloomfield's Hill, 2 miles E. of Metuchen. (a. 1851)	40	32	04.01	74	19	08.84
Perth Amboy. Episcopal Church spire. (a. 1859)	40	30	10.64	74	15	36.15
South Amboy. (a. 1851)	40	28	44.61	74	16	59.98
Morgan (?) (a. 1851)	40	28	01.06	74	15	39.33
Chestnaquack (?) (a. 1851)	40	27	37.43	74	14	43.39
Sandhills. Summit on New Brunswick and Trenton turnpike. (a. 1851)	40	24	27.30	74	32	19.08
Cranbury. Steeple First Presb. Church. (a. 1851)	40	18	23.68	74	30	48.32
New Brunswick. Rutgers College cupola. (B.)	40	29	52.73	74	26	28.12
Woodbridge Landing (?) (a. 1859)	40	32	43.23	74	14	59.71

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Fire-brick Works. A. Hall & Son's Ch'y, Perth Amboy. (a. 1859)	40	30	51.06	74	15	16.06
Perth Amboy. Presb. Church. (a. 1859)	40	30	18.09	74	15	37.80
South Amboy Depot. Pennsylvania R. R. (a. 1859)	40	29	26.32	74	16	15.58
Seward (?) (a. 1859)	40	28	52.90	74	16	13.05
Morgan (2) (?) (a. 1859)	40	28	08.05	74	15	36.15
Morgan (3) (?) (a. 1859)	40	28	05.18	74	15	33.80
Chestnaquack Point (2) (?) (a. 1859)	40	27	36.88	74	14	42.36
Clarke's Spheroid. Difference			*+02.7*			*+20.0*
Bayard. Bank of Arthur Kill, N. of Island View landing. Buried bottle. (1885)	40	35	01.66	74	12	43.94
Sawyer. Tuft's Point, N. bank Arthur Kill. Buried bottle. (1885)	40	33	38.86	74	13	26.27
Woodbridge. Spire of Presbyterian Church. (1885, same as a. 1851)	40	33	42.50	74	16	25.94
Hawk. 18 yards E. of Clark's creek. (1885)	40	33	41.77	74	14	25.40
Sewaren. Cedar stub, 160 yards N. of Sewaren hotel. (1885)	40	32	47.50	74	15	18.54
Boynton's Tile Works chimney. Near Woodbridge Landing. (1885)	40	32	26.58	74	15	21.56
MERCER COUNTY.						
Mount Rose. Top of mountain, ¾ mile E. of village. (184')	40	22	00.56	74	43	06.14
Poplar Ridge (?) (1840)	40	22	14.30	74	42	10.75
Mount Canoe. Buried cone on hill, 1¾ miles N. E. from Titusville (?) (1840)	40	19	37.76	74	51	19.98
Cold Soil (2) (?) (1840)	40	20	37.84	74	42	13.90
Pennington Seminary (cupola). (1840)	40	19	35.36	74	47	18.30
Princeton Seminary (cupola). (1840)	40	20	40.00	74	39	34.26
Princeton College (cupola). (1840)	40	20	52.06	74	39	15.26
Mapleton (2) (?) (1840)	40	21	08.62	74	36	23.83
Lawrenceville. Buried cone. Hill N. W. of village. (1840)	40	18	05.01	74	43	48.71
Lawrenceville (spire). (1840)	40	17	51.00	74	43	25.25
Hezel's Farm (2). Middle of New Brunswick and Trenton turnpike, 30 yards N. of Chas. Updeck's house. (1840)	40	18	02.77	74	40	08.69
Trenton. First Presb. Church spire. (1840)	40	13	10.23	74	45	29.54
White Horse (?) (1840)	40	11	10.70	74	42	07.51
Clarke's Spheroid. Difference			*+02.8*			*+19.6*

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
MONMOUTH COUNTY.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Matayan Point (?) (a. 1851)	40	26	50.28	74	12	19.53
Conasconck Point (?) (a. 1851)	40	27	30.90	74	10	24.21
Point Comfort (?) (a. 1851)	40	27	20.79	74	07	45.05
Compton (?) (a. 1851)	40	26	19.74	74	05	09.94
Sandy Hook (?) (a. 1851)	40	27	42.18	74	00	04.80
Sandy Hook Light-house. (a. 1859)	40	27	39.49	73	59	48.56
Pigeon Hill (?) (a. 1851)	40	24	24.49	74	04	23.33
Mount Mitchell. N. edge of Highlands. (a. 1851)	40	24	27.77	74	00	06.30
BEACON HILL. Hill 1 mile S. E. of Morganville. (1839)	40	22	23.74	74	13	22.06
Beers. Hill W. side of Keyport and Holmdel road. (1843)	40	23	30.96	74	11	06.29
Navesink (?) (a. 1851)	40	23	45.06	73	58	49.77
Navesink Light-house. (a. 1851)	40	23	42.43	73	58	48.62
Ocean House (flag-staff). (a. 1851)	40	22	51.74	73	58	13.90
Burdge. Hill N. bank of Navesink River. (1843)	40	22	59.43	74	01	25.80
Navesink (2) (?) (a. 1851)	40	23	15.34	73	58	53.50
Garriell. Hill 1 mile S. E. of Red Bank. (a. 1851)	40	20	31.69	74	02	45.79
Conover (?) (a. 1843)	40	20	38.28	74	01	07.42
Beach (1) (?) (a. 1851)	40	20	39.12	73	58	01.68
Beach (2) (?) (a. 1851)	40	20	11.87	73	58	02.84
Polhemus. Hill 2½ miles N. E. of Colt's Neck. (1843)	40	19	00.00	74	08	36.62
Shrewsbury spire. (a. 1851)	40	19	22.20	74	03	21.63
Liberty pole. Long Branch Village. (a. 1840)	40	17	55.55	73	59	52.30
DISBORO. Hill 1½ miles N. W. of Perrineville. (1840)	40	14	45.43	74	27	06.10
Baird. N. end Pine Hill, 1½ miles N. E. of Perrineville. (1840)	40	14	07.05	74	24	31.26
Debow. Hill 1 mile S. E. of Clarksburgh (?) (1840)	40	10	55.37	74	25	16.89
Freehold. Spire old court-house (?) (1840)	40	15	34.38	74	16	08.50
Grandon. Hill 2 miles E. of Freehold. (1840)	40	15	44.62	74	13	35.86
Throckmorton. Hill 2½ miles S. of Colt's Neck. (1836)	40	15	01.08	74	10	28.68
Lippencott. Hill 1½ miles N. of Shark River R. R. station (?) (1836)	40	15	17.63	74	07	18.27
West. Hill ¾ mile N. of Elberon R. R. station (?) (a. 1851)	40	16	16.24	73	59	34.71
Red Bog. On hill 2½ miles W. of Asbury Park. (a. 1851)	40	14	03.28	74	02	54.16
Newell. On hill 2 miles S. E. of Turkey. (a. 1851)	40	11	41.15	74	14	05.77
Highland of Squan (?) (a. 1851)	40	06	07.68	74	04	17.70
Sandy Hook signal (?) (a. 1859)	40	28	17.05	74	00	03.21
Conasconck Point (2) (?) (a. 1859)	40	27	30.60	74	10	24.74

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Wilson's Beacon. Back of Point Comfort. (a. 1859).	40	26	35.80	74	07	51.32
Light-house flag. Near Point Comfort. (a. 1859)	40	26	50.75	74	06	56.81
Matayan (?) (a. 1859)	40	26	48.37	74	12	18.90
Keyport spire. (a. 1859)	40	26	12.41	74	11	47.24
Conover's Beacon. (a. 1859)	40	25	14.21	74	03	01.39
Hilton (?) (a. 1859)	40	25	17.19	74	03	09.44
Carhart (?) (a. 1859)	40	25	01.13	74	02	11.66
Chapel Hill. Back Light. (a. 1859)	40	23	51.00	74	03	12.76
Chapel Hill. Light-house pole. (a. 1859)	40	23	51.68	74	03	12.67
Wilson (?) (a. 1859)	40	26	18.87	74	05	08.92
Clarke's Spheroid. Difference			*+02.8*			*+19.9*
BEACON HILL. (See above)	40	22	26.55	74	13	41.91
Throckmorton. (See above)	40	15	03.90	74	10	48.57
Garriell. (See above)	40	20	34.44	74	03	05.72
West. (See above)	40	16	18.98	73	59	54.71
Red Bog. (See above)	40	14	06.10	74	03	13.71
Red Bog (2) (?)	40	14	05.81	74	03	13.71
BURLINGTON COUNTY.						
Bordentown Observatory. (1840)	40	09	17.57	74	42	24.14
Bordentown flag-pole. (1840)	40	08	49.95	74	42	29.99
White Hill (?) (1840).	40	08	19.49	74	43	33.66
STONY HILL. Buried cone, with locust post at surface, on hill 1 mile S. of Ellisdale. (1840)	40	07	09.59	75	34	33.06
Clay banks (?) (1840)	40	07	14.49	74	47	33.41
King (?) (1840)	40	01	18.05	74	56	10.10
MOUNT HOLLY. Granite monument, top of mount. (1840)	40	00	06.12	74	46	59.70
Arney. Summit of Arney's Mount (?) (1840)	40	00	25.66	74	41	53.02
Woodside (?) (1840)	40	03	44.52	74	49	14.43
Moorestown spire. Episcopal Church. (1840)	39	57	42.27	74	56	42.09
Evesham. Summit of Mt. Laurel (?) (1840)	39	56	00.45	74	53	20.81
Rancocas (?) (1840)	40	02	33.10	74	58	20.84
Washington Hunter (1) (?) (1840)	40	00	52.51	74	58	48.73
Washington Hunter (2) (?) (1840)	40	00	52.73	74	58	57.20
Tuckerton. Near edge of upland E. of village (?) (a. 1851)	39	36	06.69	74	19	27.59
Cedar Hummock. On a well known small island in the marsh 2½ miles S. of Tuckerton (?) (a. 1851)	39	34	07.05	74	20	19.06
Clarke's Spheroid. Difference			*+03.0*			*+19.6*
Collegeville, Pa. (?) (1878)	40	02	44.22	75	01	01.96
Partridge, Pa. Jack Island, bank of Delaware. (1878)	40	03	16.62	74	58	33.33
Delanco Church spire. (1878)	40	02	58.11	74	57	25.15

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Delanco. Bank of Delaware at village. (1878)	40	02	46.15	74	57	46.20
Harrison's house cupola, Pa. (1878)	40	02	22.67	74	59	47.93
Pennypack, Pa. (?) (1878)	40	02	11.35	75	00	00.32
Hawk. S. W. end of Hawk Island, Riverside. (1878)	40	02	35.95	74	58	39.21
Fisher, Pa. Fisher's wharf, S. of Torresdale. (1878)	40	02	37.01	74	59	15.71
Plum. At water-edge on Plum Point. (1878)	40	01	56.99	74	59	26.61
Saint Vincent's school cupola, Pa. (1878)	40	01	21.10	75	01	53.09
House of Correction flag-staff, Pa. (1878)	40	01	43.63	75	00	58.73
House of Correction chimney, Pa. (1878)	40	01	48.94	75	01	04.44
Ten-Mile Point, Pa. (1878)	40	01	26.06	75	01	04.88
Tacony water tower. (1878)	40	01	42.92	75	02	41.24
Tacony. Methodist Church spire, Pa. (1878)	40	01	28.92	75	02	34.55
South's house cupola, Pa. (1878)	40	01	26.18	75	02	24.01
Bristol. Stone at Bristol street and Delaware avenue, Bridesburg, Pa. (1878)	39	59	22.64	75	04	13.22
Washington. Washington street and Delaware avenue, Tacony, Pa. (1878)	40	01	07.64	75	02	11.75
Disston's flag-staff, Tacony, Pa. (1878)	40	01	07.15	75	02	14.71
Disston's chimney, Tacony, Pa. (1878)	40	01	05.93	75	02	23.04
Fitler's chimney, Pa. (1878)	40	00	39.22	75	03	36.95
Frishmuth. On river bank, S. end of Riverton. (1878)	40	00	45.49	75	01	27.16
House of Correction, Tacony, Pa. Near S. corner of wharf. (1878)	40	01	30.72	75	00	52.76
Hunter's house. N. chimney of Clayton Cole's house, 1¼ miles S. E. from Riverton. (1878)	40	00	47.91	74	59	07.46
Lenning's round chimney, Pa. (1878)	40	00	21.34	75	03	40.29
Bridesburg, Pa. S. W. corner of Bridesburg wharf. (1878)	40	00	02.75	75	03	42.51
Lenning's square chimney, Pa.	40	00	15.74	75	03	36.57
Van Kirk. Van Kirk street, 370 feet S. E. of N. W. side of Delaware avenue, Bridesburg, Pa. (1878)	40	00	33.06	75	03	21.12
MOUNT HOLLY. Granite monument on top of the mount. (1840)	40	00	09.10	74	47	19.35
APPLE PIE HILL. Stone monument on summit of hill 3 miles S. W. of Shamong R. R. station. (1871)	39	48	26.62	74	35	23.83
Tuckerton. (See above.) (1866)	39	36	10.16	74	19	47.82
Cedar Hummock (2). (See above.) (1866)	39	34	10.58	74	20	39.31
MARTHA. Stone monument on summit 2½ miles E. of Martha Furnace. (B.)	39	40	35.87	74	28	13.12

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
OCEAN COUNTY.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Christopher. On a hill 1¾ miles S. E. of Lakewood, now a cemetery (?) (a. 1851)..	40	04	10.42	74	11	36.75
Green Island (?) (a. 1851).....	40	00	32.22	74	06	06.49
Fleming (?) (a. 1851).....	40	00	12.97	74	03	11.79
Page (?) (a. 1851).....	39	59	06.18	74	06	48.18
Stout (?) (a. 1851).....	39	57	34.71	74	04	15.43
Goose Creek (?) (a. 1851)	39	57	04.97	74	06	20.38
Cranberry (?) (a. 1851).....	39	56	37.21	74	03	58.55
Good Luck Point (?) (a. 1851)...	39	55	18.58	74	06	47.10
Philipp (?) (a. 1851)	39	53	50.37	74	04	25.90
Cedar Creek (?) (a. 1851)	39	51	44.44	74	07	52.94
Forked River (?) (a. 1851).	39	49	19.83	74	09	08.41
Island Beach (?) (a. 1851)	39	49	02.52	74	05	08.73
Barnegat Inlet (?) (a. 1851)	39	45	55.47	74	05	55.43
Barnegat Light-house (a. 1851). Old position; for new light-house, see below.....	39	45	57.21	74	06	02.20
Double Creek (?) (a. 1851).	39	44	24.84	74	10	20.39
Hickory Island (?) (a. 1851).....	39	41	11.94	74	12	43.12
Great Swamp (?) (a. 1851).	39	40	39.53	74	08	39.32
Dinner Point (?) (a. 1851).....	39	37	57.40	74	14	54.94
Hickey (?) (a. 1851).....	39	37	34.20	74	11	03.36
Cramer (?) (a. 1851)	39	35	09.24	74	12	52.76
Long Beach (?) (a. 1851)	39	33	15.89	74	14	21.23
Clarke's Spheroid. Difference			*+03.0*			*+20.0*
Whiting's Hotel, flag-staff. (1873)	39	57	13.04	74	22	46.62
BALCONY. Buried jug at summit 2 miles S. W. of Whitings. (1871).....	39	55	27.09	74	23	40.94
RIDGEWAY. Summit N. side of Cedar Bridge road, 5½ miles N. W. from Barnegat. (1872).....	39	46	34.43	74	19	33.26
BARNEGAT LIGHT-HOUSE. Present light-house. (1873).....	39	45	51.61	74	06	23.78
Barnegat. Methodist Church spire. (1873)	39	45	09.81	74	13	20.04
Gowdy's house. Cupola of Mr. J. G. Gowdy's residence, 1 mile E. of Toms River. (1873)	39	57	11.73	74	10	34.90
CAMDEN COUNTY.						
Fishcove (Hatchis) (?) (a. 1851).....	39	58	20.87	75	03	33.67
Woods Point (?) (a. 1851).....	39	57	25.27	75	05	19.23
Walnut Street Ferry (?) (a. 1851).....	39	56	34.08	75	07	27.22
Kaighn's Point (?) (a. 1851).....	39	55	42.89	75	07	33.04
Cooper's Point (?) (a. 1851).....	39	57	12.58	75	07	22.69
Haddonfield. Hill 1 mile S. of village (?) (a. 1851)	39	52	50.37	75	02	03.80
Gibbsboro (?) (a. 1851).....	39	50	17.57	74	56	39.88

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
	Deg.	Min.	Sec.	Deg.	Min.	Sec.
PINE HILL. Granite monument N.W. brow of hill ½ mile S. of Clementon. (1840)...	39	47	51.03	74	59	16.50
Morris Hill (?) (a. 1851).	39	59	21.78	75	02	17.26
Camden Church spire. (a. 1851).	39	56	41.06	75	07	10.19
Gloucester Point (?) (a. 1851)	39	53	46.11	75	07	27.36
Fish Club flag-staff (?) (a. 1851)	39	53	13.54	75	07	24.32
Powder Wharf (?) (a. 1851)	39	54	10.47	75	07	43.73
Mickle (?) (a. 1851).	39	54	37.24	75	07	02.97
Girard College, Philadelphia, Pa. (a. 1851)	39	58	23.58	75	09	54.09
State House spire, Philadelphia, Pa. (a. 1851)	39	56	52.61	75	08	41.90
Clarke's Spheroid. Difference			*+03.0*			*+19.5*
Frankford Pumping Station ch'y, Pa. (1878)	40	00	50.61	75	02	51.83
Frankford Catholic Church cross, Pa. (1878)	40	00	42.48	75	05	25.03
Horner. Buried terra-cotta pipe, 800 yards N. E. from Camden Water Works and 150 yards back from river bank. (1878).	39	57	40.85	75	05	42.31
Jenks. Jenks street and Delaware avenue, Bridesburg, Pa. (1878).	39	59	52.82	75	03	53.26
Morris (2). On hill just E. of Morris R. R. station. (1878).	39	59	23.70	75	02	36.51
Tioga (2), Pa. S. W. butting pile, end of Elevated R. R. track, Gas Works wharf, Tioga street, Philadelphia. (1878).	39	58	45.36	75	05	14.26
Fairview. Terra-cotta pipe buried 170 feet N. E. of Hatch Bros.' brick yard chimney, E. side of R. R. cut, Fish House station (1878).	39	58	28.13	75	03	56.89
Pike, Pa. Pike street and Delaware avenue. (1878)	39	59	05.80	75	04	45.48
BERLIN. Stone monument, on summit 2 miles N. E. of village. (B.).	39	48	55.85	74	54	45.07
GLOUCESTER COUNTY.						
Big Timber Creek (?) (a. 1851).	39	52	42 68	75	07	45.54
Red Bank flag-staff. (a. 1851)	39	52	17.35	75	11	01.59
Woodbury Creek (?) (a. 1851).	39	51	50.06	75	11	33.29
Mathew (?) (a. 1851).	39	51	16.54	75	12	23.33
Billingsport (?) (a. 1851)	39	51	00 24	75	14	15.88
Isaac (?) (a. 1851)	39	50	44.84	75	15	23.37
Chew. Hill 1 mile N. of Mantua (?) (a. 1851).	39	48	13.89	75	09	42.28
Oldman Creek (?) (a. 1851)	39	47	01.84	75	25	33.11
Opposite Marcus Hook (?) (a. 1851).	39	47	39.07	75	24	02.17
Tonkin's Island. West (?) (a. 1851).	39	48	48.96	75	22	31.28
Tonkin's Island. East (?) (a. 1851).	39	49	11.40	75	21	40.94
Man Island (?) (a. 1851)	39	50	19.67	75	19	08.59
Thompson Point (?) (a. 1851)	39	50	31.83	75	18	04.50
Crab Creek (?) (a. 1851).	39	50	36.40	75	17	20.33
Eagle Point (?) (a. 1851)	39	52	39.28	75	09	41.21
Opposite Chester (?) (a. 1851)	39	49	40.27	75	20	20.24

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Robbins (2). (1843)	39	44	31.29	75	19	42.75
Scull (1). (1843)	39	43	30.01	75	20	22.73
LIPPENCOTT. On hill 2 miles S. of Swedesboro. (1843)	39	43	17.44	75	18	30.36
Swedesboro spire. Epis. Church. (1843)	39	44	58.94	75	18	07.32
Caffery. ½ mile S. E. from Clarksboro. (1843)	39	47	28.44	75	12	59.73
West. 2 miles from Mullica Hill, summit of road to Mantua. (1843)	39	45	36.73	75	12	00.61
Fort Mifflin flag-staff, Pa. (a. 1851)	39	52	28.57	75	12	25.88
Chester Roman Cath. Church, Pa. (a. 1851)	39	51	02.20	75	21	19.52
Clarke's Spheroid. Difference			*+03.1*			*+19.4*
LIPPENCOTT. (See above.) (1843)	39	43	20.56	75	18	49.81
ATLANTIC COUNTY.						
Leed's Point. ½ mile S. of hotel (?) (a. 1851)	39	28	58.63	74	25	39.63
Little Egg Harbor Light. (a. 1851)	39	30	18.41	74	16	48.02
Brigantine Beach (?) (a. 1851)	39	25	48.98	74	19	37.01
Absecom. On point 1 mile S. E. of Absecon village (?) (a. 1851)	39	25	08.55	74	29	06.57
Peter's Beach. 1 mile N. E. of Absecon inlet (?) (a. 1851)	39	23	16.50	74	24	01.60
Risley's Landing. On Lake's Bay (?) (a. 1851)	39	22	48.75	74	31	11.49
Dry Inlet (?) (a. 1851)	39	20	31.28	74	27	57.42
Leedsville. Near edge of upland E. of Linwood. (a. 1851)	39	20	52.82	74	33	19.98
New Inlet (?) (a. 1851)	39	19	08.49	74	30	30.65
Somers' Point (?) (a. 1851)	39	18	38.78	74	35	02.95
Clarke's Spheroid. Difference			*+03.7*			*+20.3*
Oyster creek (?) (1867)	39	30	27.04	74	24	35.04
Leed's Point (?) (1867). (See above)	39	29	02.37	74	26	00.00
Absecom (?). (See above.) (1867)	39	25	12.43	74	29	27.03
Ryon (?) (1867)	39	22	45.09	74	31	33.70
Absecom. Light-house. (1867)	39	21	58.74	74	24	52.27
Leedsville (?) (1867)	39	20	55.88	74	33	39.42
Grove (?) (1867)	39	20	03.74	74	30	17.18
Linwood (?) (1867)	39	20	54.06	74	33	38.76
Fish (?) (1867)	39	18	39.50	74	32	34.26
Somers' Point (?) (1841)	39	18	41.90	74	35	22.46
Somers (2) (?) (1867)	39	18	42.68	74	35	23.39
River. (1883)	39	18	23.07	74	37	12.11
Ocean. (1883)	39	17	18.69	74	34	13.14
New Inlet (?)	39	19	11.58	74	30	50.17
HAMMONTON. Stone monument, on hill S. side of C. & A. R. R., 1¼ miles N. W. of village	39	38	48.05	74	49	19.29
BLANGIE. Stone monument, on summit, 2¾ miles N. E. of May's Landing	39	28	44.36	74	41	16.71

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
SALEM COUNTY.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Oldman's Point (?) (1843)	39	45	37.24	75	27	21.92
Penn's Grove (?) (1843)	39	43	59.74	75	28	19.10
Church Landing Point (?) (1843)	39	39	36.75	75	31	00.87
Allen. Buried cone on hill 1½ miles S. W. of Auburn. (1843)	39	41	14.14	75	22	28.26
Scull (2). Buried cone, 2 miles N. from Sharpstown (?)	39	40	56.57	75	20	32.89
Ellet. Buried cone, 2½ miles from Sharpstown, on land of Widow Ellet. (1843)	39	38	19.55	75	23	37.05
Reeves (?) (1843)	39	39	03.38	75	22	46.20
Acton. Buried cone, 2 miles E. of Sharpstown, on land of Widow Acton (?) (1843)	39	38	08.61	75	22	45.32
Big Mannington Hill. Buried cone, 3 miles S. W. of Woodstown (1843)	39	36	54.09	75	21	21.79
Kimsey (?) (1843)	39	38	03.11	75	33	02.74
Finn's Point. Bank of Delaware (?) (1841)	39	35	58.11	75	32	45.92
Penn's Neck (?) (1843)	39	35	38.05	75	32	16.88
Fort Delaware, Del. (1839)	39	35	18.79	75	33	49.20
Salem spire, Episcopal Church. (1841)	39	34	25.42	75	27	37.98
Elsinborough Point. In old Swedish fort. (1841) (?)	39	32	21.74	75	31	44.41
Alloway's Point. Buried cone, 147 yards N. of mouth of Alloway's creek (?) (1840)	39	30	04.77	75	31	30.83
BURDEN. 2½ miles S. E. from Quinton, and 300 yards W. of the cross-roads (?) (1840)	39	31	45.74	75	22	33.40
Stony Point (?) (1840)	39	27	29.89	75	30	49.85
Round Island (?) (1840). (See below)	39	25	18.79	75	27	13.74
Arnold (?) (1840)	39	23	14.78	75	25	40.49
Wilmington Light-house. (1841)	39	43	15.25	75	30	55.69
Wilmington town hall, Del. (1841)	39	44	26.56	75	32	42.43
Delaware City. Presbyterian Church spire, Del. (1841)	39	34	38.14	75	35	17.59
New Castle. Episcopal Church spire, Del. (1841)	39	39	35.71	75	33	27.34
Clarke's Spheroid. Difference			*+03.2*			*+19.4*
Finn's Point (2). Bank of Delaware (1875)	39	36	00.15	75	33	02.57
Finn's Point. Bank of Delaware (?) (1841)	39	36	01.32	75	33	05.22
Salem Presbyterian Church spire	39	34	24.10	75	27	59.28
Salem Episcopal Church spire. (See above)	39	34	28.58	75	27	57.30
Elsinborough. (See Elsinborough above) (1841)	39	32	24.91	75	32	03.76
Elsinborough (2). (1875). Pine stub, near old Elsinborough (?)	39	32	26.33	75	32	03.54
Elsinborough (3). (1881). 90 yards N. of last point	39	32	27.48	75	32	03.46
Alloway. (See Alloway above)	39	30	07.97	75	31	50.20
Alloway (2). Pine stub, 174 yards above mouth of Alloway's creek	39	30	08.53	75	31	48.25
Alloway (3)	39	30	15.97	75	31	48.92

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
	Deg.	Min.	Sec.	Deg.	Min.	Sec.
BURDEN. (See Burden above.)	39	31	48.93	75	22	52.85
Stony (?)	39	27	33.11	75	31	09.25
Stony (2) (?)	39	27	47.42	75	31	12.55
Stony (3). Drain-pipe planted 5 feet from high-water mark. Stony Point. (1882)	39	28	01.83	75	31	16.12
Round Island. Buried cone in marsh. (1840) (?)	39	25	22.02	75	27	33.17
Round Island (2).	39	25	27.04	75	27	36.01
Sneed (?) (1882)	39	27	32.96	75	31	01.94
Cove (?) (1882)	39	26	13.73	75	28	18.14
Pot. Drain-pipe 20 feet back from high-water mark. (1882)	39	29	06.11	75	31	27.73
Arnold. Arnolds Point (?) (1840)	39	23	18.03	75	25	59.93
Arnold (2)	39	23	17.37	75	25	55.00
Arnold (3). Arnolds Point. Drain-tile planted in marsh 80 yards back from shore-line. (1881)	39	23	18.65	75	25	54.34
Round. Drain-tile planted in marsh. (1882)	39	25	36.85	75	27	39.52
Fort Delaware (2), Del. (1875)	39	35	20.30	75	34	04.05
Stow (?) (1882)	39	22	50.27	75	24	51.89
New (?) (1882)	39	24	09.65	75	26	35.13
Fort Delaware, Del. (See above)	39	35	22.04	75	34	08.60
Reedy Island Light-house. (1881)	39	30	03.37	75	34	08.76
Delaware City Presbyterian Church spire, Del. (1840)	39	34	41.37	75	35	37.30
CUMBERLAND COUNTY.						
Barker (?) (1839)	39	26	16.76	75	21	45.94
PINE MOUNT (?) (1839)	39	25	00.57	75	19	56.46
Harris (?) (1839)	39	25	06.89	75	17	16.25
Hann (No. 2) (?) (1839)	39	25	24.01	75	15	07.01
Buck (?) (1839)	39	25	07.50	75	13	16.99
Greenwich (?) (1839)	39	23	24.39	75	20	21.71
Davis (?) (1839)	39	22	37 32	75	20	11.84
Heusted (No. 2) (?)	39	22	55.14	75	18	38.64
Wheaton (?) (1839)	39	23	26.60	75	19	05.89
Mount Pleasant. N. side Cohansey Creek, 3 miles below Bridgeton. (1839) (?)	39	23	21.96	75	15	02.76
Bush Hill (?) (1842)	39	23	56.56	75	15	23.71
Garrison (?) Hill E. side of Bridgeton and Fairton road. (1840)	39	23	33.66	75	13	02.91
Dunk's Beach (?) (1839)	39	20	32.91	75	21	50.90
Dayre (?) (1839)	39	21	44.55	75	19	53.57
Sheppard (?) (1839)	39	22	38.22	75	21	03.34
Cohansey Light-house. Old light-house. (1840)	39	20	18.39	75	21	17.48
Big Island. Buried cone. (1839)	39	19	45.61	75	18	14.08
West Point (?) (1840)	39	19	03.05	75	15	10.69
Ben Davis (?) (1839)	39	17	12.09	75	17	09.57

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Eagle Island (?) (1840)	39	17	46.00	75	14	07.56
Nantuxent (?) (1840)	39	16	33.54	75	14	25.95
Flax Farm (?) (1840)	39	16	33.25	75	12	54.39
JOSCELYNE (?) (1840)	39	18	37.02	75	08	03.49
Turkey Point (?) (1840)	39	14	55.97	75	07	21.46
Fortesque (?) (1840)	39	14	09.39	75	09	59.99
Egg Island Point (?) (1841)	39	10	23.53	75	07	49.00
Egg Island Light-house. (1840.) Old light-house, now destroyed	39	10	30.89	75	08	01.74
Oranoken (?) (1840)	39	12	04.47	75	06	24.62
Egg Island Point (?) (?)	39	10	21.79	75	07	45.94
Dividing Creek. Buried cone, S. side of creek, ¾ mile below bridge. (1840)	39	15	16.96	75	05	04.11
Port Norris (?) (1839)	39	14	33.03	75	00	57.47
East Point (?) (1840)	39	11	28.35	75	00	58.06
Elder Point (?) (1842)	39	12	39.59	75	02	32.32
Bird Island (?) (1842)	39	11	44.34	75	01	09.96
Tomlin (?) (1842)	39	13	43.58	74	59	49.96
Wiggins (?) (1842)	39	14	33.23	74	59	47.70
Robinson (?) (1842)	39	11	23.73	74	59	22.90
West Creek (?) (1842)	39	10	27.02	74	54	44.79
Carlisle (?) (1842)	39	12	03.25	74	56	48.15
Bombay Hook Light-house, Del. (1840)	39	21	46.22	75	30	18.92
Mahon's River Light-house, Del. (1840)	39	10	16.40	75	23	43.43
Clarke's Spheroid. Difference			*+03.1*			*+19.4*
Barker (?) (1839)	39	26	19.96	75	22	05.40
PINE MOUNT (?) (1839)	39	25	03.79	75	20	15.94
John Dayre. Buried cone, 1½ miles N. E. of Bridgeton (?) (1840)	39	26	23.79	75	12	46.93
Hawkins (?) (1839)	39	25	35.42	75	20	40.87
Hann. Buried cone, S. side of Bridgeton and Bowentown road. (1839)	39	25	27.09	75	15	26.63
Buck (?) (1839)	39	25	10.71	75	13	36.54
Harris (?) (1839)	39	25	10.11	75	17	35.77
Wheaton (?) (1839)	39	23	29.83	75	19	25.40
Hann (2) (Same as Hann, nearly) (?)	39	25	27.22	75	15	26.55
Greenwich (?) (1839)	39	23	27.61	75	20	41.20
Bush (?) 1839	39	23	59.79	75	15	43.25
Sheppard (?) (1839)	39	22	41.43	75	21	22.81
Davis (?) 1839	39	22	40.55	75	20	31.34
Heusted (?)	39	22	58.37	75	18	58.15
Heusted (2) (?)	39	22	58.36	75	18	58.15
Mt. Pleasant (?)	39	23	25.17	75	15	22.30
Bridgeton spire. (1840)	39	25	46.48	75	13	57.71
Laurel (?)	39	26	21.44	75	13	43.04
Woodruff. N. side of Bridgeton and Millville road, 1 mile W. of Millville township line (?) (1840)	39	24	49.75	75	08	47.25
Cedarville spire. (1840)	39	20	01.99	75	12	07.72
Cedarville. Summit N. E. of new brick church (?) (1840)	39	20	38.48	75	11	50.65

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Fairton. Buried cone on Theoph. Harris' land. (1839) (?)	39	22	33.37	75	13	12.26
Ogden (?) (1839)	39	22	06.57	75	15	28.23
Jacob's creek (2). 1½ miles N. of Cohansey light-house. Cedar stub. (1875)	39	21	40.07	75	23	38.25
Jacob's creek (?)	39	21	37.25	75	23	36.45
Dunck's Beach. On sand ridge, ½ mile N. of Cohansey light-house	39	20	36.17	75	22	10.38
Dunck's Beach (2)	39	20	36.34	75	22	10.63
Dayre (?)	39	21	47.78	75	20	13 07
Cohansey Light-house. (1840). Disused	39	20	21.64	75	21	36.98
Big Island. Buried cone. (1839) (?)	39	19	48.86	75	18	33.60
Sea Breeze. Warner House flagstaff. (1882)	39	19	26.71	75	19	14.83
Garrison (?) (1840). (Same as previous)	39	23	36.88	75	13	22.47
West Point (?) (1840). (Same as previous)	39	19	06.31	75	15	30.23
Ben Davis (?) (1839). (Same as previous)	39	17	15.36	75	17	29.10
Ben Davis (2) (?)	39	17	18.36	75	17	26.98
Eagle Island (?) (1840). (Same as previous)	39	17	49.26	75	14	27.10
Nantuxent (?) (1840). (Same as previous)	39	16	36.81	75	14	45.49
Flax Farm (?) (1840). (Same as previous)	39	16	36.52	75	13	13.95
JOSCELYNE (?) (1840). (Same as previous)	39	18	40.25	75	08	23.09
Ben. Drain-pipe sunk in sand at extreme high-water mark, Ben Davis Point. (1882)	39	17	18.47	75	17	26.97
Nan. Drain-pipe and cement below mouth of Nanticoke creek. (1882)	39	16	40.53	75	14	46.80
Dyer's Cove. Drain-pipe planted in marsh. (1882)	39	16	06.54	75	13	42.42
Turkey Point (?) (1840). (Same as previous)	39	14	59.23	75	07	41.06
Bradford's Point. Terra-cotta pipe, ¼ mile below Padget's Creek. (1881)	39	15	56.35	75	11	53.95
Fortesque. Pavilion flag-staff. (1882)	39	14	12.23	75	10	19.14
Fortesque. Big flag-staff. (1882)	39	14	15.38	75	10	14.22
Fortesque (?) (1840)	39	14	12.65	75	10	19.60
Fortesque (2). Terra-cotta pipe on sand hill 332 feet S. E. of pavilion. (1881)	39	14	07.19	75	10	16.10
Dividing Creek (?) (1840). (Same as previous)	39	15	20.22	75	05	23.72
Oranoken (?) (1840). (Same as previous)	39	12	07.74	75	06	44.21
False Point (?) (1840)	39	12	00.55	75	10	17.92
False Egg Point, at high-water mark. (1882)	39	12	01.23	75	10	11.92
Egg Island Light-house. (1882)	39	10	43.82	75	08	13.22
Port Norris. Buried cone, land of Harriet Ogden. (1839)	39	14	36.29	75	01	17.09
Elder Point (?) (1842)	39	12	42.86	75	02	51.93
Bird Island. (1842)	39	11	47.61	75	01	29.58
Wiggins. (1842.) (Same as previous)	39	14	36.49	75	00	07.31
Tomlin. (1842.) (Same as previous)	39	13	46.84	75	00	09.58
East Point. On sand hill 1½ miles E. of Maurice river (?)	39	11	31.62	75	01	17.70
Tripod (?)	39	12	36.04	75	02	43.10

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Maurice River West. Buried cone, west side of river mouth. (1840) (?)	39	12	43.20	75	02	53.16
Robinson (?) (1842)	39	11	27.01	74	59	42.54
Egg Island (2)	39	10	25.07	75	08	05.52
Maurice River Light-house. (1877)	39	11	45.23	75	01	39.53
Carlisle. Buried cone (1842) on farm of Wm. Carlisle, of Leesburg	39	12	06.52	74	57	07.80
West Creek (1842)	39	10	30.30	74	55	04.47
West Creek (2). (1881)	39	10	37.79	74	54	58.35
Elmer (?)	39	22	13 17	75	09	09.39
Ship John Light-house. (1882)	39	18	19.10	75	22	37.08
Bombay Hook Light-house. (1882)	39	21	49.49	75	30	38.34
CAPE MAY COUNTY.						
Stipson (?) (1842)	39	11	51.41	74	54	18.31
Ludlam's Landing. N. side of Dennis Creek (?) (1842)	39	10	38.46	74	50	50.00
McCrea (?) (1842)	39	09	49.32	74	50	26.09
Goshen (?) (1842)	39	07	36.35	74	53	10.93
Pierce's Landing (?) (1842)	39	04	54.33	74	54	05.78
Fishing Creek (?) (1842)	39	01	04.08	74	56	32.26
Higbee (?) (1842)	38	57	14.12	74	57	31.95
Cape May Old Light-house. (a. 1851)	38	55	48.64	74	57	38.90
Cape May New Light-house. (a. 1851)	38	55	50.42	74	57	15.57
Congress Hall. (a. 1851)	38	55	51.01	74	55	09.77
Week's Landing (?) (1851)	38	58	55.59	74	52	49.60
Two-mile Beach (?) (a. 1851)	38	57	26.13	74	50	40.10
Leaming's Point (?) (a. 1851)	39	00	56.64	74	50	58.48
Town Bank (?) (a. 1851)	38	58	36.94	74	57	21.96
Crese (?) (a. 1851)	39	03	00.05	74	49	28.91
Nummy's Island (?) (a. 1851)	39	01	39.50	74	47	09.31
Cyrus (?) (a. 1851)	39	04	28.55	74	44	01.20
Eldridge (?) (a. 1851)	39	06	03.41	74	47	17.07
Holmes (?) (1840)	39	07	32.71	74	45	53.73
Leamings Beach North (?) (1840)	39	06	26.06	74	42	12.54
Townsend (?) (1840)	39	10	23.84	74	43	09.98
Ludlam's Beach (?) (1840)	39	08	41.50	74	41	29.69
Corson (?) (1840)	39	13	41.40	74	40	35.77
Mountain Creek (?) (1840)	39	11	42.80	74	38	51.74
Weakfish Creek (?) (1840)	39	13	28.80	74	37	38.73
Blackman (?) (1840)	39	15	04.74	74	39	13.93
Beasley's Point (?) (1840)	39	16	46.91	74	37	21.48
Peck's Beach (?) (1840)	39	16	11.77	74	34	51.52
Cape Henlopen Light-house, Del. (a. 1851)	38	46	38.35	75	04	43.24
Clarke's Spheroid. Difference			*+03.2*			*+19.6*
Beasley's Point (?) (1840)	39	16	50.07	74	37	41.01
Beasley's (2). (1884)	39	17	02.53	74	37	00.20
Blackman (?) (1840)	39	15	07.92	74	39	33.47
Corson (?) (1884)	39	12	01.01	74	39	21.35
Corson (?) (1840)	39	13	44.60	74	40	55.32

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Stipson Island (?) (1842)	39	11	54.67	74	54	38.00
Ludlam's Landing (?) (1842)	39	10	41.75	74	51	09.74
McCrea. (1842)	39	09	52.62	74	50	45.96
Goshen. (1881)	39	07	39.64	74	53	30.63
Public. (1884)	39	09	03.43	74	44	48.17
Tatham. (1884)	39	06	20.34	74	43	31.72
View. (1884)	39	10	39.38	74	43	11.40
Isle. (1884)	39	10	36.65	74	40	32.66
Marshall. (1884)	39	12	13.47	74	41	47.00
Sea. (1884)	39	08	59.50	74	42	15.64
Town Bank. Hotel cupola. (1881)	38	59	14.32	74	57	30.84
Hammock. (1881)	39	07	00.00	74	53	30.65
Young. (1884)	39	13	48.24	74	40	19.20
Cedar. (1884)	39	13	34.08	74	38	12.08
Heart. (1884)	39	15	34.23	74	38	35.80
Road. (1884)	39	15	05.28	74	36	53.77
Eldridge (2). Cedar stub, Ephraim Eldridge's bay front. (1881)	39	06	06.63	74	47	36.46
Limerick Chimney. Tallest on old dwelling, Tatham's Beach. (1881)	39	05	43.37	74	43	23.69
Peck's Beach (?) (1840)	39	16	14.93	74	35	11.10
Cape May Court-house spire	39	04	53.00	74	49	29.00

Geographical Positions Determined by the State Survey.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
SUSSEX COUNTY.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
To reduce to Clarke's Spheroid add			*02.5*			*19.6*
Lemon's House. W. of Swartswood	41	04	50.1	74	51	22.8
Hardwick. Church cupola	40	59	41.6	74	51	19.4
Tranquility. Church spire	40	56	36.2	74	47	54.4
Andover, ¼ mile W. of village	40	59	07.3	74	44	29.8
Milford flag, Pa. Hill just N. E. of village	41	19	42.2	74	47	16.6

Geog. Positions Determined by the State Survey—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
	Deg.	Min.	Sec.	Deg.	Min.	Sec.
WARREN COUNTY.						
To reduce to Clarke's Spheroid add			*02.6*			*19.5*
Hope. Church spire	40	54	29.3	74	57	52.2
Warrenville. 1 mile S. W. of village	40	53	50.4	74	50	02.1
Jenny Jump Mountain	40	51	59.6	74	59	01.3
Belvidere. Presbyterian Church spire	40	49	34.0	75	04	23.4
Mt. No More	40	48	01.2	75	01	16.9
White Hall. ¼ mile S. W. of cross-roads	40	42	26.8	74	53	41.1
Easton. Court-house spire	40	41	15.4	75	12	44.2
Washington. Old chimney, bank of canal	40	45	53.0	74	58	57.7
Pohatcong Mountain	40	42	25.8	75	02	45.7
MORRIS COUNTY.						
To reduce to Clarke's Spheroid add			*02.6*			*19.7*
Seward's Hill. Chester cross-roads	40	47	10.2	74	40	15.5
Parsippany. Church spire	40	51	50.1	74	24	04.5
PASSAIC COUNTY.						
To reduce to Clarke's Spheroid add			*02.6*			*19.8*
Wayne. Powder-mills chimney	40	55	27.5	74	16	13.7
BERGEN COUNTY.						
To reduce to Clarke's Spheroid add			*02.6*			*19.8*
Darlington. E. edge of Ramapo Mountain	41	04	40.1	74	12	13.0
Ramsey's. Church tower	41	03	31.0	74	08	12.4
Wykoff. Church spire	41	00	25.1	74	10	06.2
Paramus. Church spire	40	59	04.5	74	05	13.6
Midland Park. Church tower	40	59	24.2	74	08	11.8
Schraalenburg. Church spire	40	56	22.5	73	59	20.7
ESSEX COUNTY.						
To reduce to Clarke's Spheroid add			*02.6*			*19.8*
Fairfield. Church spire	40	53	01.8	74	16	38 2
Caldwell. Flag	40	50	21.5	74	15	04.9
SOMERSET COUNTY.						
To reduce to Clarke's Spheroid add			*02.7*			*19.7*
Lamington. Church spire	40	39	35.5	74	42	52.5
Pluckamin. Church spire	40	38	49.9	74	38	13.0
Bedminster. Church cupola	40	40	12.0	74	38	23.5
North Branch. Reformed Church spire	40	35	53.9	74	40	02.7

Geog. Positions Determined by the State Survey—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
HUNTERDON COUNTY.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
To reduce to Clarke's Spheroid add			*02.7*			*19.6*
Pottersville	40	42	22.1	74	43	46.5
Readington. Church spire	40	34	02.5	74	43	49.6
Cherryville. Spire.	40	33	42.0	74	53	55.9
Quakertown. Spire	40	33	50.2	74	56	11.9
Cushetunk	40	37	22.1	74	48	07.3
Mechanicsville. Church spire	40	37	08.5	74	44	40.8
Cornhill	40	22	21.08	74	54	23.1
Rosemont. Spire	40	25	36.7	74	59	06.8
All Stations below are on Clarke's Spheroid.						
UNION COUNTY.						
Westfield. Presbyterian Church spire	40	39	14.1	74	20	52.7
Cranford. Presbyterian Church spire	40	39	28.1	74	18	11.6
Roselle. Flag-staff.	40	39	37.0	74	15	50.4
Elizabeth. First Presbyterian Church spire	40	39	45.6	74	12	56.8
Elizabeth. St. Mary's Church spire	40	39	29.9	74	13	7.8
Washington Rock. (North rock)	40	36	45.7	74	28	20.9
Netherwood. Hotel	40	37	33.7	74	24	0.4
Dunellen. Spire.	40	35	39.9	74	27	50.2
New Dover. Spire.	40	35	7.2	74	20	26.4
Rahway. First Presbyterian Church spire	40	36	53.8	74	16	51.8
Rahway. Second Presbyterian Church spire	40	36	31.8	74	16	34.1
Linden. Reformed Church spire	40	38	2.6	74	15	32.2
Linden. Episcopal Church spire.	40	37	39.7	74	15	07.0
Bay Way. Staten Chemical Co.'s chimney	40	37	56.0	74	12	15.3
MIDDLESEX COUNTY.						
Menlo Park. Tall iron stack	40	33	49.0	74	20	22.5
Van Keuren's house. 1 mile S. W. of Newtown	40	32	16.4	74	28	06.2
Metuchen. Presbyterian Church spire	40	32	25.7	74	21	34.5
Rutgers College cupola, New Brunswick	40	29	55.4	74	26	47.7
St. Jame's spire. New Brunswick	40	29	38.0	74	26	53.9
Stelton. Church spire	40	31	1.5	74	24	26.0
Kreicher's chimney, Staten Island	40	31	57.1	74	14	28.8
Tottenville. Cupola, Staten Island	40	30	30.9	74	14	37.9
State Reform School tower.	40	20	35.6	74	23	55.6
Dayton. Church spire	40	22	32.8	74	30	43.7
Cranbury. First Presb. Church spire	40	18	26.4	74	31	08.3
Cranbury. Second Presb. Church spire	40	18	50.4	74	30	51.6

Geog. Positions Determined by the State Survey—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
MONMOUTH COUNTY.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Freehold. Court-house spire	40	15	37.3	74	16	29.6
Freehold. Reformed Church spire	40	15	28.0	74	16	42.4
Key East Hotel, flag-staff	40	11	29.6	74	00	37.8
Colorado House. Ocean Beach	40	10	23.8	74	00	57.5
Beach House, Sea Girt, N. flag-staff	40	07	34.8	74	01	49.9
Disbrow Hill	40	14	48.0	74	27	26.1
Allentown. Reformed Church spire	40	10	27.1	74	35	14.6
MERCER COUNTY.						
Princeton water-tower	40	20	23.5	74	40	03.5
Princeton College cupola	40	20	55.0	74	39	35.1
Lawrenceville stand-pipe	40	17	31.9	74	44	10.9
Ewing Church spire	40	16	14.4	74	48	02.5
East Trenton. Rubber Works chimney	40	14	23.0	74	43	39.0
Trenton. State and Clinton street spire	40	13	16.8	74	45	21.3
Trenton. State House dome	40	13	13.8	74	46	13.1
Trenton. State Street Meth. Church spire	40	13	13.5	74	45	36.7
Trenton. Roman Catholic Church, Broad and Centre streets	40	12	51.5	74	45	40.6
Trenton. Bapt. Church, Centre and Bridge streets	40	12	41.4	74	45	36.4
Hamilton Square Baptist Church	40	13	46.1	74	39	37.3
Dutch Neck spire	40	16	57.5	74	36	50.3
Windsor spire	40	14	34.5	74	34	57.7
BURLINGTON COUNTY.						
Bordentown. Baptist Church spire	40	08	48.7	74	42	50.1
Bordentown. Presbyterian Church spire	40	08	36.5	74	42	37.1
Crosswicks. Spire	40	09	16.3	74	39	02.1
Florence. Foundry chimney	40	07	31.1	74	49	05.6
Burlington. St. Mary's spire	40	04	37.8	74	51	43.6
Bishop's barn. E. of Columbus	40	03	47.4	74	41	38.0
Columbus. West spire	40	04	25.0	74	43	31.4
Taylor's Mount, S. of Cookstown	40	02	03.6	74	33	01.9
Lewistown. Wind-mill	39	59	26.9	74	37	11.7
Smithville. Mill tower	39	59	10.7	74	44	54.7
Brown's Mills. (Observatory)	39	58	09.5	74	34	53.3
Mt. Laurel. (Summit)	39	56	03.5	74	53	39.3
Marlton Church tower	39	53	26.3	74	55	10.7
Medford	39	54	55.3	74	51	13.5
Retreat. Hill, 1½ miles S. E. of school-house	39	53	52.2	74	41	47.7
Huckleberry Hill. 1¾ miles N. W. of Tabernacle	39	51	24.5	74	44	15.7
Four mile. At cross-roads	39	53	08.7	74	34	11.6
Taunton. Hinchman's store cupola	39	51	12.1	74	51	21.4
Jemima Mount. 2½ miles E. of Quaker Bridge	39	43	43.0	74	27	04.1

Geog. Positions Determined by the State Survey—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
OCEAN COUNTY.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Sea Side Park. Flag-staff at post-office	39	55	15.5	74	04	44.0
Whitings. Hotel flag-staff	39	57	13.1	74	22	46.5
Buckingham, ¼ mile N. of Philadelphia and Long Branch R. R., and just W. of Ocean county line	39	55	57.9	74	28	30.8
CAMDEN COUNTY.						
Haddonfield. White spire	39	53	59.3	75	01	45.7
Ateo. Richards' house cupola	39	46	17.7	74	53	08.2
Atsion. Mill tower	39	44	21.5	74	43	30.6
Waterford. Spire	39	43	23.9	74	51	09.4
Merchantville. East spire	39	57	00.6	75	02	57.0
GLOUCESTER COUNTY.						
Stringtown (Lincoln)	39	40	13.3	75	14	18.8
Glassboro. White spire	39	42	00 7	75	06	46 7
Clayton. Spire	39	39	26.3	75	05	29.4
Iona. Tall pine in swamp, S. W. of R. R. station	39	36	10.2	75	04	38.2
Williamstown. Spire	39	40	54.6	74	59	23.2
Piny Hollow	39	35	09.9	74	55	39.7
Forest Grove. Church spire	39	31	45.8	74	59	21.8
Newfield. On hill, 1¼ miles S. E. of village	39	32	13.8	75	00	16.1
ATLANTIC COUNTY.						
Elwood. Spire	39	34	40.3	74	42	55.6
Weymouth. Stack	39	30	23.5	74	46	36.0
Richland. On hill, 1 mile S. E. of village	39	29	19.0	74	51	12.6
New Germany. Spire	39	36	26.3	74	50	49.2
Doughty's. Flag north of tavern	39	26	54.0	74	51	46.6
Buena Vista. Flag opposite R. R. station	39	30	50.6	74	55	29.7
Russia. Flag	39	22	46.2	74	48	32.9
Estellville	39	22	21.4	74	45	44.1
Miry Run	39	23	26.5	74	41	35.6
English Creek	39	22	18.3	74	39	18.3

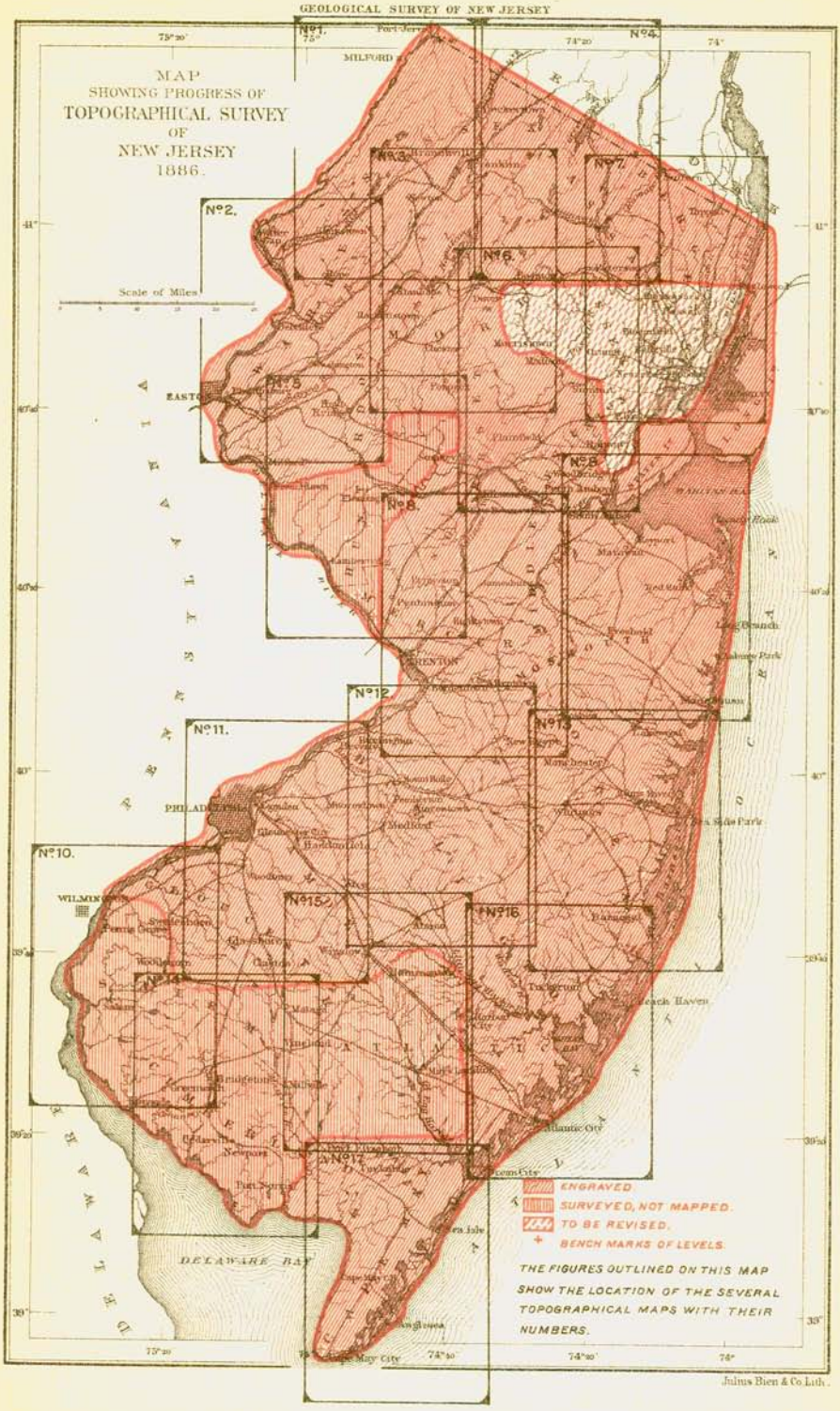
Geog. Positions Determined by the State Survey—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
	Deg.	Min.	Sec.	Deg.	Min.	Sec.
SALEM COUNTY.						
Eldridge's Hill, 225 yards S. W. of Hayne's house, at Point Airy	39	39	45.3	75	18	24.3
Daretown. Church spire	39	36	05.2	75	15	37.0
Mt. Pleasant. On hill, S. side of East Lake, S. E. of Woodstown	39	38	22.8	75	18	32.0
Centerton	39	31	45.3	75	07	44.4
Elmer	39	34	57.5	75	11	12.7
Jericho	39	29	19.8	75	21	50.2
New Boston	39	31	17.9	75	17	10.2
CUMBERLAND COUNTY.						
Vineland. Church spire	39	29	10.2	75	01	16.1
Bridgeton. Chas. R. Elmer's house cupola	39	25	37.2	75	12	50.5
Bridgeton. Baptist Church spire	39	25	43.2	75	13	58.1
Deerfield	39	32	32.2	75	13	24.2
Dividing Creek	39	18	33.7	75	05	15.1
Fairton	39	22	13.9	75	09	09.6
Woodruff	39	24	49.1	75	08	46.9
Millville. Stand-pipe	39	24	15.1	75	02	52.7
Kellogg	39	26	00.5	74	59	09.8
Pine Mount	39	25	06.4	75	20	11.5
Dutch Neck	39	23	24.1	75	15	13.0
Mulford's Landing	39	22	21.1	75	19	26.0
Muskee Hill	39	18	42.2	74	57	08.2
CAPE MAY COUNTY.						
Tuckahoe. Spire	39	17	32.4	74	45	17.6

TOPOGRAPHIC SURVEY.

The Topographic Survey of the State has been rapidly advanced during the year; there having been a larger corps of assistants employed, and consequently a larger area survey, than in any previous year since the survey began.

The parties were placed in the field April 5th, and during that month ten men were employed in leveling, contouring and surveying topographic details in Camden and Gloucester counties. Two men were employed steadily throughout the year in surveying roads in


GEOLOGICAL SURVEY OF NEW JERSEY
MAP
SHOWING PROGRESS OF
TOPOGRAPHICAL SURVEY
OF
NEW JERSEY
1886.
Scale of Miles
ENGRAVED.
SURVEYED, NOT MAPPED.
TO BE REVISED.
BENCH MARKS OF LEVELS.
THE FIGURES OUTLINED ON THIS MAP SHOW THE LOCATION OF THE SEVERAL TOPOGRAPHICAL MAPS WITH THEIR NUMBERS.
DELAWARE BAY
Julius Bien & Co. Lith.

advance of the topographic parties. May 1st, a party of six topographers, with two laborers, in charge of Mr. F. W. Bennett, was detailed to survey the meadows along the Delaware bay shore, northward from Maurice river, and when that work was suspended, June 8th, 79 square miles of tide-marsh, with its many miles of crooked creeks, had been worked over with transit and stadia.

On the 19th of June Mr. P. H. Bevier was detailed to run primary levels. The following lines were leveled from that date to August 1st: Ocean View, Cape May county, via Millville, Bridgeton, Elmer and Salem, to Gloucester city, 88.9 miles; Bridgeton to Bayside, 9.5 miles; Millville, via Vineland, to Winslow, 22 miles; Egg Harbor to May's Landing, 7 miles; Trenton, via Lambertville, to Flemington, 28.5 miles; making the total distance run 155.9 miles. Bench-marks were established along these lines and a list of them will be found appended.

When this work was completed, Mr. Bevier took charge of a transit party detailed to close the gap in the surveys of Delaware river from Frenchtown to Yardleyville, a distance of 27 miles, which work was completed August 11th, and the belt of plane-table and transit work, encircling the State, was then complete, making possible, for the first time, an accurate computation of the area of the State.

Mr. Bennett, after closing the work on Delaware bay, June 8th, prosecuted triangulation work over an area of 100 square miles in Gloucester and Salem counties until July 1st, when he resumed contouring.

With the exception of the time occupied by the above special details, Messrs. Bennett, Bevier, Luster, Staats and Atkinson, with their aids, making in all ten men, were engaged in the usual topographic work, leveling and contouring. The area covered in this way during the year, is 1,818 square miles, and the total area surveyed complete is 1,897 square miles.

TRIANGULATION.

The geodetic work of the United States Coast and Geodetic Survey having never been extended over much of the area remaining to be surveyed by us at the beginning of the year, the work of triangulating this area devolved upon the Topographic Survey. The area to

be covered in Southern New Jersey was 1,100 square miles, 100 of which was done by Mr. Bennett in June, as already stated. The services of Prof. A. A. Titsworth were secured from July 1st, and this work was placed in his charge. He was assisted by Mr. John E. Hill a part of the time. The area to be triangulated was very level and covered by tall timber, making the work rather difficult, and necessitating the erection of scaffolds from 30 to 40 feet high for the instrumental observations. As usual, the work was planned to secure a degree of accuracy which would suffice for plotting the points on a scale of 3 inches to a mile. The triangulation was executed satisfactorily, and closed on September 3d, in Southern New Jersey. Some work was done later in Hunterdon, Middlesex and Union counties, to secure additional points in the older Coast Survey triangulation, over an area of about 180 square miles. Much reconnaissance work was also done in the same vicinity, although the season closed before the angles could be measured. This triangulation was executed personally by the Topographer in Charge. An aggregate area of 1,280 square miles has been triangulated, and 59 points determined, during the season.

MAPPING AND ENGRAVING.

During the first three months of the year the topographers were engaged in plotting the field-notes of 1885; and when field-work was resumed, April 1st, the total area mapped, on the scale of 3 inches to a mile, was 5,828 square miles. Messrs. C. F. Sproul and F. Van Brakle were retained in the office, however, and continued the plotting of work, as fast as completed by the field-parties, until August, when the total area mapped had reached 6,280 square miles.

Plotting was resumed by the topographers upon suspension of field-work, December 9th, and much computation and preliminary work has been done since that date.

In accordance with the agreement with the United States Geological Survey, by which all manuscript maps are to be made in duplicate, in order that one copy may be filed in the office of that Survey at Washington, copies have been prepared for an area of about 2,850 square miles.

At the close of 1885 we reported an area of 4,438 square miles engraved. During this year an additional area of 1,840 square miles

has been completed, making the total area engraved at this time 6,278 square miles.

All of the above work is now ready to be printed, and when this is accomplished Atlas Sheets Nos. 1, 2, 3, 4, 6, 7, 8, 9, 11, 12, 13, 16 and 17 will have been published, and Nos. 5, 10, 14 and 15 will remain to be engraved and printed.

The engraving of the small map of the State, on a scale of five miles to one inch, has also been prosecuted, and is well advanced, being now more than half done.

WORK REMAINING TO BE DONE.

The field-work has now been completed over all of the area shown as unsurveyed on the small progress-map of 1885, and this work will be mapped at once and placed in the engraver's hands. The map of "A Part of Northern New Jersey," published by the survey in 1882, and surveyed during 1877–8–9–80, as its title relates, was not entirely from original surveys, but was largely compiled from various local surveys. This material was used later for the first editions of Atlas Sheets Nos. 6 and 7, as indicated also in the titles of those sheets. After the preparation of the preliminary map had proved the great utility of such work for economic and scientific purposes, and a complete survey of the State was undertaken, profiting by the experience already gained, a higher standard of work was adopted and compilation abandoned; the work from that time being entirely original, excepting the valuable geodetic work and the more recent plane-table surveys furnished us by the United States Coast and Geodetic Survey.

The actual cost of the field-work done during the period when local surveys were used, was but $2.09 per square mile, against $5.62 per square mile after 1880.

Taking these facts into consideration, it has been deemed best to revise this work and bring it up to the later standard. This work has already been begun, and the field-work of revision has been completed over 280 square miles, and the engraving over 75 square miles. Owing to the method of surveying adopted, the original field-work will all be available, and the expenditure necessary to bring the work up to the requirements of this, the most populous and important section of the State, will not exceed the difference in cost between the earlier and the later work of the Topographic Survey. The result will be a greatly improved map of the district.

This revision of the remaining 570 square miles is all the field-work now left to be executed, and it is expected that this will be accomplished early in 1887, so that it may be placed in the engraver's hands in time to have the completed Topographic Atlas ready for publication at the beginning of 1888, or one year from date.

PLAN OF PUBLICATION.

All the manuscript maps of the survey are on a scale of three inches to a mile, or 1 in 21,120. These sheets average 5x10 feet in size and number twenty.

The engraving is executed on a scale of one inch to a mile, or 1 in 63,360, and each of the above sheets requires four stones about 17 by 18 inches in size, two being for roads, streams and lettering, and two for the contour lines, making 80 stones in all. Several of these stones are grouped on one transfer stone to form an atlas sheet. These are all to be of the same size, and as large as they can be conveniently printed on a single sheet of paper. After a number of trials to ascertain what would best fit the irregular shape of the State, and the geological belts which cross it obliquely, having regard also to the location of important centers of population and business, the plan shown on the accompanying small map of the State was adopted.

The entire State requires 17 sheets to cover it. Each sheet is 24x34 inches in size. At first view it will be thought that they overlap each other and require an extra amount of engraving. The overlapping is not more than enough to give room for titles to the maps, and the engraving is not increased, as the printing is not done from the engraved stones directly, but from transfers which can be joined together in any way that may be required.

The numbering of the maps is generally from the north towards the south, and they are arranged so that those covering the same geological formation can be easily grouped together, thus:

Nos. 1, 2, 3 and 4 cover all the Archæan and Paleozoic rocks.
Nos. 2, 3 and 4 cover all the Archæan rocks and all the iron ore district of the State.
Nos. 5, 6, 7 and 8 cover the red sandstone formations.
Nos. 8 and 9, with 10, 11 and 12, cover the clay and marl districts of the State.

Nos. 8, 9, 10, 11, 12, 13, 14, 15, 16 and 17 cover the Tertiary formations.

Nos. 9, 13, 16 and 17 cover the entire Atlantic shore.

The sheets can be taken separately or the whole together. The maps are all drawn on the same system of projection, so that any two adjoining ones can be cut, fitted accurately to each other, and made into a single map, or they can be folded across and put in an atlas of 17x24 inches. These, with a map of the whole State, on a scale of five miles to an inch, and which will go on the same sized sheet with the others, will make a complete atlas of New Jersey.

The contour lines are drawn on these maps so as to show every change of 20 feet in elevation in the hilly portions of the State, and every 10 feet in the more level portions.

DESCRIPTIONS AND ELEVATIONS OF BENCH-MARKS.

In the following list all elevations are in feet and refer to mean sea level at Sandy Hook, as determined by a series of observations by the United States Coast and Geodetic Survey, extending from October 21st, 1875, to October 31st, 1881, in a continuous series. Bench-marks marked U. S. C. S., are from the line of geodetic levels from Sandy Hook, through Phillipsburg, run in 1881, by the United States Coast and Geodetic Survey. All others were determined by the State Survey. Those described as "monuments" and numbered in the descriptions, are masses of masonry imbedded in the ground, with a rounded granite post, the summit of which is the bench-mark, projecting from the top, and usually raised about 6 inches above the surface of the ground. A detailed description of these monuments, and the manner of setting them, was given on pages 14 and 15 of the report for 1885.

The objects of the primary lines of levels, run in connection with the Topographic Survey of the State, may be stated as follows: (1) To insure accuracy in the determination of elevations for topography; (2) To ascertain the exact elevation of a series of permanent bench-marks, above mean sea level, by which means any future elevation or depression of the earth's crust may be detected and measured; (3) To furnish a series of reliable bench-marks throughout the State for the use of city and railroad surveys and for all engineering purposes, in

order that such surveys may constantly add to the general fund of information as to the surface of the State, and that the value of the Topographic Survey as an aid to such surveys may be increased by having all referred to the same datum plane.

In order that the full benefit of this work may be felt, it is desirable that all railroad and city engineers shall co-operate and refer their levels to the common datum. It is expected that more bench-marks will be established in the northern portion of the State before the Topographic Survey is closed.

LIST OF BENCH-MARKS.

WARREN COUNTY.

NEAR PHILLIPSBURG. U. S. C. S. . . Eleva., 262.986 ft.

This bench-mark is the bottom surface (center) of a square cavity cut in coping stone at east end of north parapet of stone bridge (New Jersey Central railroad), over the Morris canal, about 1½ miles east of Phillipsburg.

It is marked thus— B. □ M.
1881.

EASTON, PA. U. S. C. S. . . . Eleva., 214.401 ft.

This bench-mark is the bottom surface of a square cavity cut on top of a pier (north side of New Jersey Central railroad track) of bridge across the Lehigh river at Easton. It is on the pier at the west end of wide part of bridge.

It is marked thus— U. S. B. □ M. XIX.

EASTON, PA. U. S. C. S. . . . Eleva., 357.186 ft.

This is the bottom of a square cavity cut in foundation stone at west corner of the jail at Easton. The front of the jail is built of red sandstone and the foundation of blue limestone.

EASTON, PA. U. S. C. S. . . . Eleva., 363.488 ft.

This bench-mark is the bottom surface of a square cavity cut on the sill of a blind window on east side of Easton court-house. This

side of the court-house has two blind windows, but the one used is the one nearest to the front of the building.

U. S. C. & G. S.
• H.
It is marked thus— B. ☐ M.
1881.

HUNTERDON COUNTY.

ANNANDALE. U. S. C. S. . . . Eleva., 355.049 ft.

This bench-mark is about 1 mile east of Annandale station (New Jersey Central railroad). It is the bottom surface of a square cavity cut on a projecting stone, about the center of the north abutment of overhead road bridge. The bench-mark is a little below the level of the railroad track. The stone is hard, blue limestone.

BLOOMSBURY. U. S. C. S. . . . Eleva., 326.180 ft.

This bench-mark is the bottom of a square cavity cut on top stone of northwest corner of stone bridge (railroad) over wagon road, ¼ mile west of Bloomsbury station, New Jersey Central railroad.

It is marked thus— B. ☐ M.
1881.

FLEMINGTON. . . . . Eleva., 187.52 ft.

This bench-mark is a cross cut on south end of door-sill of front entrance of court-house.

FLEMINGTON. . . . . Eleva., 186.36 ft.

This bench-mark is on top of brass head of southern "true meridian" post in front of court-house.

FLEMINGTON. . . . . Eleva., 171.33 ft.

This bench-mark is a cross cut on west end of door-sill of door in southwest corner of stone Presbyterian Church, at forks of street.

RINGOES. . . . . Eleva., 240.91 ft.

This bench-mark is a cross cut on second stone step from the bottom of north abutment on west side of railroad track, at road crossing just north of depot.

MT. AIRY STATION. . . . . Eleva., 137.40 ft.

This bench-mark is a cross cut on fourth stone step from bottom of south abutment of bridge over highway, on west side of railroad.

LAMBERTVILLE. . . . . Eleva., 70.05 ft.

This bench-mark is a cross surrounded by a triangle on the northeast corner of large corner-stone on north end of west wall of lock on canal feeder.

LAMBERTVILLE. . . . . Eleva., 72.91 ft.

This bench-mark is a cross cut on south end of door-sill of the center or ladies' waiting-room door on east side of railroad station.

LAMBERTVILLE. . . . . Eleva., 81.42 ft.

This bench-mark is a cross cut on east end of stone door-sill under portico of Baptist Church, on Bridge street.

SOMERSET COUNTY.

BOUND BROOK. U. S. C. S. . . . Eleva., 32.483 ft.

This bench-mark is the bottom surface of a square cavity cut on top of stone abutment (northeast corner) of New Jersey Central railroad bridge, about ¼ mile east of Bound Brook station.

It is marked thus— B. ☐ M.

BOUND BROOK. U. S. C. S. . . . Eleva., 35.744 ft.

This is the bottom of a square cavity (1 inch square by ⅛ inch deep), cut on top stone of west end of north abutment of road bridge over Raritan river, at Bound Brook.

It is marked thus— B. ☐ M.
XIII.
1881.

SOMERVILLE. U. S. C. S. . . . . Eleva., 81.800 ft.

This is the bottom surface of a circular cavity in the metal on top of the "true meridian" granite post, in grounds of the court-house, Somerville.

SOMERVILLE. U. S. C. S. . . . . Eleva., 91.280 ft.

This bench-mark is, as usual, the bottom surface of a square cavity cut in stone, at the base of the easternmost pillar of the front of the court-house, Somerville.

It is marked thus— G. B. ☐ M. U. S. C. & G. S. 1881.

NORTH BRANCH STATION. U. S. C. S. . Eleva., 84.880 ft.

This bench-mark is the bottom surface of a square cavity cut near the top of the southwest corner of New Jersey Central railroad bridge over the north branch of Raritan river, a short distance east of the North Branch railroad station.

It is marked thus— B. ☐ M. XV.

WESTON. . . . . Eleva., 42.97 ft.

A triangle cut on the coping of Delaware and Raritan canal lock and six feet north of east edge of lock bridge.

EAST MILLSTONE. . . . . Eleva., 45.48 ft.

A triangle on the southwest corner of a stone supporting south gate-post at entrance to N. S. Wilson's brick residence, south of Thatcher's drug store at easterly corner of Market street and Railroad avenue.

GRIGGSTOWN. . . . . Eleva., 44.07 ft.

On summit of stone, indicated by an arrow, standing at east corner of Edgar's mill on west side of canal at Griggstown.

GRIGGSTOWN. . . . . Eleva., 50.53 ft.

A triangle on the coping of west lock-wall under east edge of bridge at Delaware and Raritan canal lock, half a mile south of Griggstown.

ROCKY HILL. . . . . Eleva., 43.91 ft.

Center of triangle cut on the east end of stone door-sill at entrance of old stone grist-mill beside race, 50 rods west of railroad station.

MIDDLESEX COUNTY.

NEW BRUNSWICK. . . . . Eleva., 70.951 ft.
Elevation of underground mark, 65.709 ft.

This monument (No. 1) is on Rutgers College campus, at a distance of 35 feet, measured on a perpendicular from the face of the front wall of the main college building, the perpendicular being erected from the middle of front entrance door, which door is in the middle of south side of the building.

NEW BRUNSWICK. . . . . Eleva., 17.62 ft.

A cross cut on a large coping stone at south end of lock-chamber and on the east wall of the second, or "deep" lock of the Delaware and Raritan canal.

METUCHEN. U. S. C. S. . . . . Eleva., 83.641 ft.

This bench-mark is a slight circular concavity, bounded by a triangle, cut on the west end of the south wall (near base) of the stone bridge near Metuchen tank station of Lehigh Valley railroad. By means of this bridge the Pennsylvania railroad crosses over the Lehigh Valley railroad.

SOUTH PLAINFIELD. U. S. C. S. . . Eleva., 63.860 ft.

This bench-mark is the bottom surface of a square cavity (1 inch square by $\frac{1}{3}$ inch deep), cut on top of stone abutment at northwest corner of a small iron railroad bridge, about 150 meters (492 feet) east of South Plainfield station of Lehigh Valley railroad.

It is marked thus— B. □ M.

NEW MARKET. U. S. C. S. . . . Eleva., 49.179 ft.

This bench-mark is the bottom of a square cavity, cut on top stone of south end of west abutment of a small railroad bridge, about $\frac{3}{4}$ mile west of New Market station, Lehigh Valley railroad, and 200 meters (656 feet) west of mile post (13 miles to Perth Amboy).

It is marked thus— B. □ M.

MORGAN STATION. U. S. C. S. . . . Eleva., 5.611 ft.

This bench-mark is the surface of stone in center of triangle, cut on top of the southeast pier of the draw-bridge, at Morgan station, of New York and Long Branch railroad. The bridge crosses Cheesequake creek.

(This bench-mark has apparently settled. C. C. V.)

PERTH AMBOY. U. S. C. S. . . . Eleva., 7.782 ft.

This bench-mark is between Perth and South Amboy, on one of the piers of the long bridge across Raritan bay. It is on the pier on which the north end of the draw-bridge rests (east side of track), and is, as usual, the bottom surface of a square cavity, 1 inch square and $\frac{1}{2}$ inch deep.

It is marked thus—

F.
B. □ M.
U. S. C. & G. S.
1881.

N. B.—This bench-mark has settled. Its elevation in 1886, is 7.53 ft. C. C. V.

PERTH AMBOY. . . . . Eleva., 60.600 ft.
Elevation of underground mark, 55.855 ft.

This monument (No. 2) is located in a triangular grass plat in the public park on the center line of High street, 97.75 feet southwesterly from its intersection with the center line of Market street. The intersection of said streets is marked by a sunken monument from which the city surveys start.

PERTH AMBOY. . . . . Eleva., 57.400 ft.

This bench-mark is on the east end of stone door-sill of Market street entrance of the city hall.

KINGSTON. . . . . Eleva., 57.71 ft.

A triangle cut on the east edge of west wall of Delaware and Raritan canal lock.

MERCER COUNTY.

WASHINGTON'S CROSSING. . . . . Eleva., 57.01 ft.

This bench-mark is a cross cut on southwest corner of coping stone on west end of wall on north side of outlet sluice of feeder at south end of station platform.

TITUSVILLE. . . . . Eleva., 63.23 ft.

This bench-mark is a cross cut on east end of stone door-sill of front door of brick Presbyterian Church.

PRINCETON. . . . . Eleva., 208.510 ft.

Center of triangle cut on the north end of the door-sill at west entrance to the Hall of Science, on college campus.

PRINCETON. . . . . Eleva., 217.180 ft.

A cross cut on top of water-table at the northeast corner of East College, on college campus.

MILLSTONE AQUEDUCT. . . . . Eleva., 58.940 ft.

A triangle cut in the center of the memorial plate on top of the south end of the west abutment of aqueduct carrying the Delaware and Raritan canal over the Millstone river, two miles south of Kingston.

TRENTON. . . . . Eleva., 54.250 ft.

On broad water-table, 3.2 feet above pavement, in re-entrant angle of stone moulding. The point is indicated by an arrow-head, and is 1.1 feet south from produced line of south jamb of the most southerly window on the west side of the United States Government building, at the northeast corner of Montgomery and State streets.

TRENTON. . . . . Eleva., 56.36 ft.

A triangle cut on the coping of north side of stone pivot-pier of railroad bridge over canal at entrance of feeder, one block north of Perry street.

TRENTON. . . . . Eleva., 52.610 ft.

A triangle cut on the northeast corner of the most northerly coping stone of west lock-wall of Prison lock of Delaware and Raritan canal.

MONMOUTH COUNTY.

SANDY HOOK. U. S. C. S. Mark A. . Eleva., 11.432 ft.
Mark B. . Eleva., 9.419 ft.

These two bench-marks are cedar posts, 4 feet long and 8 inches in diameter, sunk in the ground, with ends projecting above surface of ground about 4 inches. In the center of top of each post is a copper nail surrounded by 5 other similar nails, in the form of a pentagon. The posts are 12 meters apart, and bear east-northeast from the steamer landing (passenger wharf), and nearly northeast from the tide-house, and distant from it about 500 meters (1,640 feet). They are also 95 meters northwest of the red engine-house of New Jersey Southern railroad, and are placed in the edge of a strip of cedars, where the ground is elevated a few feet above the marsh. The southeasterly one is bench-mark B., and the other one, which is 2 feet higher, is bench-mark A.

SANDY HOOK. U. S. C. S. . . . Eleva., 19.552 ft.

This bench-mark is a cross on the head of a copper bolt driven into the wall of the main light-house, at Sandy Hook. The main light-house is an octagonal tower, resting upon a circular foundation of unhewn stones. This foundation projects on all sides about 8 inches beyond the base of the tower, so as to form a sloping ledge. The copper bolt is a few inches westward of the northwest angle, and 9¼ inches above the ledge above referred to.

SANDY HOOK. U. S. C. S. . . . Eleva., 15.509 ft.

This bench-mark is the center of the inner edge of the second embrasure from the southwest corner of the fort, at Sandy Hook.

HIGHLAND STATION. U. S. C. S. . . Eleva., 7.637 ft.

This bench-mark is a granite post, projecting about 2 feet above surface of the ground; it is on west side of track of New Jersey

Southern railroad, about $\frac{3}{4}$ mile north of Highland station. About 150 meters (492 feet) southwest of it there is a small, deserted shanty. The center of top surface of the stone is the bench-mark.

NAVESINK LIGHT. U. S. C. S. . . Eleva., 202.464 ft.

This bench-mark is a mark on top surface of a heavy granite post near Navesink light-house. The post is deeply imbedded and its top projects about $1\frac{1}{2}$ feet above the surface of the ground. It is 13 meters (42.6 feet) south of the southernmost tower of Navesink Highlands light-house.

NAVESINK LIGHT. U.S.C.S. Primary Mark D. Eleva., 207.579 ft.

This bench-mark is the bottom surface of a square cavity (about 1 inch square) cut on a sloping ledge at southeast corner of base of southernmost light-house tower at Navesink Highlands light.

It is marked thus— U. S. B. ☐ M. 1881.

SEABRIGHT. U. S. C. S. Mark IV. . . Eleva., 9.283 ft.

This bench-mark is the bottom surface of a square cavity (1 inch square) cut on the north wing-wall of the west abutment of bridge over the South Shrewsbury river, at Seabright. The top of the wing-wall forms a series of steps, and the bench-mark is cut on the first step below the top.

It is marked thus— B. ☐ M.

OCEANPORT. U. S. C. S. . . . . Eleva., 3.499 ft.

This is the bottom surface of a square cavity cut on the south pier of the draw-bridge known as the Oceanport draw-bridge, about $1\frac{1}{2}$ miles north of the Branchport station, New Jersey Central railroad.

It is marked thus— B. ☐ M.

It is on west side of railroad and some distance below its level.

RED BANK. U. S. C. S. . . . . Eleva., 38.499 ft.

This bench-mark is the bottom surface of a cavity cut in center of top of a marble post set in the ground in the yard of the house of Rev. B. F. Leipner, at Red Bank, N. J. The marble post is over 5

feet in length, and buried so that the top projects about 5 inches above the surface of the ground. The house of Mr. Leipner stands at southwest corner of Monmouth and Pearl streets. The bench-mark is close to southeast corner of the house. The top of stone bears the following inscription:

U. S.
B. ○ M.
1881.

RED BANK. . . . . Eleva., 43.13 ft.

This bench-mark is a cross cut on northwest corner of lower stone step of west or Monmouth street entrance of M. E. Church, on southeast corner of Broad and Monmouth streets.

RED BANK. . . . . Eleva., 45.77 ft.

This bench-mark is a cross cut on south end of front door-sill of First National Bank on Broad street.

MATAWAN. U. S. C. S. . . . . Eleva., 55.083 ft.

This is the center of a triangle cut on the east corner of a flagstone in front of Benjamin Tuttle's front gate, Main street, Matawan. It is about $\frac{1}{3}$ mile from the station of the New Jersey Central railroad.

MATAWAN. . . . . Eleva., 35.66 ft.

This bench-mark is a cross cut on south end of stone door-sill of Episcopal Church on Main street.

FREEHOLD. . . . . Eleva., 186.63 ft.

A cross cut $2\frac{1}{2}$ inches south of the intersection of the three joints formed by the three most southerly stones in the south corner of the large triangular base of the Monmouth Battle-Field Monument. The cross is $2\frac{1}{2}$ inches south of the north apex of the stone which abuts on its south sides against the octagonal gun-pedestal, which is built at the south corner of the triangular base.

FREEHOLD. . . . . Eleva., 178.15 ft.

A cross cut on east end of stone door-sill of the sheriff's office, being the most easterly of two doors in the middle of the front of Monmouth county court-house.

FARMINGDALE. . . . . Eleva., 71.70 ft.

On most easterly intersection of rails in the frog at crossing of Freehold and Jamesburg and New Jersey Southern railroads.

MONMOUTH BEACH. . . . . Eleva., 10.252 ft.

A cross cut on east end of lower stone step of southern flight at entrance, 40 feet from and in front of Episcopal Church, near Life Saving Station No. 4.

NORTH LONG BRANCH. . . . . Eleva., 7.26 ft.

On a marble monument, 150 yards north of Charles Van Note's blacksmith shop, at east side of Ocean avenue, just north of a low place in the road.

WEST END. . . . . Eleva., 12.256 ft.
Elevation of underground mark, 7.574 ft.

This monument (No. 3) is erected according to the description already given (page 14, report 1885), but its top is placed even with the surface of ground. It is located on the lot of Life Saving Station No. 5, West End, and is placed at a distance of 10 feet measured perpendicularly from the middle of the west end of station building. The line of face of north abutment of the Ocean avenue bridge, over Lake Takanassee, passes 6 feet to south of center of monument, and the magnetic bearing of this line is S. 75° 30′ E.

The monument is 22½ feet back from the line of Ocean avenue.

LAKE TAKANASSEE BRIDGE. . . . Eleva., 16.715 ft.

A cross cut on north end of west wing-wall of the northern abutment at the foot of the iron post at end of railing of bridge over Lake Takanassee (Green's Pond), on Ocean avenue, near Life Saving Station No. 5, West End.

ASBURY PARK. . . . . Eleva., 22.184 ft.

On water-mark at southwest corner, just over the corner-stone, of First M. E. Church, at corner of Grand and First avenues, Asbury Park.

OCEAN BEACH. . . . . Eleva., 20.151 ft.

A cross cut on south end of stone door-sill of front entrance of brick school-house, at Ocean Beach.

SPRING LAKE. . . . . Eleva., 18.351 ft.

Elevation of underground mark, 13.978 ft.

This monument (No. 4) is located on the lot of Life Saving Station No. 8, Spring Lake, on the east side of Ocean avenue, between Ocean Beach and Spring Lake. At the time of setting the monument the station building was so located that the northerly edge of the roof was about on the line of the lot, but the front was about 25 feet on the avenue. The monument was set 27.6 feet back from the west end of station, and 5 feet south of its south side.

It may also be located as follows: Beginning at the point where the line of south curb of St. Clair avenue intersects the center line of Ocean avenue, and running thence N. 22′ 15″ E., 973 feet along center line of said avenue to a point in line with south side of station; thence along the station 52.6 feet; thence at right angles to station, 5 feet to the monument.

The monument was set with its top level with the surface of ground, which was a little higher than the surrounding surface.

SEA GIRT. . . . . Eleva., 19.47 ft.

A point of an arrow-head cut in the stone under second pillar of the piazza at northeast corner of the northern of the two four-story buildings of the Beach House, Sea Girt.

MANASQUAN. . . . . Eleva., 21.78 ft.

A cross cut on east end of sand-stone door-sill of the First National Bank, on Main street, just east of entrance to South street.

BURLINGTON COUNTY.

BORDENTOWN. . . . . Eleva., 15.53 ft.

A triangle cut on the west end of stone door-sill at the south entrance to fire-room of Bordentown Reservoir and Water Co.'s pump-house, near the outlet lock of the Delaware and Raritan canal.

BORDENTOWN. . . . . Eleva., 24.17 ft.

A triangle cut on coping stone at the east end of the north abutment of railroad bridge over roadway, just north of lower Bordentown railroad station.

WHITE HILL. . . . . Eleva., 14.24 ft.

On a protuberance indicated by an arrow and the letters B. M., on the southeast corner of the flagstone coping of the northwest wall of bridge over ice pond, on the road to Burlington, one mile west of White Hill.

BURLINGTON. . . . . Eleva, 12.53 ft.

Cross cut on dressed stone at west end of door-sill of main entrance to Baptist Church, at northwest corner of Broad and Stacy streets.

BURLINGTON. . . . . Eleva., 11.30 ft.

A cross on northwest corner of projecting ledge of iron post at northwest corner of iron bridge over Assiscunk creek, on Main street.

DEACON'S. . . . . Eleva., 80.56 ft.

A triangle cut on water-table at southwest corner of brick schoolhouse, on east side of turnpike, $\frac{3}{8}$ mile southeast of Deacon's station.

MOUNT HOLLY. . . . . Eleva., 185.47 ft.

On the northwest corner of granite monument, located on the summit of Mount Holly, and which marks the United States Coast and Geodetic Survey triangulation point, Mount Holly.

MOUNT HOLLY. . . . . Eleva., 16.88 ft.

On northwest corner of door-sill of National Bank, on northeast corner of Main and Mill streets.

MOUNT HOLLY. . . . . Eleva., 42.97 ft.

On the northwest corner of marble door-sill of main entrance to Burlington county court-house.

BIRMINGHAM. . . . . Eleva., 31.29 ft.

On the most southerly of two bolts on the top of northwest wing-wall of bridge over race, 100 yards north of Birmingham railroad station.

PEMBERTON. . . . . Eleva., 39.23 ft.

On the southwest corner of granite block, upon which rests the south end of west iron arch of bridge over mill pond, South Pemberton.

TUCKERTON. . . . . Eleva., 22.632 ft.
Elevation of underground mark, 17.972 ft.

This monument (No. 8) is set in the northwest corner of the Presbyterian church-yard, at the corner of Main and Cedar streets, 3.2 feet back from the front fence, being in line with the south fence line of Main street, west of Cedar street, and 3 feet east of the east line of Cedar street. It is 32.9 feet from the northwest corner of the church.

OCEAN COUNTY.

WHITINGS. . . . . Eleva., 173.46 ft.
Elevation of underground mark, 170.583 ft.

This monument (No. 16) is located at the cross-roads in Whitings, where the road from New Egypt to Toms River crosses the road running along the west side of the New Jersey Southern railroad from Woodmansie to Manchester. It is set in the center line of the former road, and in line with the trees planted along the west side of the latter road, between the sidewalk and wagon track. It is 41.5 feet southwest of the southwest corner of Mr. Wright's store; 11 feet from the west line of the street running nearly north and south; 88 feet to center of the main track of the New Jersey Southern railroad; 21 feet to center of nearest maple tree of the row on the north; 45.4 feet to center of the next; 21.7 to center of nearest maple tree of the row on the south, and 46.9 feet to the next.

The top of this monument is below the surface.

WHITINGS. . . . . Eleva., 172.53 ft.

On granite monument marking northwest corner of roads. It is 7 yards distant from southeast corner of large hotel, now unoccupied.

MANTOLOKING. . . . . Eleva., 4.146 ft.
Elevation of underground mark, 0.780 ft.

This monument (No. 5) is located on the lot of Life Saving Station No. 11, Mantoloking, on the beach about half a mile south of the railroad station. It is placed N. 67° E., 2 feet from the southwest corner of the lot. The location with reference to property line surveys is as follows: Beginning at a corner on the salt meadows, which is S. 14° W., 281 feet from the point of meadows at east side of mouth of a small creek, and N. 85° W., 150 feet from head of same creek; running thence N. 86° E., 550 feet to the intersection of this line with the produced west line of above-mentioned lot; thence N. 22° E., 33½ feet to southwest corner of lot; thence N. 67° E., 2 feet to the monument.

[This monument is set 3½ feet deep, and rests on the old meadow which underlies the beach at this place. The turf of the meadow was not disturbed, but an area of cement was spread right upon it. It can scarcely be entirely depended upon, but shrinkage of the new cement and settlement of stone had only amounted to .014 feet one month after setting.]

TOMS RIVER. . . . . Eleva., 30.38 ft.
Elevation of underground mark, 25.40 ft.

This monument (No. 6) is placed in the southwest corner of the Ocean county court-yard, 3 feet back from the iron front fence and 3 feet east of west line of lot. Measured parallel with Washington street, it is 28.75 feet west of the west line of Allen street produced, 72.3 feet west of center line of court-house, and 145 feet west of southern marble true meridian monument which stands in southeast corner of the yard. The monument is also distant 69.6 feet southwesterly from the southwest corner of court-house.

TOMS RIVER. . . . . Eleva., 32.67 ft.

A cross cut on east end of stone door-sill of main entrance of Ocean county court-house, Toms River.

WARETOWN. . . . . Eleva., 12.664 ft.
Elevation of underground mark, 8.429 ft.

This monument (No. 7) is located at the cross-roads at the Hopkins House, where the center line of the road from Waretown station, New

Jersey Southern railroad, to the shore of Barnegat Bay, intersects the easterly fence line of the main shore road. It is 86.2 feet from southwest corner of hotel, 17.7 feet from northeast stone pier under porch of store, and 20.7 feet from center of willow tree standing just to southwest of it. Measuring along the produced first course of the road running by a small graveyard to the bay, the distances are, to edge of upland, 1,540 feet, to ordinary high-water mark, 2,850 feet. The top of monument was placed just below the surface of the road.

WARETOWN. . . . . Eleva., 20.72 ft.

On center of southwest side of large granite (Falkinsburg) monument, on top of small, flat projection of the top base-stone directly under the polished inscription-face, upon the bottom of which is cut, "Died May 10, 1855." The monument is in the Waretown cemetery, east of main shore road.

BARNEGAT. . . . . Eleva., 35.76 ft.

A cross cut in east end of lowest flagstone step on south side of the basement front door of Baptist church.

CAMDEN COUNTY.

CAMDEN. . . . . Eleva., 30.64 ft.

A cross cut on southeast end of highest step of main entrance to new Camden county court-house, on Federal street.

CAMDEN. . . . . Eleva., 21.23 ft.

A cross cut on north end of north door-sill on east side of station at junction of Camden and Atlantic and Pennsylvania railroads, at corner of Tenth and Market streets.

CAMDEN. . . . . Eleva., 34.53 ft.

On easterly corner of pedestal, over the builders' names (Krips & Shearman), of the soldiers' monument, on Haddon avenue, just north of city hall.

MERCHANTVILLE. . . . . Eleva., 80.11 ft.

On the west end of marble door-sill (close by corner of brick work), of the east front door of new railroad station.

GLOUCESTER FERRY. . . . . Eleva., 5.91 ft.

A cross cut on southeast corner of slate slab on top of rubble wall, southeast of Gloucester ferry pier, and 56 yards in a southerly direction from Buena Vista Hotel.

KIRKWOOD. . . . . Eleva., 60.04 ft.

On cross on southeast corner of slate slab on south side of outlet of pond, on dam opposite railroad station.

WINSLOW. . . . . Eleva., 112.019 ft.
Elevation underground mark, 107.779 ft.

This monument (No. 18) is located in the grass plat, 22.5 feet west of flag-pole. It is in the center line of road running south of New Jersey Southern railroad station, and is about in center line of roads running to Hammonton and Waterford. The following measurements were taken from the monument: N. 46° 30′ E., 57 feet to large oak; N. 6° 30′ W., 41 feet to another large oak; 123.25 feet to southeast corner of Hay & Co.'s store; 50 feet to corner of glass works fence; 55 feet perpendicularly to south line of road to New Germany; 58 feet to southwest street corner, and 73 feet to northeast corner of house on this southwest corner.

WINSLOW. . . . . Eleva., 112.76 ft.

A cavity cut in foundation at south corner of brick chimney, at south corner of Hay & Co.'s steam flour mill, at Winslow. An arrow-head points to it, and it is 1.8 feet above surface of ground.

GLOUCESTER COUNTY.

WOODBURY. . . . . Eleva., 62.32 ft.

This bench-mark is a cross cut on southeast corner of the lowest of three marble bases of soldiers' monument in front of court-house.

WOODBURY. . . . . Eleva., 37.28 ft.

This bench-mark is a cross cut on south end of stone door-sill of front entrance of G. G. Green's brick laboratory, which faces the railroad just south of West Jersey railroad depot.

WOODBURY. . . . . Eleva., 58.11 ft.

This bench-mark is a cross cut on south end of stone door-sill of front door of brick Presbyterian Church, on Main street.

SWEDESBORO. . . . . Eleva., 40.43 ft.

This bench-mark is a cross cut on north end of marble door-sill of front door of brick M. E. Church, on northwest corner of Main street and Railroad avenue.

SWEDESBORO. . . . . Eleva., 44.822 ft.

This bench-mark is a cross cut on north end of door-sill of National Bank.

ATLANTIC COUNTY.

LEEDS' POINT. . . . . Eleva., 52.691 ft.
Elevation of underground mark, 48.648 ft.

This monument (No. 9) is located just west of the hotel at forks of roads to Port Republic and to Absecon. It is at the intersection of the center line of Absecon road with the south line of Port Republic road. The following measurements were taken: To northeast corner of store at southwest corner of roads, 52.5 feet; to center of small cedar north of and opposite the store, 69.2 feet; to center of wild cherry tree at southeast road corner, 22.5 feet, and to center of maple tree standing on the south side of Point road, east of forks of roads, 75.9 feet.

The top of this monument is just below the surface of the road.

ABSECON. . . . . Eleva., 24.232 ft.
Elevation of underground mark, 19.561 ft.

This monument (No. 10) is located in the small triangular grass plat where the main road from Philadelphia and Egg Harbor City enters the main shore road from Absecon to Leeds' Point. It is set in the center line of the Philadelphia road and 12.75 feet west of the center line of the Shore road (the road being 49.5 feet wide). It is also 64 feet from the corner of old house standing in yard at the west street corner; 62.6 feet from corner of house on the south street corner, and about in range with its northeast end, and 131.9 from corner of new house on the east street corner.

The top is level with the surface of ground.

ABSECON. . . . . Eleva., 30.66 ft.

On east end of stone door-sill of Methodist Episcopal Church, about 220 yards west of the above primary monument.

MOUNT PLEASANT. . . . . Eleva., 13.96 ft.

A cross cut on bluestone door-sill of northerly door at east side of Atlantic City water-works pumping station, just north of Mount Pleasant.

ATLANTIC CITY. . . . . Eleva., 8.954 ft.

On an old United States Coast Survey tidal bench-mark cut on northwest side of base of Absecon light-house. It is under the south end of a window-sill, and is a small shelf cut in the convex water-table, with the letters " U. S. C. S." cut above it.

ATLANTIC CITY. . . . . Eleva., 10.184 ft.

A cross cut on north end of stone door-sill of Atlantic City National Bank, at northerly corner of Atlantic and North Carolina avenues, the door being on Atlantic avenue.

SOMERS' POINT. . . . . Eleva., 28.84 ft.
Elevation of underground mark, 24.596 ft.

This monument (No. 11) is placed on the brow of the hill in front of the old Somers homestead, a brick building on the Shore road just south of the railroad crossing, at Somers' Point. It is set in the center line of the road which runs to the west and is 75 feet from the southeast corner of the house; 52 feet due west of a small cedar standing on the east side of road, and N. 63° E., 52 feet from a large cedar standing at the southwest road corner.

The monument was placed with its top level with surface of ground.

HAMMONTON. . . . . Eleva., 102.82 ft.

A cross cut on the water-table on south side of front door, and 3.1 feet from corner of three-story concrete store standing on east side of Bellevue street, and on north side of Camden and Atlantic railroad.

DA COSTA. . . . . Eleva., 80.14 ft.

A cross cut 0.40 feet from each edge of stone at southeast corner of coping of southeasterly culvert wall on Camden and Atlantic railroad, one mile west of Da Costa station.

EGG HARBOR CITY. . . . . Eleva., 56.573 ft.
Elevation of underground mark, 52.511 ft.

This monument (No. 17) is located on southwest side of Agassiz street and the southeast side of Buffalo avenue, 5 feet from the street and avenue lines, and 3 feet inside of center of hedge which stands 2 feet from the street and runs around the School Park. There are three parks on the southwest side of Agassiz street, the School Park being in the middle. Excursion Park lies northwest of Buffalo avenue; School Park lies southeast of it and runs to Agricultural Fair Grounds, and these Fair Grounds extend from School Park to St. Louis avenue.

The monument is 251.8 feet to the northwest of the north corner of the school-house, 26.5 feet from center of a large maple tree on Buffalo avenue, 12.45 feet from center of another tree standing to northeast of former, and 44.93 feet from center of large maple tree standing on southwest side of Agassiz street.

EGG HARBOR CITY. . . . . Eleva., 60.27 ft.

A cross cut on south corner of upper outside flag-stone step in front of side door of brick store on the north corner of Philadelphia avenue and Agassiz street.

DOUGHTY'S. . . . . Eleva., 25.75 ft.

A cross cut on coping stone at east end of south wall of culvert on Camden and Atlantic railroad, 60 yards east of 11–49 mile-post, just west of Doughty's station. The cross is 0.75 feet from the corner.

MAYS LANDING. . . . . Eleva., 19.89 ft.

This bench-mark is a cross cut on west end of stone door-sill of front door of Atlantic county court-house.

MAYS LANDING. . . . . Eleva., 20.66 ft.

This bench-mark is the arrow-head engraved on the brass top of the south "true meridian" post standing in the court-yard.

MAYS LANDING. . . . . Eleva., 18.82 ft.

This bench-mark is a cross cut on east end of stone door-sill of front or north door of the American Hotel, just northeast of court-house.

SALEM COUNTY.

WOODSTOWN. . . . . Eleva., 47.67 ft.

This bench-mark is a cross cut on south end of marble door-sill of front entrance of brick Baptist Church, on Main street.

WOODSTOWN. . . . . Eleva., 46.12 ft.

This bench-mark is a cross cut on north end of lowest stone step of front entrance of Woodstown Hotel.

WOODSTOWN. . . . . Eleva., 58.74 ft.

This bench-mark is a cross cut on southwest end of marble door-sill of brick National Bank of Woodstown.

SALEM. . . . . Eleva., 14.67 ft.

This bench-mark is a cross cut on south end of granite door-sill of front entrance of Episcopal Church, on Market street.

SALEM. . . . . Eleva., 15.88 ft.

This bench-mark is a cross cut at the foot of fluted column on south side of entrance to surrogate's and clerk's office.

RIDDLETON JUNCTION. . . . . Eleva., 41.25 ft.

This bench-mark is on the frog (1 foot from its point), at the junction of the railroad from Swedesboro with the railroad from Elmer to Salem.

DARETOWN. . . . . Eleva., 127.80 ft.

This bench-mark is a cross cut on north end of stone door-sill of front entrance of Daretown Presbyterian Church.

ELMER. . . . . Eleva., 116.83 ft.

This bench-mark is a cross cut on west end of marble door-sill of front entrance of brick public school-house.

CUMBERLAND COUNTY.

BRIDGETON. . . . . Eleva., 29.61 ft.

This bench-mark is a cross cut on north end of store door-sill of east door of Bridgeton water works, on east side of East Lake.

BRIDGETON. . . . . Eleva., 22.41 ft.

This bench-mark is a cross cut on east end of door-sill of main front entrance of First Baptist Church on Commerce street.

BRIDGETON. . . . . Eleva., 54.25 ft.

This bench-mark is a cross cut on west end of large upper stone step of front entrance of stone Presbyterian Church on Commerce street, in West Bridgeton.

NEAR BRIDGETON. . . . . Eleva., 91.00 ft.

This bench-mark is on the east rail of West Jersey railroad, and the south rail of New Jersey Southern railroad at their crossing about two miles north of Bridgeton.

BAY SIDE. . . . . Eleva., 7.51 ft.

This bench-mark is on root of oak tree in edge of grove near turntable of New Jersey Southern railroad.

VINELAND. . . . . Eleva., 108.10 ft.

This bench-mark is a cross on north end of stone door-sill of north door on west side of Vineland station of West Jersey railroad.

VINELAND. . . . . Eleva., 118.05 ft.

This bench-mark is a cross cut on east end of front or north door-sill of First Baptist Church, on south side of Landis avenue, just west of Ninth street.

VINELAND. . . . . Eleva., 115.76 ft.

This bench-mark is a cross cut on east end of stone door-sill of First M. E. Church on northeast corner of Landis avenue and Seventh street.

MILLVILLE. . . . . Eleva., 33.45 ft.

This bench-mark is a cross cut on the water-table on southwest corner of Millville National Bank on northeast corner of Main and Second streets.

MILLVILLE. . . . . Eleva., 28.79 ft.

This bench-mark is a cross cut on south end of stone door-sill of main entrance to Workingmen's Institute.

CAPE MAY COUNTY.

OCEAN CITY. . . . . Eleva., 10.298 ft.
Elevation of underground mark, 5.320 ft.

This monument (No. 12) is set about 3 feet south of the north corner of the new life saving station lot, which runs from the corner of Atlantic avenue and Fourth street, northeasterly 100 feet along said avenue, and southeasterly 130 feet along said street. It is set about 2.1 feet southwest of the northeast line of the lot. It is about 400 feet from high-water line at this time.

SEA ISLE CITY. . . . . Eleva., 5.193 ft.
Elevation of underground mark, 1.130 ft.

This monument (No. 13) is set just south of the north corner of the new United States light-house lot, which is located on the east side of the Sea Isle and Ocean City railroad, in the south corner of block 62, and is bounded on the southeast by the beach, and on the southwest by Whelen street.

The monument is set 2 feet from the northwest line of the lot and 2 feet from the northeast line, which makes it 2.8 feet from the north corner of the lot.

SEA ISLE JUNCTION. . . . . Eleva., 15.86 ft.

This bench-mark is on the frog (1 foot from its point) of the switch, just north of the station.

CAPE MAY COURT HOUSE. . . . Eleva., 19.498 ft.
Elevation of underground mark, 14.961 ft.

This monument (No. 14) is set in the east corner of Cape May county court-yard, 4 feet from the front or street fence, and 5 feet

from the line-fence between the court-yard and the M. E. church-yard. It is also 81.7 feet from the center of the south "true meridian" post, 62 feet from the north one, 54 feet from east corner of court-house and 42 feet from south corner of M. E. Church.

COLD SPRING. . . . . Eleva., 20.70 ft.

A cross cut on north end of northerly stone door-sill of Cold Spring Presbyterian Church (brick).

CAPE MAY CITY. . . . . Eleva., 10.876 ft.

This bench-mark is a cross cut on stone, under east corner of West Jersey railroad station.

CAPE MAY. . . . . Eleva., 6.409 ft.
Elevation of underground mark, 1.829 ft.

This monument (No. 15) is located on the Cape May light-house lot, just southeast of Cape May Point and about two miles west of Cape May City.

The Cape May and Sewell's Point railroad divides the light-house property into two parts.

The monument is set in the east corner of the south part, 2 feet from the line-fence of the railroad and 2 feet from the southeast line of the lot. The United States Life Saving Station stands on the south and the light-house on the north part of the lot. The corners of the lot are marked by square granite posts.

Beginning at the southwest corner of lot, the line runs S. 62° 40′ E., 206.8 feet to south corner; thence N. 28° 30′ E., 214.25 feet to a point 2 feet southeast of the monument, the whole distance to the next corner being 424.6 feet. From the first-mentioned corner the magnetic bearing is N. 1° 40′ E., from the second N. 10° W., and from the third N. 28° W., to the center of the light-house.

CAPE MAY. . . . . Eleva., 8.244 ft.

On northwest corner square stone monument in southeast corner of light-house lot.

CAPE MAY. . . . . Eleva., 13.187 ft.

On United States Coast Survey tidal bench-mark of 1867 cut on east side of projecting water-table at base of Cape May light-house.

COMPARISON OF TIDES ALONG THE COAST OF NEW JERSEY BY MEANS OF THE PRIMARY LEVELS.

At Sandy Hook the United States Coast and Geodetic Survey has taken a series of observations, with a self-registering tide-gauge, extending continuously from October 21st, 1875, to October 31st, 1881. The mean of all the readings of this series is taken as mean sea level at this place and is the datum-plane (the zero) for all elevations. This series of observations makes the mean rise and fall of the tide at Sandy Hook 4.7 feet. The gauge was placed at the New Jersey Southern railroad wharf on the inner side of the Hook.

In the following lists the observations compared by means of United States Coast Survey tidal bench-marks, as they give a series representing very closely the mean of tides at the given date, are most exact. It should be mentioned, however, that from contraction or broadening of the inlets from year to year it is almost certain that the mean of the tides in all of the bays, &c., changes from year to year. Observations of the present height of high-water are necessarily approximate, being from single observations or from testimony of residents familiar with the tides, but are believed to be correct within one or two-tenths of a foot.

Elevations of the tide-marsh do not necessarily correspond to present high-water, but the marshes are probably slightly higher than any mean high-water that has prevailed for any length of time, for perhaps a half century past.

It will be noticed that high-water in the bays is much lower, generally, than in the ocean, but, as the range of tide is much less, both mean tide and low-water are much higher than in the ocean. The fact is that high-water is of too short duration to enable the bays to fill through the contracted inlets. The study of the tides in Barnegat bay reveals the fact that for some time after high-water the tide sets in the inlet, and later from a central point in the bay in both directions, *i. e.*, toward the head of the bay and toward the inlets, and high tide at the head of the bay is several hours later than in the ocean outside the beach. It is hoped that as the survey progresses it will be possible to gain much more information as to the tides.

LOCALITY.	ELEVATION IN FEET.			
	TIDE MARSH.	HIGH WATER.	MEAN TIDE.	LOW WATER.
Sandy Hook, U. S. C. S.	.....	2.35	0.00	-2.35
Woodbridge creek, Woodbridge and Sewaren road	3.02	.....	.....	.....
Mouth of Cove's Mill creek, north bank of Raritan	3.08	.....	.....	.....
Cheesequakes creek at railroad bridge	2.45	.....	.....	.....
Perth Amboy, Lewis street	.....	2.40	.....	.....
One-quarter mile northwest of Matawan.	2 84	.....	.....	.....
Flat creek; road from Keyport to Keansburg	3.14	.....	.....	.....
Two miles west of Port Monmouth	.....	2.76	.....	.....
Red Bank, Navesink river, 1884	.....	1.62	.....	.....
Clay-pit Creek, Navesink river, 1884	.....	1.76	.....	.....
Parker's creek, 1 mile north of Oceanport, 1884	1.91	.....	.....	.....
Manasquan river, north side	2.05	.....	.....	.....
Mantoloking, on Barnegat bay	1.40	.....	.....	.....
Bay Head, Barnegat bay	0.98	0.67	.....	.....
Metedeconk river, 1 mile east of Cedar Bridge, range of tide about 0.70 ft	.....	0.85	.....	.....
Kettle creek, U. S. C. S., gives range of tide 0.47	.....	.....	.....	.....
Toms river, U. S. C. S., observations of 1876, west of Island Heights	.....	0.89	0.52	0.16
Toms River, 1885, at village bridge	.....	0.80	.....	.....
Cedar creek, 1885, at shore road	.....	2.76	.....	.....
Cedar creek, U. S. C. S. observations, 1874, range of tides 0.75	.....	.....	.....	.....
Waretown (Barnegat bay)	.....	1.31	.....	.....
Barnegat. End of Bay avenue	1.40	.....	.....	.....

LOCALITY.	ELEVATION IN FEET.			
	TIDE MARSH.	HIGH WATER.	MEAN TIDE.	LOW WATER.
Barnegat Landing, on Double creek, range of tides, U. S. C. S. observations, 1874, 0.75	.....	.....	.....	.....
Barnegat inlet, range of tides in the bay, 2.04, from U. S. C. S. observations, 1866	.....	.....	.....	.....
Osborne's island, north side of Great bay	.....	1.59	.....	.....
Great bay, mouth of Mullica river	.....	1.94	.....	.....
Willett's house, north shore of Great bay, 1 mile back from New inlet	2.21	.....	.....	.....
Willett's house, from U. S. C. S. observations of tides in Great bay, 1872. (Compare above for 1885.	.....	2.70	1.00	-0.70
[For reason for this change of about -0.70 in height of high-water, see maps showing changes at New inlet, in report for 1885.]				
Wharf at Bond's Long Beach house, range of tide 2.35 feet, from U. S. C. S. observations, 1873	.....	.....	.....	.....
Oswego river, at Bridgeport, 1884	.....	1.42	.....	.....
Mullica river, at Lower Bank bridge, 1884	.....	1.45	.....	.....
Mullica river, at Gloucester landing, 1884	.....	1.26	.....	.....
Port Republic, Nacote creek, 1884	.....	1.80	.....	.....
Absecon creek, shore road, 1883	.....	1.75	.....	.....
Absecon bay, west side, 1883	2.17	.....	.....	.....
Absecon inlet, range of tide inside of beach 3.95, from U. S. C. S. observations, 1872	.....	.....	.....	.....
Atlantic City, draw-bridges	2.08	.....	.....	.....
Great Egg Harbor bay, Somers Point, April, 1883	.....	2.01	.....	.....
Great Egg Harbor bay, Somers Point, September 8th, 1885	.....	2.05	.....	.....
Great Egg Harbor bay, mouth of Tuckahoe river	2.86	.....	.....	.....

LOCALITY.	ELEVATION IN FEET.			
	TIDE MARSH.	HIGH WATER.	MEAN TIDE.	LOW WATER.
Tuckahoe bridge, 1884	2.37			
End of shore road, Beesley's point, 1884	2.46			
Great Egg Harbor bay, mouth of Great Egg Harbor river	2.06			
Lake's creek, English creek road		2.52		
English creek, at English Creek village		2.84		
Gibson's creek, Gibson's Landing	3.37	2.79		
Great Egg Harbor river, mouth of Miry run		2.40		
Steelman's Landing, Estellville creek		2.50		
South River, Mays Landing and Estellville road		1.01		
Great Egg Harbor river, High Bank Landing		2.20		
Great Egg Harbor river, Mays Landing		2.00		
Embanked meadow, Mays Landing	(1.51)			
Corson's inlet	2.67			
Sea Isle City	2.56			
Ocean View, at Van Gilder's mill pond, 1884	1.74			
Jenkins' sound, Shell-bed landing, 1884	2.40			
Cape May Landing, 1884, from a short series by the U. S. C. and G. S		2.05	-0.15	-2.35
Fishing creek, Delaware bay shore, 1884	2.59			
Dyer's creek, bay shore road, 1884	2.60			
Dennis creek landing, embanked meadow, 1884	(1.37)			
Mauricetown, Maurice river, 1884		2.32		
Manantico creek, Millville and Port Elizabeth road		3.25		
Maurice river, Millville		3.10		

LOCALITY.	ELEVATION IN FEET.			
	TIDE MARSH.	HIGH WATER.	MEAN TIDE.	LOW WATER.
Dividing creek, Port Norris road	1.16	1.96	.....	.....
Oranokea creek, Beaver Dams (very low meadow)	0.77	.....	.....	.....
Cedar creek, Cedarville	.....	2.77	.....	.....
Nantuxent Neck, near edge of upland	2.70	.....	.....	.....
Fortesque road, near edge of upland	2.37	.....	.....	.....
Fortesque Beach, U. S. C. S. observations, 1880, give as range of tides 6.00 ft.	.....	.....	.....	.....
Sea Breeze, U. S. C. S. observations, 1880, give as range of tides 6.18 ft.	.....	.....	.....	.....
Sea Breeze road, near edge of upland	2.75	.....	.....	.....
Greenwich wharf, Cohansey creek	3.40	3.40	.....	.....
Buena Vista, embanked meadow	(-0.46)	.....	.....	.....
Fairton (embanked meadow on Mill creek)	(0.39)	3.55	.....	.....
Cohansey creek, 1½ miles below Bridgeton, embanked	(-0.12)	.....	.....	.....
Cohansey creek, Bridgeton	.....	3.30	.....	.....
Bayside	3.71	2.76	.....	.....
Strathem's Neck	2.91	.....	.....	.....
Strathem's Neck, embanked meadow	1.04	.....	.....	.....
Stow creek, 1 mile below Canton	2.69	2.61	.....	.....
Canton, embanked meadow	0.42	.....	.....	.....
Stow Neck	2.84	.....	.....	.....
Stow Neck, recently embanked meadow	(2.11)	.....	.....	.....
Alloway's Creek Neck, 3 miles below Hancock's Bridge	1.58	.....	.....	.....
Alloway's creek, Hancock's Bridge	.....	1.92	.....	.....

LOCALITY.	ELEVATION IN FEET.			
	TIDE MARSH.	HIGH WATER.	MEAN TIDE.	LOW WATER.
Alloway's creek, Quinton	.....	2.49	.....	.....
1½ miles west of Hancock's Bridge, embanked	-0.83	.....	.....	.....
1½ miles northeast of Elsinborough Point, embanked	-1.57	.....	.....	.....
½ mile west of Salem, embanked	-1.99	.....	.....	.....
Salem creek, at Salem	.....	3.30	.....	.....
Salem creek, 2 miles below Sharpstown	.....	2.30	.....	.....
Raccoon creek, at Swedesboro	.....	3.06	.....	.....
Timber creek, Westville	.....	3.35	.....	.....
Philadelphia, Old Navy Yard, U. S. C. S. observations of 1878, compared by bench-mark at Swanson and Reed streets	.....	2.67	-0.34	-3.34
Rancocas creek, Mount Holly	.....	3.33	.....	.....
Delaware river, Burlington	.....	3.80	.....	.....
Delaware river, Bordentown	.....	3.70	.....	.....

NOTE.—When no other date is given, observations were made in 1885 and 1886.

II.
GEOLOGICAL SURVEYS.

ARCHÆAN OR PRIMITIVE ROCKS.

The Archæan rocks are the lowest, the oldest and the most irregular in arrangement and position of any in the Geological Series. In studying out their condition, and attempting to ascertain their orderly arrangement, the Geologist is obliged to consider the changes they have undergone since their original deposition. They must have undergone very great changes in their position and relations to the present surface and in their appearance, and some also in their composition. The Archæan rocks of New Jersey form no exception to this general statement. They are found in the narrow belt which crosses the State in a northeast and southwest direction, between its northeast boundary line and the Delaware river. Its breadth on the New York boundary is from Suffern's station, on the east, almost to the Wallkill river on the west, which is about twenty-three miles; and along the Delaware, from Holland station on the south, to about three miles above Phillipsburg on the north, which is not far from eleven miles. In length it averages nearly sixty miles. In some of the valleys there are deposits of the lower fossiliferous rocks, but the greater part of this area contains only those of Archæan age. The area within these bounds is not far from one thousand square miles. It includes the most mountainous part of the State, and large portions of it are still in forest. The surface in that portion which is south of the line of glacial drift, is much freer from boulders than that to the north of it, and the whole aspect of the country is different. The terminal moraine, which marks the southern border of the glacial deposits, crosses the Archæan rocks in a well-marked line, which is within two or three miles of the Del., Lack. and Western R. R. line, all the way from Morristown to Belvidere, and divides the Archæan area into two nearly equal parts. The mountain ranges, which are

the characteristic features of this area, all have nearly the same general direction as the whole belt, though, when carefully noted, the separate ridges are found to have a trend somewhat nearer to the meridian than the whole belt has. For example, the valley in which the Green Pond Mountain lies can be entered on the south side of the belt, near Clinton, in Hunterdon county, and followed up in a northeasterly direction till it comes out on the north side of the belt a few miles north of Greenwood lake. Or it may be said that while the general direction of the belt across the State is N. 54° E., that of the shorter mountain ridges and valleys is N. 44° E., a difference in direction of 10 degrees.

Another feature of the shorter ridges has long been noted; this is that their crests are not level, but in the majority of cases are the highest at their southwest extremities, where they terminate with abrupt and steep ends, while towards the northeast the crests descend gently and for longer distances, till they reach the level of the valleys.

These varieties of appearance and structure must all have been produced since their first deposition. For it is the opinion of geologists that the strata or layers, which can still be plainly distinguished in the rocks, were once spread out in flat and nearly level beds, which were continuous over large areas, perhaps much larger than the whole of this belt. The beds of limestone, of iron ore, zinc ore, and some others of minor importance included in this area and interbedded with the other rocks, were of more limited extent, and occupy only narrow strips or belts which extend in the general direction of the whole belt.

Under the influence of heat, pressure, water and chemical action, the beds have undergone great changes in the arrangement of their mineral and chemical constituents, and the rocks which now make up their mass, probably have little resemblance to what they were at the beginning.

The strata, too, have been greatly changed in position as well as in condition. By the general shrinkage of the earth's crust the strata have been subjected to powerful pressure across the breadth of the belt, and also in the direction of its length. The pressure first mentioned has narrowed the belt not by condensing or solidifying its materials, but by forcing the strata to bend and form in great wrinkles or folds, which run in the direction of the belt. These are on so large a scale as to make mountain ridges and valleys.

The original crests of these ridges are called *anticlinal folds*, as in Fig. 1, and their line of direction along the crest is an *anticlinal axis*.

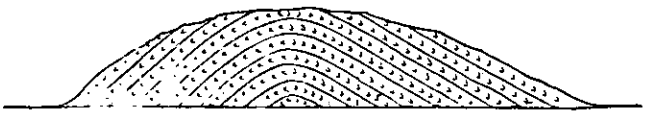


Fig. 1.

Anticlinal fold in the Archæan Rocks near Charlotteburg, Morris County. Scale, 25 feet to an inch.

The depressions in the folds are designated as *synclinal folds*, and the line of direction along which the fold extends, is the *synclinal axis*. These folds have, since their formation, been much worn and changed in their appearance and relative heights. From the very conditions of their formation, it will be seen that the anticlinal folds would have little hindrance to their cracking into fragments as they were bent over, and in that state most easily moved or worn away by the elements. On the contrary, the synclinal folds being held in by pressure on both sides while the bending was in progress, were kept solid and comparatively free from fractures, and so least liable to be worn away. From this condition of the rocks, it happens that the ridges and depressions of the original folds are not so conspicuous on the surface, at this time, as they must have been when first formed. In fact it is quite as common now to find a synclinal axis on the top of a ridge, as represented at Fig. 2, as to find it in a depression; and

Fig. 2.

Synclinal fold in a hill North of Berkshire Valley, Morris County. Scale, 400 feet to an inch.

the anticlinal axes are found in many cases on lower ridges or even in depressions.

The tracing out of these folds is an important part of the geologist's work, and it can be done with certainty, where exposed surfaces of rock can be found. The lines of stratification are still plain, and the slanting or inclined position of the strata which is called the *dip*, shows in most cases the location of the axis about which the fold was made. The angle of dip is measured in degrees below the level sur-

face, and is an important element in geological descriptions. The direction in which the folds run is measured by the surveyor's compass and is called the *strike*. The anticlinal folds are sometimes plainly seen in hills, when they may be spoken of as saddles, and the synclinal folds, which are equally well seen, are known as *basins* or *troughs*.

The pressure lengthwise upon the belt appears to have been accompanied by numerous fractures across it. These fractures, from their appearance in the New Jersey rocks, and the changes effected along them, must have been generally in a north-northwest and south-southeast direction, and with a steep descent or *nade* towards the northeast. The effect of pressure across these fractures and in the direction of the belt, instead of producing folds, has caused the rocks upon the two sides of the fractures to move upon each other; that upon the northeasterly side rising and moving slightly towards the southeast, or that upon the southwesterly side of the fracture moving downwards and towards the northwest under the other rock. The strata of rock are in this way displaced at the fractures, and the changed positions are called *offsets* or *faults*.

An obvious effect of this movement of the rock is to tilt, or change the direction of, the axes of the folds from a horizontal position, and give them a slope or inclination downwards towards the northeast, and a little more towards the north than they were before. This inclination of the line of folding is called the *pitch*. The fact of this inclination has long been noticed by the miners in the iron mines, and the term originated with them. It has not generally been understood even by geologists and mining engineers, and is frequently confounded with the dip, though it is almost at right angles to that line, and is in the direction of the strike, except that the pitch is inclined and not horizontal.

The ores of iron and zinc which are found in these Archæan rocks, are in beds which are conformable to the stratification of the rocks, in which they constitute interposed strata. The only important noticeable difference is, that while, as a rule, the beds of rock extend without important variation for long distances both in length and breadth, the beds of ore appear as if deposited in long narrow strips with defined terminations in length and breadth, and which lie in the general direction of the belt. They have been subjected to the same changes from their original position as those which the rock-strata

have undergone. They show marked examples of folds, of axes of folding, of faults and of pitch, and from the fact that they have been extensively mined, their structure has been more fully exposed than that of the rest of the rock-strata.

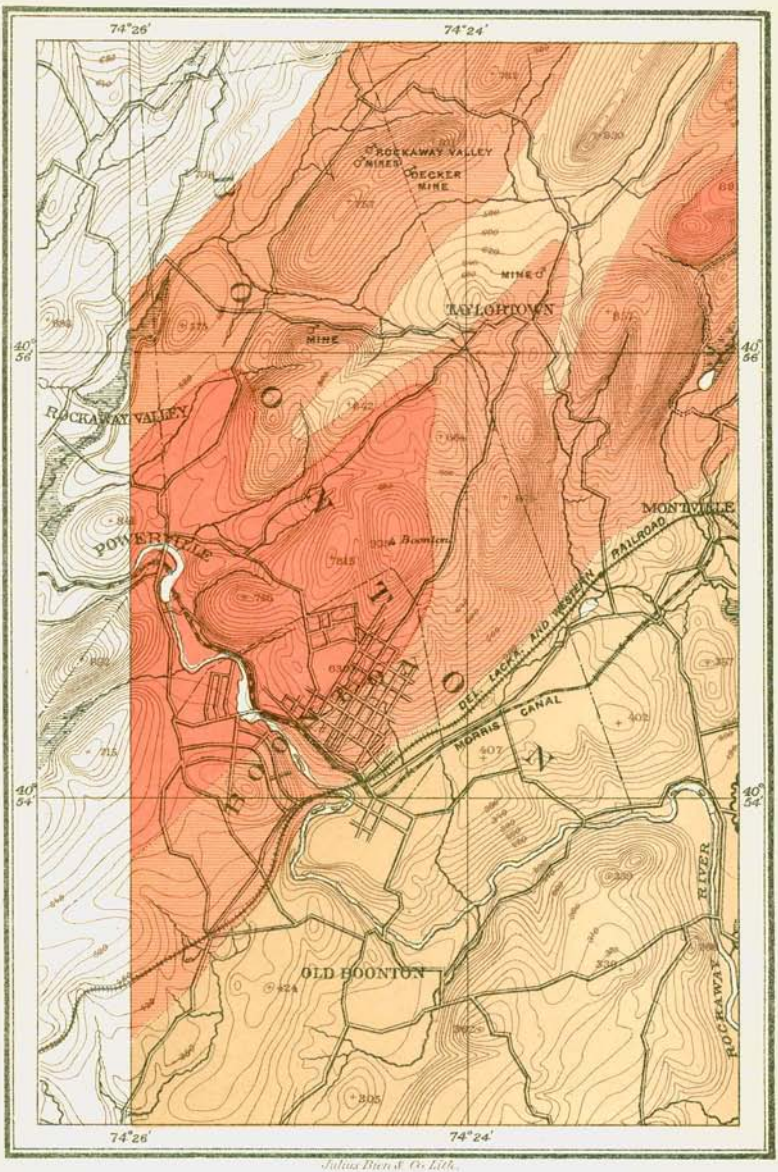
There are other minor peculiarities and marked features of the rock structure of this age, which will be more fully brought out as the field-work and descriptions progress. These prominent ones have been noted in succession in many of our preceding reports. Prof. H. D. Rogers, in his report of 1840, called attention to the interrupted ridges which make up the main belt of the Archæan rocks. Dr. Kitchell, in his reports for 1854–6, called special attention to the northeasterly *pitch* of the rocks, and to the faults which traversed the rocks and ore beds. Prof. Smock, in the report for 1884, pointed out the occurrence of areas of massive rocks which occupy some of the ridges of the Archæan belt, and which appear to be the remains of anticlinal ridges which have been denuded of their overlying strata, and thus have had their lowest, oldest and most solid layers exposed. He also showed the opportunity these exposures presented for a study of the lithological structure of the rocks of this whole belt. In the report of 1885, Dr. N. L. Britton made studies along eleven sections which he drew across this belt, at regular intervals between New York boundary on the northeast, and the Delaware river on the southwest, and fairly began the work of preparing a systematic and detailed description of the geological structure of the country and of the different rocks and ores found in this district, and their geological relations to each other and to the surface.

During the past summer, Dr. Britton has been engaged upon this work, and his report upon it is herewith presented.

DR. BRITTON'S REPORT FOR 1886.

In last year's report* the conclusions then reached regarding the Archæan rocks of the State were presented. An account was given of work previously done on them; considerable space was devoted to a discussion of the different kinds of rocks composing the Archæan strata, with notes on their mineralogical composition and occurrence; the eleven section lines traversed across the system were briefly described; the statement of the existence of massive areas of granitic,

*Ann. Rep. State Geol. 1885, pp. 36-55.



Julius Bien & Co. Lith.

GEOLOGICAL MAP OF A PORTION OF MORRIS COUNTY
NORTH OF BOONTON.

Massive Group | Iron bearing Group | Gneissic and Schistose Group | Triassic Red Sandstone

granulitic and syenitic rocks, made in the report for 1884,* was confirmed, the location of many of these was given, and the inferior position of the rocks composing these areas as regards the more stratified deposits surrounding them was noted; it was shown that the system might best be called "Archæan" rather than Azoic, Eozoic or Primitive, and its possible divisibility into two or more parts was remarked upon; some space was also given to the consideration of the contact phenomena presented by these ancient rocks with the overlying sandstones, limestones and slates of Palæozoic age.

During the past year the study of the lithology of the system, including both the metamorphic and eruptive rocks, has been continued, and all the specimens collected have been labeled and catalogued, and are ready to be sent to the museum in the new State House, at Trenton, when this is completed; many additional areas of massive rocks have been approximately located, and the boundaries of others found last season more accurately defined; gaps in the sections, due to poor exposures of rock along the lines traveled last year, have been filled up by studying portions of the country a little north or south of the lines, and certain areas of the region have been very carefully examined and the several divisions of the Archæan series which we hope to establish have been marked out on the topographical maps. This has been work requiring a great deal of time and the utmost care, as we have considered it necessary to visit every outcrop that can be found and locate it on the maps. The plan adopted was to take a massive area as a center and from that work outwards till the more stratified rocks were encountered, and then to search for exposed contact points; in this way evidence was obtained which fully confirms the hypothesis formerly advanced that the rocks of the massive areas underlie the surrounding strata.

A portion of Morris county north of Boonton was thus surveyed and the observations thereon are here represented; the southern parts of Pochuck mountain, from Hamburg to Decker pond, were examined and are illustrated on an accompanying map; the territory between Greenwood lake and the valley of the Wanaque river has been partly studied, as has that between Berkshire valley and Lake Hopatcong. The survey of these is not yet sufficiently complete for illustration. As much of the region is covered with soil and drift, the boundaries of the divisions can never be absolutely determined, and we often

*Ann. Rep. State Geol. 1884, pp. 65-68.

have to connect widely distant points in laying down the lines of separation.

Many of the iron mines have been visited during the summer and autumn, and a chapter of notes on their geological structure and present condition will be found in another place in this report.

THE GEOLOGICAL AGE OF THE ROCKS.

The Archæan rocks of Canada have been divided by the geologists of the Canadian Geological Survey into two systems, and this division has formed the basis for nearly all subsequent study of them, both in America and Europe. The lower and older of these was termed *Laurentian*, by Sir William Logan, in his report for 1852–3; the upper was named *Huronian*, by Dr. T. Sterry Hunt, in 1855.

As a whole our New Jersey Archæan Series corresponds well, lithologically, with the Laurentian System of Canada, though some of the rocks which compose it there have not been found within our limits. The most notable of these is the Norite, a rock of great extent in Canada and the Adirondack region of New York State; none of this has been found in place in New Jersey. Dr. Hunt has regarded this rock as characteristic of a distinct division of the Laurentian, the *Norian*. If, however, as has been argued by Hawes and other recent writers, this is really an eruptive rock, and thus no part of the stratified deposits, we may leave it out of account in considering the equivalency of the metamorphic rocks of Canada and New Jersey. We have so far been unable to identify the Huronian System in the New Jersey Series.

THE SUCCESSION OF MEMBERS.

The recognition of the fact that the massive Quartz-Syenites, Granulites and Granites underlie the more stratified rocks, and form the base of the Archæan Series, opened the way for observations to determine the sequence of occurrence of these, and certain results have now been reached which may here be presented. We will provisionally divide our Archæan rocks into three groups of strata. These may, perhaps, be found susceptible of further logical subdivision as the study of the region is carried forward. In designating these three divisions as *groups* we follow the report of the French Committee of the International Geological Congress to the meeting

at Berlin, in 1885,* and also follow this report in using the term *series* as applied to the Archæan or Primitive rocks as a whole. Our three divisions are based on stratigraphical evidence, but the rocks of the three groups considered collectively are quite distinct, and thus the classification is both stratigraphical and lithological. Up to the present time we have found no indications of unconformability between any of the three groups, but rather a gradual transition from one into the others through strata of variable mineral composition. This feature is in itself not more remarkable than the gradual change from one sedimentary rock into another, examples of which we find in all the more recent geological formations, such as the passage of a sandstone into a shale, or of a shale into a limestone, or of coal into shale through beds of impure carbonaceous material; and it only indicates that there was no cessation of deposition during the Archæan era, but that the conditions under which sedimentation took place were slowly but constantly changing, and thus different materials were laid down at different times. While no extensive chemical investigations of the rocks have yet been made, we are safe in concluding, from the widely different mineralogical composition of the lower and upper strata, that these differ greatly in chemical composition.

Our proposed classification of the rocks may be concisely represented in the following table, the oldest group at the bottom:

PRIMITIVE SERIES—ARCHÆAN ERA. LAURENTIAN (?) SYSTEM.	*III. Gneissic and Schistose Group.*	Biotite Gneiss; Garnetiferous Gneiss; Feldspathic and Quartzose Hornblende Schists; Talc Schist; Tremolite Schist; Kyanite Schist; Tourmaline Rock; Graphite and Graphitic Schist; Pegmatite and Granites in segregated masses; Bedded Diorite; Red Hematite; impure Crystalline Limestone and Serpentine.
	II. Iron (Magnetite) Bearing Group.	Stratified Granulites, Hornblendic Granulites and poorly Micaceous Gneisses with beds of Feldspathic Hornblende Rocks; beds of Magnetite with Black Mica Schists and Chloritic Schists; segregated coarse Quartz Syenites; Franklinite; Crystalline Limestone; Dolomite and Ophiolite locally containing scattered flakes of Graphite.
	I. Massive Group. . .	Quartz-Syenite, Granulite, Hornblendic Granulite and Granites, with little or no apparent bedding, but showing on fresh exposures a lamination or parallel arrangement of the crystals indicative of some phase of sedimentary origin.

* See "The Work of the International Geological Congress and its Committees," by Dr. Persifor Frazer, 1886, pp. 94–95.

I. The Massive Group.

The inferior position of the massive rocks has already been alluded to. The fact has been abundantly verified in the field-work of the past season, and is here illustrated by sections drawn from observations on outcrops and mines in various parts of the Archæan region. Fig. 3 represents a section about 800 feet long in a northwest and southeast direction, on the road from Berkshire valley to the Hurd mine, Morris county, at nearly the highest point on this road, and shows the strata of the Iron-Bearing Group resting on either side of an anticlinal axis of massive Quartz-Syenite. No mine has been opened within the limits of this section, but the stratified rocks are those of the Iron-Bearing Group.

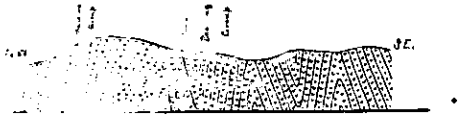


Fig. 3.
Section on the Berkshire-Hurdtown road.
Scale, 1 inch = 400 feet.

This section represents as well the folding of the beds. At Ringwood, the mines are in stratified Granulites, which rest on the flank of the mountain to the west. (Fig. 4.)

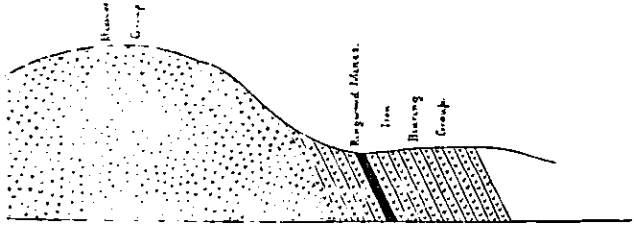


Fig. 4.
Section through the Ringwood Mines.
Scale, 1 inch = 400 feet.

The Green Pond mines occupy a similar position in relation to a massive anticlinal axis, which has the eastern escarpment of the Copperas mountain, composed of the coarse red Oneida conglomerate on its summit. (Fig. 5.)

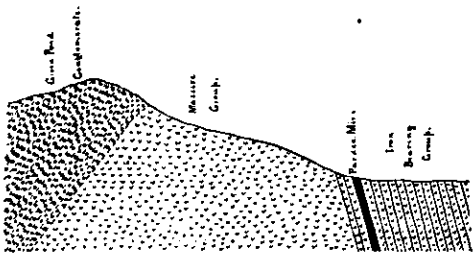


Fig. 5.

Section through the Green Pond Mines at the east base of Copperas Mountain.

At the Cascade mine (Fig. 6), on the Sussex railroad between Andover and Waterloo, the magnetite-bearing rocks rest on the massive Granulites, which, in the stone-quarry near by, are indistinctly bedded and laminated.

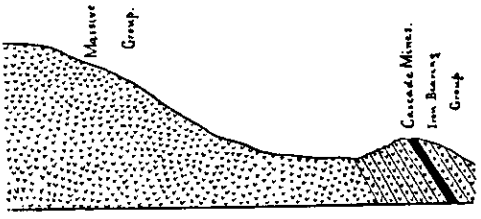


Fig. 6.

Section through the Cascade Mine near Waterloo, Sussex County.
Scale, 400 feet to an inch.

At all these places, and indeed at all points where the rocks of the Massive Group and those of the Iron-Bearing Group come together, the passage from one to the other is gradual. But where those of the Gneissic and Schistose Group rest directly on the massive rocks, the transition is more abrupt, though no unconformability has yet been made out. This relation is shown in Fig. 7, representing a section about 2,000 feet long across the southern end of the Pochuck mountain, northwest of Hamburg, Sussex county. Here the massive rock is mainly Granite, though at points north of the section some massive Granulite is exposed. The Gneisses and Schists dipping to the southeast form the crest of the mountain, which is synclinal in structure, as is shown farther on at Fig. 10. The position of the Iron-Bearing Group is between the Granite and the Schists, but it is not represented at this part of the mountain. Farther northeast in the

same range the iron-bearing rocks come in and are seen in their proper position. The old Bird mine was opened in them, and some ore was taken from it to the Franklin Furnace.

Illustrations of these relations of the systems might easily be multiplied, but the foregoing are sufficient to show that the rocks of the Massive Group underlie everything else, and are hence, geologically, the oldest deposits exposed in the State.

The rocks of this basal system of Archæan rocks were described in last year's report, and some additional notes on them may be found in the chapter on Lithology in the present one. We have called them *massive*, and this adjective is well applied, for they are the densest and most compact. It must not be inferred, however, that they are absolutely devoid of stratification. Indeed, on fresh surfaces—such as those exposed in quarries and railroad cuttings—some lamination or parallel arrangement of the minerals can always be observed, and in at least one area, west of Brook Valley, in Morris county, there are extensive outcrops of heavily bedded Granulites and Quartz-Syenites, in which no great masses of Magnetite have been found that would seem to belong to the Massive System. Over other wide areas, however, the outcrops are extremely dense, and it is only in excavations that lamination may be detected. We have satisfied ourselves that the lamination here alluded to is really parallel to the ancient bedding of the rock. It has been argued by various writers that mere lamination is no proof of a sedimentary origin, as it exists in some rocks of unquestioned igneous origin. In these granitic and syenitic areas, however, we have always found that when bedding-planes are distinguishable, they are parallel to the lamination, and that in the upper groups the same is true. There is, indeed, no evidence adducible in favor of an igneous origin for these rocks, but all indications point to their deposition as sediments of one kind or another, and to the more or less complete obliteration of the bedding-planes, by the excessive metamorphism to which they have been subjected. The question of their actual mode of formation we prefer to leave until more exact knowledge of their nature has been obtained, by their study under the microscope and by chemical analysis. It appears to us, however, from the vast amount of alkalies that the presence of so much feldspar implies, and for other reasons, that they could not have been formed from any such mechanical sediments as make up the shales and sandstones of more recent geological systems,

and it is very reasonable to suppose that the conditions of sedimentation from the waters of the Archæan ocean were different from those existing in subsequent times, but we have not sufficient data at present to enter the discussion of this extremely interesting question.

The simplicity of mineral composition is a notable feature of these basal rocks. Probably as much as 99 per cent. of those exposed in New Jersey and southern New York is made up of orthoclase, quartz, hornblende, oligoclase and biotite, and these occur in relative abundance about in the order named. Orthoclase feldspar is certainly the most abundant constituent and biotite or oligoclase the least, though the amount of triclinic feldspar is surprisingly large, nearly every specimen that has been critically examined showing more or less of it.

The gradual transition from the rocks of this group into the magnetite-bearing strata of Group II., without any unconformability to show a stratigraphical break, is evidence in favor of the hypothesis that the massive rocks were not land areas around which the iron-bearing strata were deposited, but indicates that the sedimentation of the ferruginous matters, which are now beds of magnetic iron ore, took place from the same ocean which had previously deposited the materials now forming the massive rocks.

Attention may also be called to the fact that none of the occurrences generally cited as evidences of life during the deposition of the Archæan strata, such as graphite, limestone, etc., are present among the rocks of this group.

From descriptions given in the reports of the Geological Survey of Canada, we infer that our massive group is very similar, lithologically, to the rocks there termed the "Fundamental Gneiss," and denominated by Dr. T. Sterry Hunt in his "Report on Azoic Rocks, etc.," to the director of the Second Geological Survey of Pennsylvania,* the "Ottawa Gneiss," from its development near that city. If the two systems should prove to be identical, following the established precedent of naming geological horizons after places where their strata are well exposed for study, we may later adopt the name "Ottawa" for this group, but we object to the expression "Ottawa Gneiss" as misleading. With us, at least, the rock is never a gneiss, for that implies a micaceous, well-stratified rock, while these are very indistinctly bedded, and, as a whole, contain very little mica.

*Second Geol. Survey Penn., Report E., Part i., p. 155, 1875.

II. The Iron-Bearing Group.

This division of the series is well characterized by the occurrence of beds wholly or mainly composed of magnetic iron ore, which furnish the material for the great iron industry of the State. All the mines which have produced ore in paying quantities, and, indeed, all from which any considerable amount of ore has been taken, are enclosed by rocks of this group. While the microscope shows that in some of the massive rocks scattered grains of magnetite sometimes occur, and while small pieces and grains of this mineral may be found in the schists and gneisses, no *deposits* of ore are known in either the lowest or the uppermost group of the series, but all occur within the limits of Group II., and thus form one of its most characteristic features. All the deposits of magnetite are true beds, and so are those of zinc ore at Franklin Furnace and Ogdensburg. They are strata conformable to the surrounding rocks, agreeing with these in strike, dip and pitch, though, as has long been remarked, they are generally more local than the rock strata. They are sometimes very irregular in shape, however, from the foldings and contortions of the rocks, but careful examination of mines sufficiently opened always shows that they are beds and not *veins*, although this name is commonly applied to them, and, indeed, they are thus best known to all engaged in mining. If this feature of their structure were more generally understood, the opening and working of mines would be more certainly and economically accomplished. It is a fact that no real vein of iron ore has been found in the State.

The beds are never of uniform thickness throughout their whole extent, but are alternately wide and narrow, forming "shoots" and "pinches." In some cases the deposit is entirely lost along a "pinch," but in others it is simply narrowed. An interesting feature of the "pinching" is that it commonly results from a bulging inward of the foot-wall of the deposit, which, in the miners' language, is expressed as "the ore is cut out by the foot-wall coming in;" this is not invariably so, but certainly more often than otherwise. The foot-wall is, except in overturned beds, the ancient surface on which the ore was deposited, and this structure might be explained by supposing this to have been uneven. But there is nothing to show that any folding occurred until after the final deposition of the beds, for they have all been folded together, and some other way of accounting for it seems

necessary. The suggestion has been made that the structure may have been produced at the time of folding, while the rocks were yet in a somewhat plastic condition, by the denser materials underlying the ore being forced into it along certain lines, the ore being thus squeezed into its present shape. It is difficult to imagine the details of such a process, but something of a similar character has been remarked in certain beds of coal.*

Many of the magnetite beds are near the base of this group, and thus close to the massive rocks; such are those worked at Ringwood, and the Green Pond belt. Others appear to be higher in the series, as the great Hibernia deposit. In the upper part of the group, where many beds of feldspathic hornblende rock and poorly-micaceous gneisses are found, as may be seen in the cuts along the D., L. & W. and C. R. R., just west of Dover, but little magnetite exists, and these beds grade insensibly into those of Group III., where no workable ore deposits have been found.

The mineral Apatite, phosphate of lime, occurs in many of the ore-beds in considerable quantity, and is, perhaps, present in greater or less quantities in all of them. It is found abundantly in small grains in all the mines of the belt extending from Mount Hope to Hacklebarney. Some years ago a deposit of Magnetite, Pyrite, Pyrrhotite and Apatite was worked at Nolan's Point, on Lake Hopatcong.†

The Crystalline Limestones of this group appear to be in general slightly above the horizon of the beds of Magnetite, although a few mines have been opened in them, as the old workings at Franklin Furnace described on page 659 of the Geology of New Jersey, 1868. One line of these mines was in the white limestone, but very near its contact with the underlying Granulites, etc.; the other was in the Granulites themselves. None of these are now worked. The bed of Zinc ore is geologically a little above the iron deposits and is in a synclinal fold. The structure at Franklin Furnace is illustrated in figure 9 of this report. The Kanouse Mine, at the western base of the Ramapo mountain, half a mile east of Midvale station, N. Y. and G. L. R. R., is about in the same position, lying nearly between the Crystalline Limestone and the Granulites. At Ringwood, white limestone is reported in the workings of one of the mines, though it occurs mainly to the east, and stratigraphically above the ores. The

*See "Coal, Iron and Oil," by S. H. Daddow and B. Bannan, 1866, pp. 270-272, fig. 95.

†Geology of New Jersey, 1868, p. 603.

old Andover mine is nearly in the line of strike of the Crystalline Limestone at the quarries near by, and to the northeast of them, the pitch of the limestone carrying it beneath the ore. The Kishpaugh mine, near Great Meadows station, Warren county, is on the western side of a low hill which has the old Rose Crystal marble quarry, opened in a pink variety of Crystalline Limestone, on its eastern side. The rocks at the mine dip S. E., while at the quarry they dip N.W., indicating a synclinal structure which would bring the limestone up on the western side of the fold near the mine. But the limestone is a local deposit, being known only in two widely-separated belts, and occurs in the proximity of only a few mines. It is not of general distribution in the system. From the occurrences above noted it is evident that its horizon is very close to that of the magnetite ore bodies, and probably a little above them.

Graphite is abundant in the great Crystalline Limestone area of the Vernon and Upper Wallkill Valleys. It occurs in disseminated scales and grains, and has not been there observed in sufficient quantity to warrant mining. It has also been observed in the eastern belt of Crystalline Limestone at Sanders' Quarry, near Mendham, Morris county.

The strata which we have included in Group II. are, apparently, very similar, lithologically, to those grouped as the "Grenville Series" in the Geology of Canada, 1863, p. 839, which, like our Iron-Bearing System, rests on more massive rocks. In the chapter on "The History of Pre-Cambrian Rocks," in his book entitled "Mineral Physiology and Physiography," Dr. T. Sterry Hunt remarks: "We distinguish at the base of the Eozoic System, a massive and essentially granitoid gneiss, with little or no mica. To this fundamental rock, sometimes called the Ottawa Gneiss, and of unknown thickness, succeeds what has been named in Canada the Grenville Gneissic Series, made up in great part of a gneiss somewhat similar to that last mentioned, with intercalations of Hornblendic Gneiss, of Quartzite, of Pyroxenite, of Serpentine, of Magnetite, and of Crystalline Limestone, the latter often dolomitic and sometimes attaining thicknesses of a thousand feet or more. The Grenville Series, the strata of which are generally highly inclined, has an aggregate volume of not less than 15,000 or 20,000 feet, and appears to rest unconformably upon the fundamental or Ottawa Gneiss."

This description agrees in the main with the composition of our

Iron-Bearing Group of the Highlands of New Jersey and Southern New York. There would seems to be some differences, however. We have found no true Quartzite in the area hitherto studied, though in the Pardee mine, at the foot of Copperas mountain, there is a rock composed of extremely finely-divided Magnetite and Chalcedonic Quartz in about equal proportions. Segregated vein Quartz is of frequent occurrence in the mines, but we have yet to find any real bed of Quartzite. As regards Pyroxenite we must withhold judgment; the rock has not been identified in New Jersey, but note has been made of the occurrence of rocks rich in Pyroxene in one or two areas of limited extent; there is an abundance of it at several of the mines, but there it is rather a mineral than a rock. All the other strata mentioned by Dr. Hunt are represented in our territory. We can report no unconformability between this Group and the Massive one, however, and do not think that it is, in New Jersey, of any such immense thickness.

Messrs. Whitney and Wadsworth, in their paper on Azoic rocks,* propose the name *Siderian* for Magnetite, Hematite and Menaccanite, but do not further define the division. We have found no Hematite in the Iron-Bearing Group, except as a surface alteration product of Magnetite—the "red ore"—though we may perhaps admit Menaccanite, some of the Magnetites being titaniferous. Their grouping is a strange one, because it would make the Hematites of the Lake Superior region, and the Magnetites of Canada, New York and New Jersey, of equal geological age, while it is certain that these Magnetites are older.

It will be remarked that in the strata of Group II. we have all the phenomena generally adduced as indicative of life in Archæan times; there are Crystalline Limestones, Graphite, Apatite and Iron Ores, while, as was shown before, none of these are known in the Massive Group. It is true, also, that we here have much greater variety in the minerals found in the rocks; the Crystalline Limestones, in particular, furnish a large number of different kinds.

III. The Gneissic and Schistose Group.

This division is composed of all the Archæan rocks which overlie, and are hence, geologically, younger than the Iron-Bearing strata. In

* Bull. Mus. Comp. Zool., Vol. VII., p. 562.

some portions of the area they rest, indeed, directly on those of the Massive Group, as the Iron-Bearing Group was not deposited uniformly, but is locally absent; here they may be recognized by their lithological characters, and by following their outcrops until they are traced to those of the Iron-Bearing rocks, and there noting the rela-

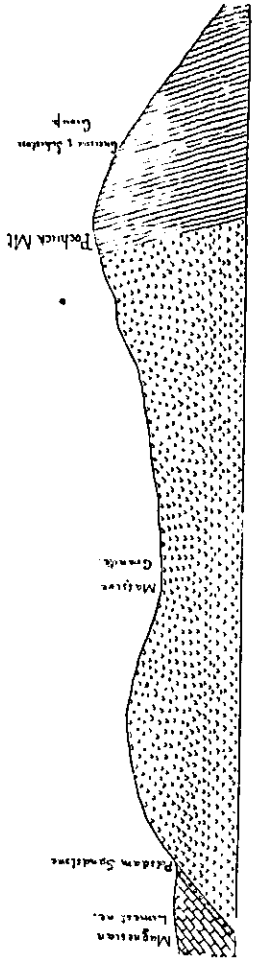


Fig. 7. Section through the Pochuck Mountain northwest of Hamburg, Sussex County.

tions of the two; this has been successfully accomplished whenever there are enough exposures. As the rocks of these two upper groups merge gradually, it is difficult to tell at many points just where the boundary lines are to be drawn on the maps, though these can generally be located within a hundred feet. At points where the Iron-Bearing rocks are not represented in the series, and the lower and

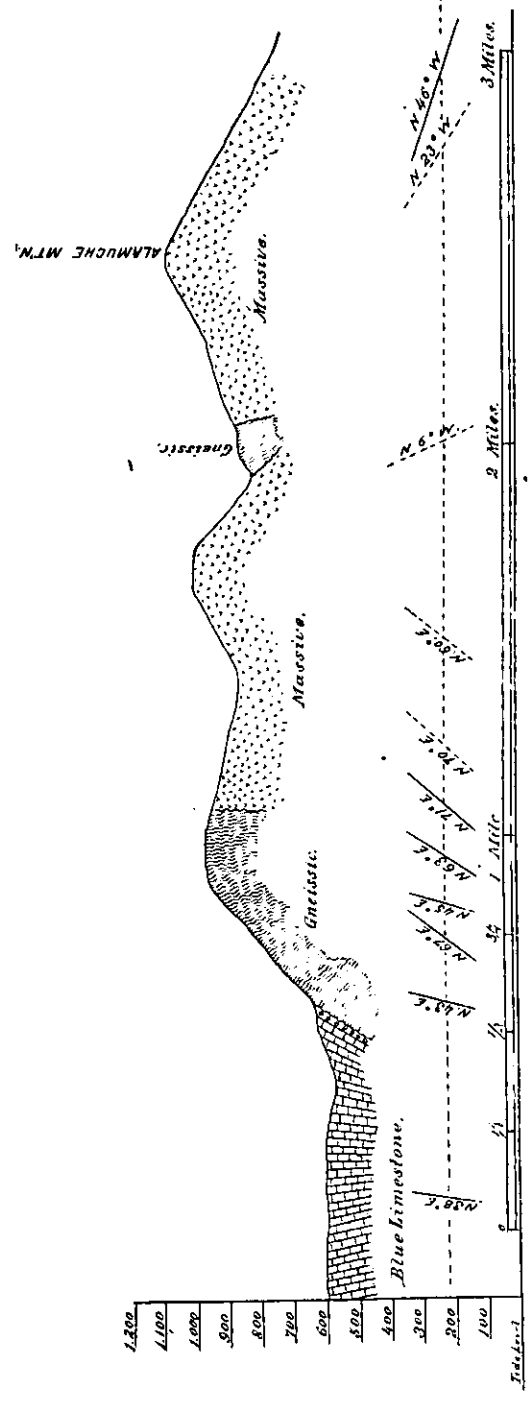


Fig. 8.

Showing the strata of the Gneisic Groups in Synclinal folds in the Massive rocks of the Allamuche Mountain.

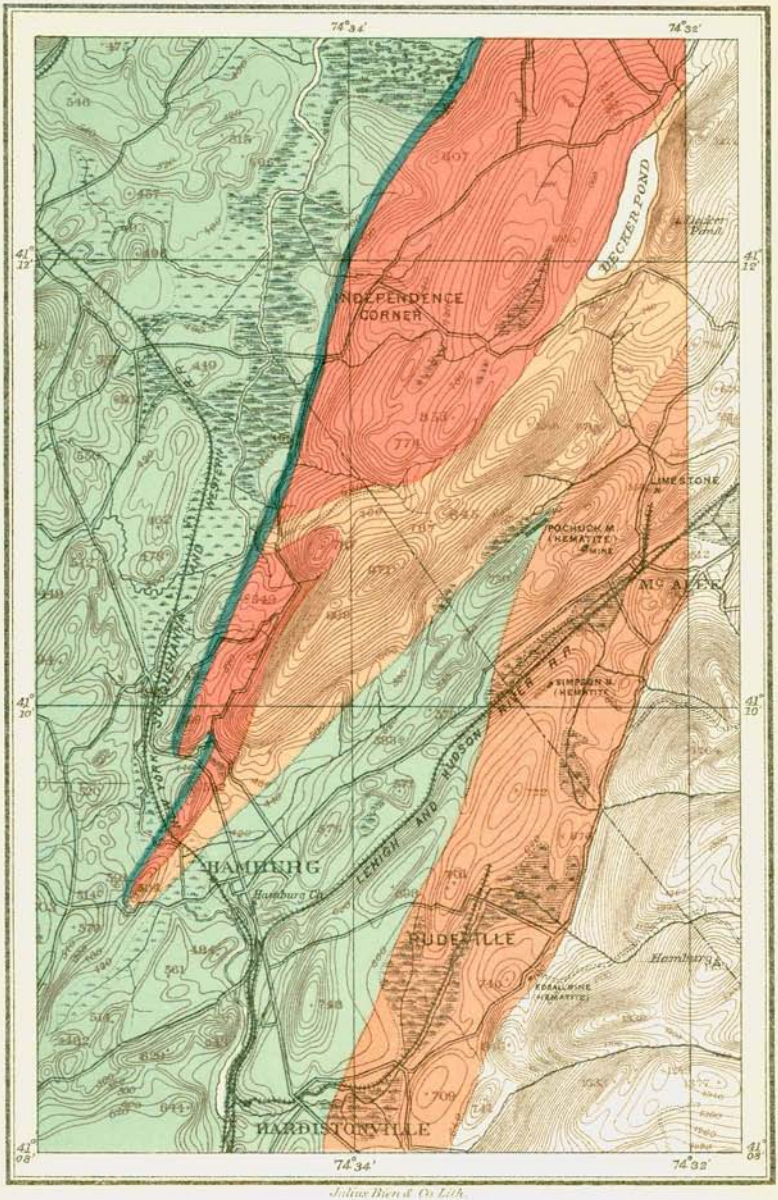
upper groups come directly in contact, the change is more abrupt and the boundaries can be more accurately determined. The relative positions of the Massive and Schistose rocks in the Pochuck mountain, Sussex county, is shown at Fig. 7, and in the Alamuche mountain, at Fig. 8, which was used in last year's report as well.

Biotite Gneiss is the most common rock of the group; Hornblende Schist is also abundant, but the others named in the table on p. 77, are only locally developed.

This Gneissic and Schistose Group of New Jersey agrees in certain respects with the descriptions of the *Montalban System*, a name applied by Dr. Hunt to the schistose rocks of the White Mountains of New Hampshire, and other regions. There, however, the rocks are certainly more schistose than those of our Group III., taken as a whole, and the same is true of New York Island and the southern parts of Westchester county, N. Y., which Dr. Hunt has also referred to the Montalban, and in this last-mentioned region there are very extensive beds of Crystalline Limestone, which rock is but poorly represented in our Group III.

But there are areas in Westchester county underlain by less schistose rocks—true Gneisses, varying to Granulites—surrounded by the Micaceous and Honblendic Schists, and the rocks of these areas greatly resemble those of our Third Group, being, indeed, practically identical in appearance and mineral composition. And, further, some of the New Jersey rocks are as schistose as any of Westchester county. So, in the end, it may be desirable to refer all of our rocks above Group II. to the Montalban, regarding this only as a division of the Laurentian, and not as a distinct and separate system.

The Archæan area at Trenton is composed of rocks which are very similar to those of this group of the Highland Series. They are Gneisses and Hornblendic Gneisses, Feldspathic and Quartzose Hornblende Schists, and some Mica Schist; among these are large, irregular, segregated masses of Granite and Pegmatite. The dip of the rocks of this area appears to be uniformly southeast, at very steep angles—from 70° to vertical—and the strata are much contorted. Gneiss, probably of this group, underlies a portion of Jersey City. This area was described in the Geology of New Jersey, 1868, on pp. 323–325. Here it is associated with Serpentine, and this outcrops abundantly along the river bank at Castle Point, Hoboken. Gneiss, from it range, apparently in this group, has also been met in a well bored at Perth Amboy.



GEOLOGICAL MAP
OF A PORTION OF THE SOUTHERN PART OF POCHUCK MOUNTAIN
NORTH OF HAMBURG

Massive Group | Gneissic and Schistose | Crystalline Limestone | Magnesian Limestone | Potsdam Sandstone

GEOLOGICAL STRUCTURE.

The structure of the Archæan Series has been described in several former reports, and its most salient features have long been known to geologists; a brief review of these, with the addition of other details which have been observed during the field-work of the two past seasons, may not be out of place here.

The Archæan strata were originally deposited in nearly horizontal positions; very rarely, however, are any portions of them seen in such positions at present. They are, indeed, almost universally inclined, and the angle of this inclination, or *dip*, is generally steep, in most cases greater than 45° from the horizontal. As has already been remarked, this inclination of the beds has been brought about by the contraction of the solid crust of the earth, as the gradual cooling of its highly-heated interior progresses, the powerful forces of lateral pressure thus developed having wrinkled the surface, creating ridges along certain well-marked lines; these we call Mountain Ranges, or Mountain Systems. The Highlands of New Jersey and Southern New York are portions of the great Appalachian Mountain System, which is practically continuous from Eastern Canada to Georgia. A table of observed amounts and directions of dips may be found in the report for 1883, pp. 39–50. In the Archæan regions of New Jersey and Southern New York the dip is generally southeastward, but by no means universally so. These inclined strata are the sides of folds into which the beds were bent by the forces accompanying the contraction of the crust.

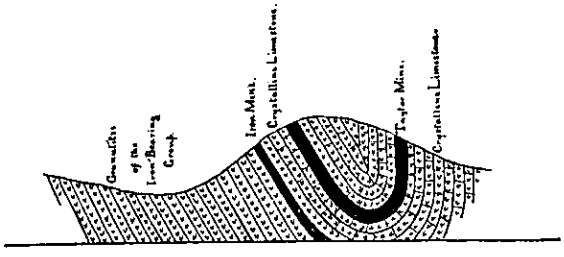


Fig. 9.

Section through the Zinc Mines at Franklin Furnace, Sussex County.

These folds are of two main types. When a fold is concave above, as shown at Fig. 2, it is called *synclinal*, the beds dipping towards a common line; this type is very common in the Highlands, many of

the ridges of the Iron-Bearing and Schistose Groups offering good examples. Fig. 9, a section drawn through the zinc mines at Franklin Furnace, is an excellent illustration of a synclinal fold. The southeast arm, worked in the Taylor mine, is, at the surface, nearly vertical, changing, however, to a northwestward inclination as depth is reached, while the northwest arm, on which the Trotter mine is opened, dips 60° S. E., joining the other below and forming a basin-like, synclinal fold.

The crests of the southern parts of the Pochuck mountain, in Sussex county, of the Gneissic and Schistose rocks, are also synclinal folds, as is shown at Fig. 10.

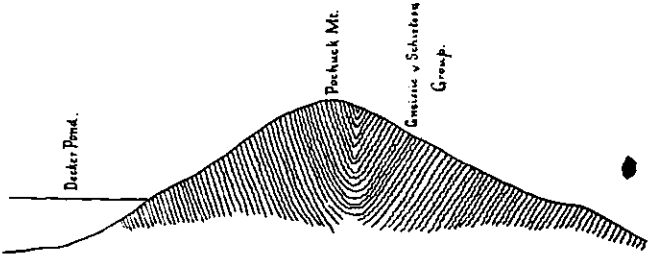


Fig. 10.
Synclinal fold in the Pochuck Mountain east of Decker Pond.
Scale, 400 feet to an inch.

Another one in the southwestern spur of the 857′ hill, three miles northeast of Boonton, in rocks of the Iron-Bearing Group, is illustrated at Fig. 11.

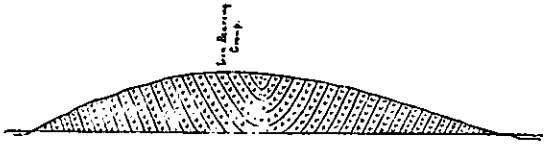


Fig. 11.
Synclinal fold in a hill northeast of Boonton.
Scale, 1 inch = 400 feet.

Anticlinal folds are concave downwards, the strata dipping in opposite directions from a common line; these are also of common occurrence. Fig. 12 illustrates a fold of this character just east of the Beach Glen mine, having the ore-body on its northwestern flank,

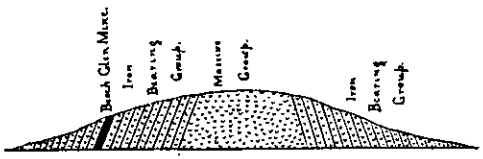


Fig. 12.

Anticlinal fold at the Beach Glen Mine, Morris County.
Scale, 1 inch = 400 feet.

dipping 75°–80°. Just east of the mine excavations, and especially at their southwestern end, the strata of Granulite may be seen curving over towards the southeast, and along the road to Meriden, 500 feet east of the mine, they dip 75° S. E.

Hickory Hill, north of Mount Hope, Morris county, appears to be an anticlinal ridge, as is shown at Fig. 13.

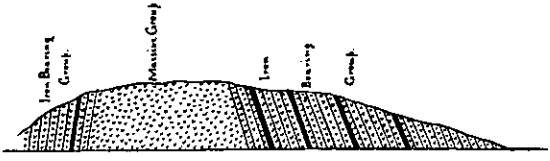


Fig. 13.

Section through Hickory Hill, Morris County.
Scale, 400 feet to an inch.

The large ore-bodies on its southeastern side dip 70° S. E., while the rocks near its summit, which contain one or more small beds of ore, dip 80° N. W. There is a "core" of Massive rock between the two. It is uncertain whether there is a similar one on Mount Hope, as there are few good outcrops there.

Sheep Hill, at Boonton, where the signal of the Geodetic Survey was placed, is another illustration of an anticlinal fold with Massive Quartz-Syenite in the center.

Fig. 3 illustrates another near Berkshire Valley, Morris county, and many additional examples might be given.

Where these anticlinal folds are found in ridges, their summits have generally been worn away by erosion, as in those shown in Figs. 3, 12 and 13. Rarely the top is more nearly entire, as in Fig. 1. When they occur in valleys, however, as many of them do, it is found that a great part of the strata has been torn away by the forces of erosion, and, indeed, the valley has been formed in this

manner, as has already been explained by Professor Cook, on p. 71 of this report.

The axial planes of both synclinal and anticlinal folds are seldom vertical in the Archæan of the Highlands. They generally incline towards the southeast, both sides dipping in that direction, though at different angles, the southeastern sides being steeper in inclination or vertical. The synclinal at Franklin Furnace (Fig. 9) shows this, its axial plane dipping 75° S. E. Sometimes the sides dip equally in the same direction, as shown at Fig. 14, a section through the southern end of the long hill west of the New York and Greenwood Lake railroad, between Monk's station and Hewitt. Here the Massive Granulite occupies the center of the fold and forms the hill, while the Gneisses on either side dip about equally to the southeast.

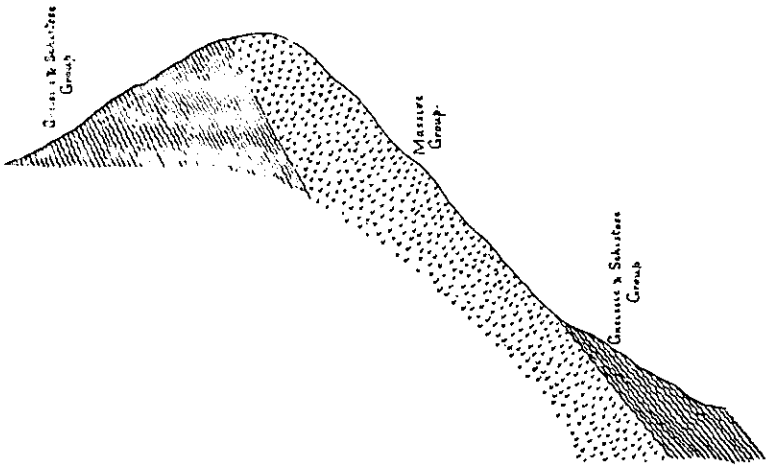


Fig. 14.

Section through a hill west of Monk's Station showing an overturned Anticlinal fold. Scale, 1 inch = 400 feet.

This forms what has been called an *overturned* or *isoclinal* fold. This one is an overturned anticlinal, but synclinals are also found in this position. An isoclinal was figured on p. 59 of the Geology of New Jersey, 1868, but it is not known whether it is of the anticlinal or synclinal type. Many other isoclinal folds are indicated in the field-observations. Indeed, most folds are somewhat inclined, and as this inclination is generally towards the southeast, the prevalent

dip of the rocks towards that quarter of the compass is explained. The reason why most of the folds have been given this southeasterly inclination is not yet obvious to us. It would seem that there must have been along the northwestern border of the area a resisting mass or ridge, against which all to the east had been crumpled. There are extensive areas of Massive rock along the western side of the Pochuck mountain, and also in the Jenny Jump mountain, both of which are along the northwestern margin of the Archæan area. But there are equally extensive, and equally Massive rocks in the center, and towards the eastern side of the area. This question must be given more study before a conclusion can be reached regarding it.

In a few observed cases the axial planes incline towards the northwest. The section through Marble mountain, on the Delaware river, above Phillipsburg, published in last year's report, shows one of these. Here the western arm is nearly vertical, the eastern dipping 40° N. W. This section was drawn with the vertical scale greatly exaggerated, making the ridges appear much higher and sharper than they really are. In the present report all the figures are drawn with the horizontal and vertical scales equal.

But the contraction of the earth's crust did not take place entirely in one direction, but in all directions, though that part of it which has produced the folds is most marked in its results, and the bending of the strata was accompanied by fractures. These fractures occurred whenever the bending pressure suddenly overcame the resistance offered to it. Indeed, all the forces generated by the contraction are yet in operation, for the shrinkage is still in progress. The fractures of the strata still occur and give rise to the most violent shocks, which are transmitted to long distances through the rocks, and are known to us as earthquakes.

These fractures cause portions of strata to move past adjoining portions, and dislocations of many thousands of feet are recorded, though nothing like so great an amount of displacement has yet been observed in New Jersey. The planes of fracture are known by miners as *offsets*, and by geologists as *faults;* the surfaces along which the movement has taken place are often smoothed or even polished, and are then known as "*slickensides.*"

Fig. 15 represents three faults lines through the Mount Pleasant mine, near Port Oram, Morris county, and illustrates the breaking and displacement of the ore-body. It is taken from the report of 1883, and reduced one-half in size.

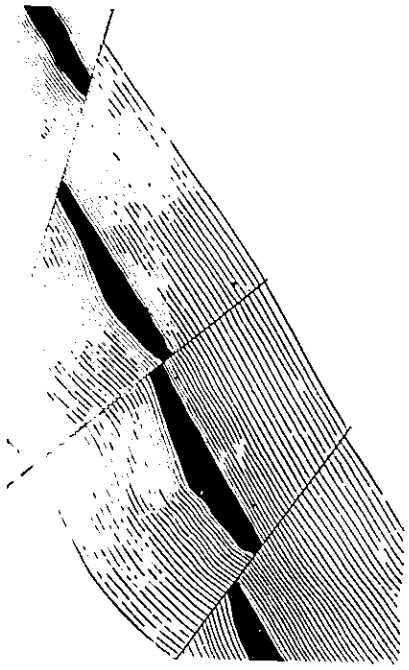


Fig. 15.

Vertical Cross-section of the Mount Pleasant Mine, looking northeast, showing faults.

The faults traverse the rocks in all directions, though many, and perhaps most of them, are at various angles across the folds, and thus across the *strike* of the rocks; others, however, are parallel to this; one of these occurs in the Mount Pleasant mine, and at one point has a throw of 35 feet, and a *hade* of 60° N. W.

It is apparent how, in the folding of the strata, the contraction of the interior of the earth is taken up. This only does it in one direction, however, viz., that across the lines of folding. The contraction at right angles to this is taken up by the strata in an entirely different manner. It has long been known that few of the folds are horizontal; their axes are almost universally inclined, as is diagrammatically shown at Fig. 16.

A nearly complete fold in this inclined position occurs in the Gneisses of the Pochuck mountain, but erosion has, in most cases, greatly obscured the structure, and some parts of the folds are generally worn away. In our Archæan rocks the inclination of the folds is almost universally northeastward, and is called the *pitch* of the

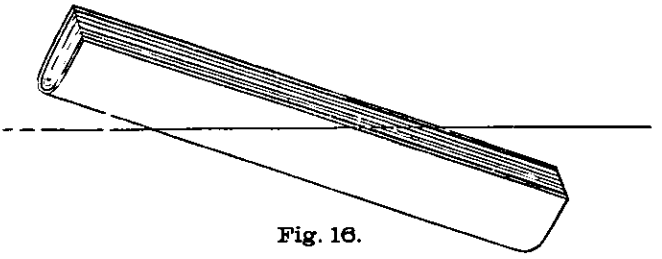


Fig. 16.

rocks. In the iron and zinc mines this feature is well understood, and many mines are operated through slopes sunk on the pitch of the thickened portions of ore-beds. Fig. 17 illustrates the pitch of the Ford and Scofield ore-beds on the Ogden Mine railroad. These are probably but thickened parts of the same bed. The pitch is by no

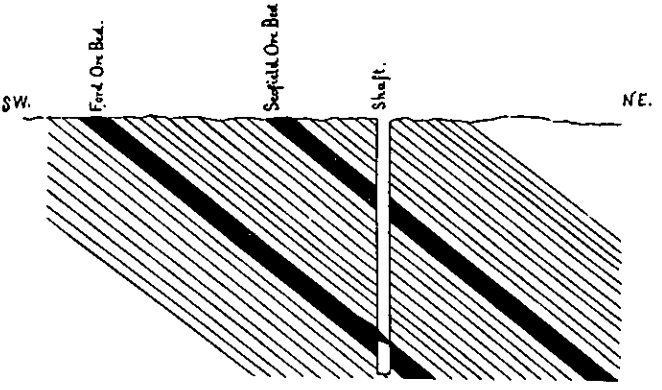


Fig. 17.

means confined to the ores themselves, as has been supposed by some, but is shared by all the rocks, as the above explanation of its cause necessitates. It can be observed and approximately measured on almost every outcrop where stratification is apparent.

The following observed angles of pitch give an idea of the amount and direction of the inclination of the folds; these measurements are additional to those published in the report for 1883, page 55:

LOCALITY.	Amount and Direction.
Near south end of Decker pond	10° N.E.
Summit of hill east of Decker pond	15° N.E.
Eastern base of hill east of Decker pond	5° N.E.
Hill southwest of Roe pond, Pochuck mountain	10° S.
One mile west of Roe pond on road to Milton, Sussex county	30° N.E.
Crest of Pochuck mountain, one mile south of Decker pond	10° S.W.
Southwest opening Mine hill, Franklin Furnace	30° N.E.
Along railroad east of Hurd mine, Lake Hopatcong	26° N.E.
One-half mile south of Hurd mine	25° N.E.
Mount Hope, Jugular bed	30° N.E.
Orchard mine, Port Oram	30° N.E.
Teabo mine	21° N.E.
White Meadow mine	10° N.E.
Beach Glen mine	15° N.E.
East of Beach Glen mine, along road to Meriden	12° N.E.
East of Hibernia mine tunnel	30° N.E.
Lower Wood mine, Hibernia	27° N.E.
Kitchell mine, Copperas mountain	22° N.E.
Three hundred feet northwest of Kitchell mine	15° N.E.
Charlotteburg mine, Morris county	20° N.E.
Davenport mine, Copperas mountain	25° N.E.
Pardee mine, Copperas mountain	25° N.E.
Black Hills mine, southwest of Dickinson mine, Ironia	35° N.E.
De Hart mine, Ironia	35° N.E.
Bryant mine, Mine Hill	33° N.E.
Beemer mine, Hortons, Morris county	20° N.E.
Mount Olive mines	10° N.E.
North of High Bridge, along Raritan river	40° N.E.

These observations, together with those in the report for 1883, give measurements of pitch from all over the Archæan region, and show that it is a very constant feature, indicating that nearly all the folds are more or less inclined. It will be noticed that the inclination is nearly always towards the northeast, there being but two exceptions to this in the above list, and four in the table printed in 1883. Three of these are in ore-beds, viz., the Langdon mine, south of Hacklebarney, which pitches 15°–20° S. W., the Kishpaugh mine, at Great Meadows, 15° S. W., and the Lawrence mine, Randolph township, Morris county, has also a S. W. pitch. At least 90 per cent. of the observations show the northeast pitch, and this averages about 30°.

Now, if this northeastern inclination of the folds continued, without a break, along the whole of the Archæan Highlands of New Jersey and Southern New York, any section of a bed outcropping at any point would be located consecutively deeper and deeper as its strike was followed northeastward. Regarding the angle of pitch as 30°, every mile towards the northeast would bury the bed nearly half a mile deeper, so that a bed outcropping at Boonton would at Pompton be about five miles below the surface, at Suffern about ten, and at West Point thirty-five, and across the Hudson, in Putnam county, New York, would be fifty to sixty miles deep. But, as we find the same rocks outcropping at intervals all along the lines of strike, it is apparent that this is not the real structure. We have already alluded to the numerous faults which traverse the rocks, and shown that many of them are across the folds, and it is to these that we may look

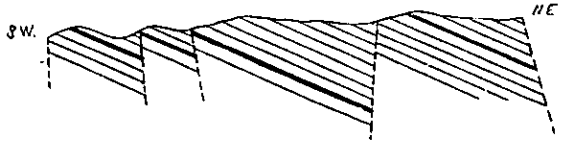


Fig. 18.

for an explanation of this fact. They are best seen and studied in the iron mines. They are generally of upward throw, the parts northeast of each fault being moved upward, or those to the southwest moved downward, the resulting positions of the beds being relatively the same in either case. The planes of faulting may be nearly vertical or quite steeply inclined. The general result of this breaking of the folds may be diagrammatically represented as in Fig. 18.

It is plain that this tilting shortens distances along the strike of the beds.

The faults are not always of sufficient throw to bring any one part of a bed to the surface, and even if they were we cannot always find it, so much of the region being covered with decayed rock, soil and Glacial Drift.

This "pitch and fault" structure is illustrated by the narrow bed of Crystalline Limestone and Serpentine in the eastern Highlands. Beginning at the southwest it is first known at Sanders' quarry, near Mendham, Morris county; it is next seen only after a space of about ten miles, at Gordon's quarry, near Montville, Morris county, though it may be brought to the surface many times between these two points, the district being one of few outcrops; then there is another interval of six miles and the limestone appears along the western side of a meadow east of Mud pond, and two miles northwest of Pompton,

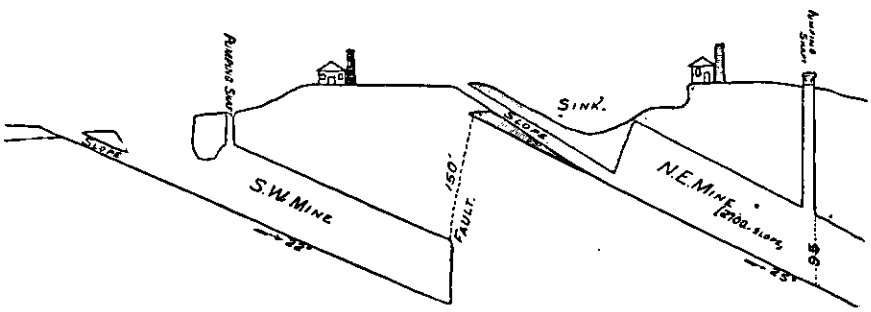


Fig. 19.

Longitudinal Vertical Section through the Hurd Mine, Hurdtown, Morris County. Scale, 1 inch = about 300 feet.

Passaic county; one mile to the northeast it is again seen, and again, after another mile, at Van Houten's quarry, and at several points in and near the valley of the Wanaque river to Ringwood. In this valley there are good exposures of all the rocks, and points on both sides of some of the folds, as shown in the limestone outcrops. From Ringwood to Fort Montgomery, on the Hudson, it is known at intervals; many of these outcrops are shown on the large wall-map of the State published in 1868, which includes a considerable part of southern New York. The iron-ore beds illustrate this pitch and fault structure at many places. As good an example as we know is the

Hurd mine, where the ore body has been thrown about 150 feet upward, as shown at Fig. 19.

In most of these faults across the folds the beds appear to be moved laterally, but we have so far been unable to ascertain definitely that

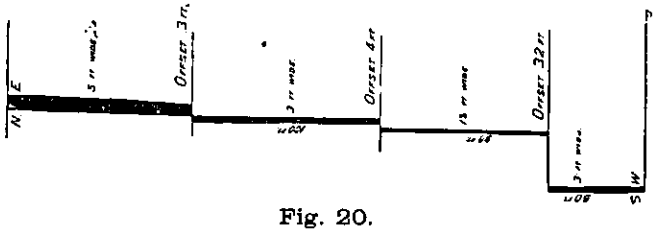


Fig. 20.

Plan of Faults or Offsets at the Randall Hill Mine, Mine Hill, Morris County. Scale, 1 inch = 100 feet.

the real movement in the rocks has been other than upward, and indeed these apparent lateral throws are readily explained without recourse to any assumed lateral motion, for it is apparent that if an inclined fold be broken across, and one part be raised, and the immense amount of erosion to which the region has been subjected, be considered, the two parts would not be in line. The relative positions of the ore-beds on the southeastern slopes of Mount Hope and Hickory Hill illustrate this structure. A map of the two is shown at Fig. 21.

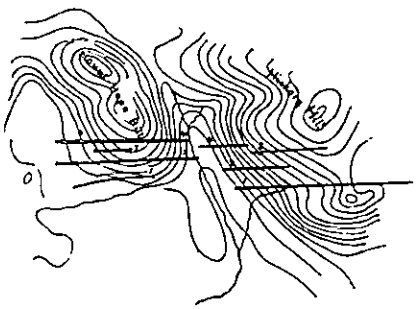


Fig. 21.

Map of Mount Hope and Hickory Hill, Morris County, showing the dislocation of iron ore beds by the fault between the hills.

There are several beds on Mount Hope, dipping about 70° S. E.; the same beds are repeated on Hickory Hill, but they all outcrop about 160 feet to the southeast of where their continuations might be looked for. If only vertical movement has taken place, a fault of

about 450 feet vertical throw would be required. So, at Port Oram, there is a fault or offset in the valley of the Rockaway river, between the Orchard mine and the Washington mine; the ore-bed in the Washington and its northeastern continuation, the Meadow or South Mount Pleasant mine is between 150 and 200 feet southeast of a line drawn through the Orchard mine workings; the dip is here about 57° S. E., and a vertical movement of about 270 feet is required. These are the greatest faults indicated in our field observations, but there may very well be others of greater throw which we have so far failed to discover.

But besides the folding and the "pitch and fault" structure, there is still another way in which strata of the earth's crust have been affected by the contraction of its interior. The strike of the rocks is observed to vary considerably in short distances, showing that the arms of the folds are not always straight, but often curved, and sometimes they are very greatly curved, first in one direction and then in another, the strike thus becoming a sinuous line.

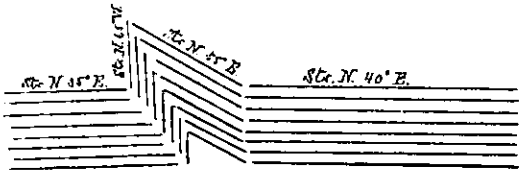


Fig. 22.

Plan of strike of broken strata, west of Monk's Station.
Scale, 400 feet to one inch.

The great amount of contortion has, indeed, always been a subject of remark, and is so well known that it demands but little attention at the present time. A good illustration may be found on p. 75 of the report for 1883. This bending of the strata is of all degrees, varying from slight undulations to great curves of hundreds of feet. Indeed, wherever we find the strike much changed from a prevalent northeastern direction, we have illustrations of this structure, and northwestern strikes have been observed in nearly all parts of the Archæan area. This bending of the folds has evidently been accomplished by great pressure, for sometimes the beds are seen broken across, as in Fig 22, which represents this feature, as shown in the Gneissic Group at the southern end of the long hill west of the New York and Greenwood Lake railroad, between Monk's station and

Hewitt. There is also a break of this kind indicated on the northern side of the Ogden Mine railroad, between Minnisink station and Nolan's Point, Lake Hopatcong. Everything shows that the rocks have been under great strains of tension and compression, and some of them are doubtless still under the action of these forces.

NOTES ON THE LITHOLOGY.

In last year's report we presented a list of the kinds of rocks which had then been found in the Archæan regions of the State, with brief descriptions of their mineral composition and structure, and notes on their occurrence. The study of Lithology has since been continued, and the following remarks on those there mentioned, and on a few additional kinds since met with, may be of interest. Those interested in following our studies of the rocks are specially referred to the report for 1885, pp. 40–46.

I. Metamorphic Rocks.

GRANITE.—It was noted that this rock occurred in some of the massive areas, and the Sparta mountain, Sussex county, was cited as one of these. It has since been found that there is a great development of Granite along the western side of the southern end of the Pochuck mountain, it being nearly continuous from Hamburg to Independence Corners, Sussex county, in a belt one-quarter to one-half mile wide (see Fig. 7), underlying the well-stratified Gneisses and Schists which form the crests and eastern slopes of the mountain. Good contacts of the two groups may be seen near the summit of the 909-foot hill (see the topographical atlas) northwest of Hamburg village. This Granite contains much Biotite Mica, but farther north, in the same mountain, it is replaced by non-micaceous Massive rocks—Granulites and Hornblendic Granulites—which occupy the same inferior position with regard to the Schists and Gneisses east of them as the Granite of the southern end of the range. There is some plagioclase feldspar in these Granites, and some specimens may thus be determined as *Granitite*. The Granite in these Massive areas appears to be local; it is not nearly as abundant as the other Massive rocks. There is also considerable Granite near the old iron furnace at Hewitt station, on the Greenwood Lake railroad;

here it appears to grade into the Gneisses, and is perhaps but a modified condition of these.

The occurrence of Granite in irregular, segregated masses in the Schists and Gneisses has already been recorded; these masses are associated with *Pegmatite*, this being a very coarse variety of Granite.

QUARTZ SYENITE.—This characteristic rock of many Massive areas has been given considerable attention. Thin sections were prepared for microscopical examination by Mr. James F. Kemp, who has furnished the following descriptions of typical specimens:

I. Field No. 234, from a Massive area on the New York and New Jersey State line, between mile-posts 23 and 24, east of Greenwood Lake. The rock consists of Orthoclase, Quartz and Hornblende. The Orthoclase is filled with curious inclusions of irregular prismatic shape, which have optical properties indicating them to be some mineral, and not a glass nor hollow spaces. The Hornblende is very dark colored, and unless ground exceedingly thin, is almost opaque.

II. Field No. 190, from the Storm King mountain, Hudson River, is very similar to 234, but contains, as accessory minerals, Plagioclase, or Triclinic Feldspar and Zircon.

III. Field No. 333, from the western ridge of the Wawayanda mountain, south of Vernon, Sussex county, consists also of Orthoclase, Quartz and Hornblende, and contains a few scattered grains of Magnetite.

We have, ourselves, examined many other specimens of this rock, and find that it commonly contains disseminated grains of Magnetite, though as yet no large mass of iron ore has been seen in any of the massive areas, though many ore-beds are near their borders.

GRANULITE AND HORNBLENDIC GRANULITE.—These rocks occur in the massive areas, and also form most of the strata which enclose the great deposits of magnetic iron ore. They are very different from the Granulite of Saxony, which contains much Garnet, and from an examination of hand specimens, appears more thinly bedded, and in our classification, would more properly be distinguished as a fine-grained Garnetiferous Gneiss, though its mica is not very abundant. Garnet has, however, been seen in our Granulites, as Field No. 649, from Brook valley, Morris county, illustrates. In the use of the term, we have followed Professor Dana in his Manual of Mineralogy

and Lithology, p. 439; authors do not, however, agree on this point, for MM. Fouqué and Michel-Levy, in their Mineralogie Micrographique, Plate VII., Fig. 2, call a rock from Grape creek, Colorado, Granulite, which has the following mineral composition: Mica, Oligoclase, Magnetite, Orthoclase, Microcline, Quartz and Apatite.

Our rocks contain much Plagioclase. A specimen (Field No. 331) from the massive western ridge of the Wawayanda mountain, examined by Mr. Kemp, proved to be almost entirely of this Feldspar, Hornblende and Quartz, being present in but insignificant amounts. Field Nos. 377 from Pompton, and 441 from Denville, were also studied by Mr. Kemp, and found to consist of Quartz, Plagioclase and Orthoclase; in No. 377, traces of Hornblende and Magnetite were detected.

We have introduced the name Hornblendic Granulite for rocks of this nature, which contain an appreciable amount of Hornblende, but not as much as the Quartz-Syenites. But, between Quartz-Syenite on the one hand and Granulite on the other, there are all stages, the amount of Hornblende being variable. As we have already shown, this group of rocks constitutes the base and the lower beds of the Archæan Series in New Jersey.

Mica Schist.—The occurrence of much black mica in the iron ore-beds has always been remarked, and reference was made to it last year, where it was stated that some of this was probably Lepidomelane. This statement was based on blow-pipe tests and the general appearance of the mineral. Chemical analysis does not confirm this supposition, however. A specimen from the Chester Highland mine (formerly known as the Cromwell mine), at Chester, Morris county, analyzed by Mr. H. C. Bowen, of the School of Mines, Columbia College, New York, gave the following result:

	Per cent.
Loss by ignition	1.332
Lime (CaO)	3.763
Magnesia (MgO)	23.177
Manganous oxide (MnO)	0.145
Ferric oxide (Fe_2O_3)	10.482
Alumina (Al_2O_3)	10.389
Silica (SiO_2)	41.753
Potassa (K_2O)	8.552
Lithium (Li)	strong trace.
Sodium (Na)	" "
Fluorine (F)	" "
	99.593

From the above analysis it appears that the mineral contains far too much magnesia for Lepidomelane, and is to be classed as Biotite. Other analyses will, however, be necessary to show that all of it is of this composition.

There is evidence of much of the mica having suffered considerable alteration from its original chemical composition, in its loss of elasticity and its hydration, and there appear to be materials in the iron mines intermediate between Biotite and the Chloritic Group of minerals. Much of the so-called "Blue Slate," at Hacklebarney, is of this nature, mixed with extremely fine-grained Magnetite.

Except in the iron ore deposits schistose micaceous rocks are of rare occurrence in the Highlands. There is considerable development of them, however, along the eastern side of the southern end of the Pochuck mountain, to the northwest and north of Hamburg, Sussex county, and an outcrop may be seen along the northern of the two roads leading from that place to Independence Corners. The rock has also been seen in several other localities, always associated with Gneiss, much of which is more or less schistose.

The following Metamorphic rocks may be noted as additions to the list published last year:

Tremolite Schist.—Consists mainly of the fibrous Amphibole mineral Tremolite, with Biotite and Quartz. It occurs in the Gneissic and Schistose Group of the Pochuck mountain, on the eastern side of the range, near McAfee.

Kyanite Schist.—Composed of Kyanite, Mica and Quartz, was found in the same group as the last, at the eastern base of the mountain, near McAfee.

Bedded Diorite.—The rock Diorite occurs generally as an eruptive, but it is also found in the stratified condition. It consists essentially of the minerals Plagioclase Feldspar and Hornblende, though others are commonly present in small quantities. Field No. 621, from near the Pennsylvania railroad bridge, on the shore of the Delaware, at Trenton, is of this type. Mr. Kemp studied this rock, and found it to consist of Plagioclase, Hornblende, Magnetite and Biotite; as matters of petrographical interest he states that the Hornblende is peculiar, the edges of the crystals being uniformly blue or green, and

show optical properties different from the inner portions, which are normal Hornblende. This is interbedded with Gneissic rocks, having strike N. 35° E., and dip 80° S. E.

Field No. 415, from the western slope of the Pimple hills, in Sussex county, is similar, and probably to be classed with the Bedded Diorites, though more study of it is needed to determine this certainly. Mr. Kemp remarks: "It consists of Plagioclase, Hornblende, Augite and Magnetite with traces of Titanium. The intermingling of Hornblende and Augite is exceedingly interesting from a petrographical standpoint. The one is probably an alteration or development of the other. The same cracks continue through the two minerals, and they project into each other, and border on each other, with no sharp crystalline distinction. Yet the Hornblende is deep green or brown and pleochroic, the Augite well-nigh colorless, and showing no traces of pleochroism. This development, or possible alteration, of the two minerals is a very prominent question among mineralogists." Other specimens of stratified Hornblendic rocks may prove to be of this nature, but the above are the only ones which have been accurately studied.

Bedded Diabase.—The rock Diabase also occurs more commonly in dykes or irregular masses of eruptive origin, but it is also known in the stratified condition. It consists essentially of the minerals Augite and Plagioclase; Magnetite is commonly present as well. We have hitherto found but a single locality of this rock in the bedded state. This is in the hanging-wall of one of the ore-beds of the Charlotteburg mine (Field No. 717). It is a fine-grained, very granular rock. Mr. Merrill finds that it is composed of Augite, which is very abundant, Plagioclase, Magnetite, and a very little Hornblende. This mineral composition classifies it as a Diabase. It is well stratified, having strike N. 20° E., and dip 60° S. E. It is not improbable that this will be found in other localities.

II. Eruptive Rocks.

In this class we will consider only such rocks as occur in dykes or injected masses across or among the metamorphic strata. They are generally dark colored from the hornblende or augite, and fine-grained, so that the component minerals can only be satisfactorily determined

by grinding chips very thin and studying them with a microscope provided with attachments for polarizing light. In this manner the optical properties of the component minerals are ascertained, and these may thus be recognized and the rock properly classified. Most of this work has been done by Mr. J. F. Kemp, and unless otherwise stated, the determinations are his.

DIORITE.—Consists essentially of Plagioclase Feldspar and Hornblende. Magnetite is commonly present as well. The following specimens have been studied:

I. Field No. 499, from a dyke three to four feet wide, cutting across the Crystalline Limestone in John Ennachst's quarry, about one mile northeast of Oxford church, Warren county. It is a fine-grained, dark-colored, much-decayed rock, having a distinct columnar cleavage. Specific gravity, 2.98 to 3.01. It consists of Plagioclase, Hornblende and Magnetite. The Plagioclase is in grains 0.1 mm. to 0.3 mm. in diameter, somewhat decomposed to a milky white, semi-opaque substance. The Hornblende is in grains varying from 0.1 mm. to 1.0 mm. in diameter, of a bright green color, showing moderately strong pleochroism.

II. Field No. 501, from a dyke in Crystalline Limestone near the zinc mine on the Raub farm, two miles northeast of Oxford church. The rock is moderately fine-grained, and in color dark grayish-black. Specific gravity, 3.056. It consists of Hornblende, Plagioclase, Titaniferous Magnetite, and a very little Biotite. The Plagioclase is much altered, the alteration beginning in spots in the interior of the crystals, showing a change to an epidotic mass. The Hornblende is in irregular grains and is strongly pleochroic. The titaniferous character of the magnetite is shown in the presence of Leucoxene.

III. Field No. 393, from a cut on the New York, Susquehanna and Western railroad, near Wallace Corner, west of Oak Ridge. This rock is coarsely crystalline, and occurs in irregular masses in the stratified granulites, which are here very much contorted and twisted from their normal northeastern strike at right angles, having strike N. 45° W., and dip. 55° N. E. Its specific gravity is 3.06. It consists of Plagioclase, Hornblende and Titaniferous Magnetité. The Plagioclase is almost entirely altered to a greenish-yellow epidotic mass, the change here proceeding along the lines of cleavage and cracks, leaving specks of fresh feldspar in the middle of the crystals.

Small spots of alteration are also seen in the interior of the fresh feldspar. The Hornblende is in irregular grains, showing its characteristic pleochroism and cleavage, and is much less altered than the Plagioclase, but where altered affords a green chloritic product. The titaniferous magnetite crystals exhibit almost without exception the white Leucoxene; in many cases the unaltered mineral remains only in small grains or threads.

IV. Field No. 524, from a cut on the Central railroad, one-fourth of a mile east of Annandale. Consists of Plagioclase, Hornblende and Magnetite. The Hornblende is quite fresh and unaltered, but the Plagioclase is much changed.

The following additional specimens collected in New York State, in the northeastern continuation of our Archæan Series, may here be noted:

V. A large dyke in the Forest of Dean Mine, near Fort Montgomery. Its original component minerals are Plagioclase, Hornblende and Magnetite. As secondary minerals occur Quartz and Calcite; and as alteration products, chloritic substances. This alteration is of an exceedingly interesting character, but its description would be out of place in this connection.

VI. From dykes of large size north of Jones' Point, Hudson river, in cuts of the West Shore railroad. These were originally Diorites, but are greatly decomposed. One of the dykes is eleven feet wide, and has a slaty structure, due to the exfoliation of the rock in decaying.

VII. From small dykes intersecting the micaceous schists in the cut on the West Shore railroad, at Stony Point. These dykes are very numerous. They may be seen branched, and well illustrate the intrusive nature of the Diorite.

Mica Diorite.—This contains Biotite Mica in addition to the constituent minerals of Diorite, but the amount of Biotite is variable, and only those rocks which have it in considerable quantity are included under this head:

I. Field No. 345, from an outcrop on the wagon-road at Stonetown, Passaic county, nearly opposite the church. This is a rather coarse-grained rock of striking appearance, the component minerals being discernible with the naked eye. It consists of Plagioclase, Hornblende, Biotite and Titaniferous Magnetite. The Plagioclase is

in large twinned crystals, and is somewhat altered to a milky-white substance. The Hornblende is in large crystals, which show its characteristic cleavage and strong pleochroism. The Biotite is in threads, and is not very abundant, so that the rock is, in fact, intermediate between Diorite and Mica Diorite in this respect.

II. Field No. 145, from an irregularly shaped mass of curious appearance in the massive Quartz-Syenites of the Dunderberg mountain, in a cut on the New York, West Shore and Buffalo railroad, above Jones' Point, Hudson river, New York, is of the same mineralogical composition as the last specimen, but contains more Biotite in strings and twisted masses of plates. It is a true Mica Diorite.

DIABASE.—Consists essentially of Plagioclase and Augite; Magnetite is generally present, and other minerals may occur in small quantities. It differs from Dolerite in not containing Olivine as an *essential* constituent, though olivitic Diabases are recognized. Much of the rock of the numerous trap dykes of the Triassic red sandstone area of New Jersey is Diabase. The dykes of it in the Archæan rocks are mainly of small size. The following specimens have been examined:

I. Field No. 440, from an outcrop 30 feet in width and over 50 feet long, 300 feet southeast of Gordon's Crystalline Limestone quarry, at the foot of Turkey mountain, near Montville. The rock is fine-grained and has a slaty cleavage, which gives the outcrop a strange aspect. It is surrounded by massive or very heavily-bedded Granulites and Quartz-Syenites. The rock consists of Plagioclase, Augite and Titaniferous Magnetite, all very much altered. The Plagioclase is in large, irregular crystals, partially changed to an epidotic mineral. The Augite is invariably surrounded by bright green masses of a chloritic material, the original mineral showing itself only in spots in the interior. The chloritic mineral polarizes as a mass of threads. The Titaniferous Magnetite is almost wholly changed to Leucoxene. Mr. Kemp remarks that this specimen very closely resembles a Diabase from the Fichtelgebirge, in Bohemia, of Middle Devonian Age, described by Von Gumbel, in "Geog. Beschreibung des Fichtelgebirges," p. 206, both in its alteration and general appearance, and further, that it is unlike any Triassic Diabase examined by him.

II. Field No. 491, from an old mine on the Jenny Jump mountain, about two miles north of the Kishpaugh mine. This rock must

form a dyke of considerable thickness, as it is found in masses two or three feet in diameter, but as the excavations have caved in it was not seen exactly in place. It is dark grey in color and moderately coarsely crystalline. It consists of Plagioclase, Augite, Magnetite, Apatite and a very little Biotite, with some quartz as a secondary product, and a chloritic alteration mineral. The Plagioclase is in crystals 1 mm. to 2 mm. long, 0.5 mm. broad; these are twinned and altered along cleavage cracks to a milky-white substance, and in spots to an epidotic mineral. The Augite is in irregular grains, seldom showing crystal outlines, and altered in many places to a chloritic mineral. Magnetite is in scattered grains, some of it titaniferous. Apatite is very abundant in prisms 0.5 mm. long by 0.1 mm. broad.

III. Field No. 559, collected from loose masses southeast of Marble mountain and northwest of Stewartsville, Warren county, evidently drifted from the hills. It is a nearly black, fine-grained rock, and consists of Plagioclase, Augite, Magnetite and amorphous material. The Plagioclase is in small, rod-shaped crystals, somewhat altered to an amorphous, milky-white substance. The Augite is in irregular grains 0.5 mm. to 1.0 mm. in diameter, somewhat altered to a chloritic mineral. The Magnetite is in strings.

IV. Field No. 560 was collected with the last. The rock is more coarsely crystalline than No. 559, and contains as an additional constituent Apatite in small prisms.

V. Field No. 510. This specimen was selected from many loose masses on the eastern side of Schooley's mountain, half a mile southwest of Middle Valley station on the High Bridge Branch of the Central railroad. These were not seen exactly in place, though certainly not far moved, and are associated with massive or heavily bedded Granulites. It consists of Plagioclase, Augite, Magnetite and Olivine, and is thus an *Olivine Diabase*. The Plagioclase is fresh, and in twinned crystals 1.0 mm. to 3.0 mm. long by 0.5 mm. to 1.0 mm. wide. The Augite is in irregular grains, rarely showing a well-defined crystalline outline. The Olivine is in irregular grains, very rarely showing any crystal faces. It is remarkably fresh, being water-clear, but seamed with characteristic cracks and lines of alteration, and is very rich in Magnetite inclusions. The presence of Olivine is of much lithological interest. Professors E. S. Dana and Hawes detected it in the Diabase of the Connecticut River Valley.

VI. Field No. 698, from a cut on the Ogden Mine railroad one-

fourth mile north of Minnisink station. This was examined by Mr. Merrill and myself. It consists of Plagioclase, which is very abundant, Orthoclase in a few crystals, Augite abundant, and much Hornblende, though this appears to be less plentiful than the Augite. The rock is therefore to be classed as a *Proterobase*, a variety of Diabase containing Hornblende.

KERSANTITE.—Is a micaceous Diorite containing considerable Augite and otherwise differing from the rocks here called Mica Diorites.

I. The rock of the great dyke which cuts across the Taylor zinc mine at Franklin Furnace, described by Professor B. K. Emerson as Mica Diabase,* has been referred to Kersantite by Rosenbusch. This dyke is 20–24 feet wide in the mine excavations. Some of the rock is amygdaloidal in appearance, this being caused, as has been pointed out by Professor Emerson, by the enclosure of globules of Willemite, melted by the heated rock. There are also thin dykes of the same rock in other places in the open cut of the mine. Not the least interesting feature of this dyke is the fact that the same rock outcrops at a point about one-fourth of a mile northwest of the mine in a hill of magnesian limestone, just east of the road to Hamburg, and a few hundred feet northeast of the church, and it is reported that it was also found in digging the cellar for the stone house, built by the late Samuel Fowler, Esq., just west of this Hamburg road. If the dyke is continuous from the mine to these points its length is over one-fourth of a mile. It cuts through both the Archæan and Lower Silurian limestones, neither of which appear to be perceptibly altered by the molten rock. In the hill of magnesian limestone above noted the limestone may be seen very close to the Kersantite. The same, or a very similar rock, occurs in numerous masses along a brook on the western side of the Pochuck mountain, about a mile and a half north-northwest of Hamburg. This has not yet been carefully studied, however.

II. We may here note the occurrence of similar rocks in the Crow's Nest and Storm King mountains, on the Hudson river, exposed in the cuts of the West Shore railroad. These are in what appear to be

* For a detailed description of the rock of this dyke, and its action on the zinc ore, see Prof. Emerson's paper in the American Journal of Science, 3d Series, Vol. XXIII., pp. 376–379.

dykes of various widths in nearly vertical positions, cutting across the massive Quartz Syenites. In Crow's Nest they are especially well shown in its northern spur, a few hundred feet above the fiftieth mile-post from Weehawken. This rock is compared by Mr. Kemp to a Kersantite from Campo Major, Portugal, and to another from Heimbach, Nassau, Germany. The dykes in Storm King are substantially the same as those in Crow's Nest, but contain a little more Hornblende. Both differ from the Franklin Furnace rock in being more coarsely crystalline.

PORPHYRITE.—These rocks consist of a very fine-grained "ground-mass," in which feldspar crystals are developed.

I. Field No. 433, from a well-marked dyke of dark-colored rock, which cuts directly across the crystalline limestone at Gordon's quarry, near Montville. It is about 8 inches wide, and dips 27° S. W. Its strike is N. 45° W., thus crossing the strata nearly at right angles, as they here have strike N. 42° E. The rock is of remarkably high specific gravity, which Mr. Kemp determined from chips at 3.28 and 3.30. This dense structure is probably due to cooling under pressure in the narrow space. The "ground-mass" is of a light-brown color in thin sections, showing in places the irregular radial or parallel arrangement of minute crystals, which has been described as "felsosphaerit." In this are crystals of a feldspathic mineral, too badly decayed to be exactly determined. Small grains of Magnetite are also scattered through the ground-mass. From the excessive decomposition it is impossible to say definitely whether the rock is Quartz Porphyry or Porphyrite.

II. Field No. 216, from a narrow dyke in Quartz Syenite on the Ramapo mountain, on the State line northwest of Suffern, between the Ramapo river and mile-post No. 16. This rock has a beautiful porphyritic structure, and a specific gravity of 2.86.

It may here be noted that these porphyritic rocks occur also in the Archæan of New York, and we have specimens of them from both sides of the Hudson.

The above list includes all the igneous rocks so far carefully studied. We have numerous additional specimens awaiting examination. Their study may reveal the presence of other eruptives, but a beginning at least has been made. Eruptive Granite is certainly of rare occurrence. The dyke of this rock on the D., L. and W. R. R., near Butzville,

mentioned and illustrated in the Geology of New Jersey, p. 61, is on record as an example, but most of our Granite is either in the Massive Group of metamorphic rocks, where there is no evidence of its having been melted, or else it is in the form of very coarse-grained, irregular masses, segregated from Gneisses and Schists.

PALEOZOIC ROCKS.

The rocks of the Green Pond Mountain range have been the subjects of examination, by Mr. F. J. H. Merrill, during a part of the last season. The prominent features of this remarkable mountain range are well known. Its long, high and abrupt ridges, its rough conglomerate rock and its wooded surface are noticed by the most careless observers. With very few fossiliferous beds, and the rocks themselves having little resemblance in composition or structure to any others in the State, its geology has been something of an unsolved problem for a long time. Silurian fossils were found in the rock at Upper Longwood in 1858, others near Newfoundland in 1865, and Devonian fossils, both Upper and Lower, were found at Greenwood lake in 1867; still others in the same range, but further N. E., in Orange county, New York, were discovered in 1880. In 1885, Dr. Britton obtained some fossil Brachiopods from loose fragments of coarse white conglomerate near Pickatinny. All the principal groups of the Silurian and Devonian systems are probably to be found in this region.

Mr. Merrill has been successful in finding new localities of fossils, and in working out some of the intricacies of its geological structure. His report upon the work done is herewith presented, and is as follows:

Green Pond Mountain Group.—The work of the season of 1886, on this formation, has been chiefly confined to the immediate vicinity of Newfoundland, but examinations have been made of the geological structure at Middle Forge, Upper Longwood, Woodstock and Milton, and an excursion was made along the west side of the Bearfort mountain as far north as the gorge or pass which has been formed through the ridge northwest of West Milford. The results of this investigation may be briefly stated to be the accumulation of

proof, both stratigraphical and palæontological, that the red conglomerate of the Green Pond, Copperas, Kanouse and Bearfort mountains is the equivalent of the Oneida, that the fossiliferous limestone formerly judged to be Trenton, proves from a more extensive study of its fossils to be Lower Helderberg, and the blue slates of the Longwood and West Milford valleys, which outcrop at Petersburg, Oak Ridge, &c., as well as between West Milford and Newfoundland, are of Hamilton age. The relative position of these strata is therefore identical with that illustrated in the Geology of New Jersey, 1868, pp. 81, 82, 83 and 144. At the time of that report these beds were believed to be respectively equivalent to the Potsdam, Trenton and Hudson river groups. During the past summer, however, the fossiliferous limestone at Cobb's place was found by Dr. N. L. Britton to be of Lower Helderberg age, and subsequently on visiting the outcrop at Upper Longwood with him, we found the fossils there to be of the same horizon. A number of these specimens have been submitted to Prof. R. P. Whitfield, who has satisfied himself of their age. The following forms were identified from Cobb's place: *Spirifer Vanuxemi, Chætetes Helderbergiæ, Meristella* sp. (?) figured in Pal. N. Y., Vol. 3, Pl. 45, Fig. 1, not described. *Pterinea* sp., *Strophomena* sp. There are, however, many others which have not yet been determined.

About ¼ mile east of J. P. Brown's hotel, at Newfoundland, is an outcrop of white conglomerate and quartzite, containing an abundance of casts of brachiopods and cyathophylloid corals, among the former *Spirifer arrectus* being very abundant; no other species could be determined, but Renssellaeria and other Devonian genera were apparently represented. A *Conocardium* and a trilobite, *Dalmania* were also found, as well as numerous casts of *Tentaculites* sp. (?) From the specimens shown him Prof. Jas. Hall considered this fauna to be a mixture of Oriskany and Corniferous forms.

This rock is also found southwest of Brown's hotel, in a knoll west of the residence of Mr. Theo. Brown, where fossils are not infrequent. They are corals allied to *Zaphrentis,* and brachiopods, but the casts are too imperfect to permit of identification.

This fossiliferous grit also occurs at Upper Longwood, between the slate and the fossiliferous limestone, and here Dr. Britton found a loose fragment containing the major portion of a large specimen of

Spirifer arenosus, which was unquestionably not far from its nidus, as other fossiliferous fragments lay around in the vicinity.

With this short resumé of the more important discoveries, we shall now consider the series in detail.

In the annual report of the State Geologist for 1884, pp. 29–35, is to be found an interesting history of the study of the Green Pond mountain rocks, and it will be seen from this that we must credit Prof. W. W. Mather with having first enunciated a correct estimate of the geological horizon of the red conglomerate.

In the same report is also published an abstract from the Geology of New Jersey, 1868, pp. 84–87, on the structure of the Green Pond, Copperas, Kanouse, Bowling Green and Bearfort mountains. This is, in the main, correct as regards its stratigraphical details, and its few errors will be discussed, so far as known.

The following scheme is a preliminary statement of what is now known of the lithological characters of the series in question. With more careful study of the region it will doubtless need revision as to the thickness of the beds.

			AGE.
Greywacke-slate	Bearfort and Schunemunk mountains	700 ft.	Hamilton.
Blue Argillite and Greywacke	Longwood and West Milford valleys	1,000 ft.	Hamilton.
White Calc. Conglomerate and Siliceous Grit	Newfoundland, Upper Longwood and Pickatinny	50 ft.	Corniferous. Oriskany.
Blue Limestone with Fossils	Upper Longwood, Milton, Newfoundland, &c.	200 ft.	Lower Helderberg.
Red Shale	Newfoundland, &c.	200 ft.	Medina.
Red Conglomerate	Green Pond mountain, &c.	600 ft.	Oneida.
		2,750 ft.	

The thicknesses given are estimated minima, with the exception of the red shale, which is 200 feet in thickness, as nearly as may be.

RED CONGLOMERATE.—The lowest member of the series consists, as already stated, (Ann. Rep., 1884, p. 43,) of a thickly-bedded conglomerate, which at the base is quite coarse, consisting of white pebbles varying from ½ inch to 2 or 3 inches in a matrix of reddish, siliceous sandstone. Toward the upper part of the member, however,

there are some beds of reddish or even white quartzite, such as occurs near Cobb's place, southwest of Newfoundland. There are also layers of reddish, slaty quartzite. At Gould's quarry, near Macopin, where the conglomerate rests unconformably on the lower magnesian, or Calciferous limestone, some boulders of this rock 6 inches to 2 feet in diameter are inclosed in it. The estimate of thickness is based on the exposures in the face of the cliff southwest of Newfoundland, where there is a vertical section of 494 feet across beds, having an average dip of 15°, and an unknown thickness is concealed at the base, and in the Copperas mountain, where the indicated thickness, measuring across the dip, is over 600 feet.

The distribution of the red conglomerate is discussed in detail under the head of "Green Pond Mountain Rocks," in the Geology of New Jersey, 1868, pp. 79–87, and this description, in part, with some additions, is reprinted in the annual report for 1884. Though the whole of this ground has not yet been examined, the description is believed to be, in general, correct, with the exception that the low ridge north of the Pequannock river, at Newfoundland, is an anticlinal of the white Oriskany-Corniferous grit. It is erroneously referred to in the Geology of New Jersey, 1868, p. 84, and Ann. Rep., 1884, p. 42, as consisting of the red conglomerate in place.

In discussing the rocks at Clinton Falls (Geol. of N. J., p. 86, and Ann. Rep., 1884, p. 42,) they are considered as belonging to the horizon of the red conglomerate; as shown elsewhere in this report, however, they are of Hamilton age.

In considering the age of the red conglomerate, it remains to be said that it overlies the Lower Silurian Limestones unconformably, as at Middle Forge and Gould's quarry, and is in turn overlain conformably by a Lower Helderberg Limestone. From its lithological characters and resemblances it appears most proper to consider it as equivalent to the Oneida conglomerate.

Red Shale.—Overlying the red conglomerate at Upper Longwood, Woodstock and southwest of Newfoundland is a series of layers of soft red shale, possessing a marked cleavage which does not coincide with the bedding. The divergence is well shown by the following measurements at Woodstock: Strike of beds N. 21° E., of cleavage N. 17° E. Dip of bedding 45° E. by S., of cleavage 60° E. by S. At Newfoundland, the relation of cleavage to bedding

in the red slate of the ridge on the road to Green Pond, is illustrated in Fig. 23.

In that portion of the slate which outcrops immediately on the road the cleavage is at right angles to the bedding. The figure illustrates the direction of the cleavage about 50 feet above the road.

This rock is about 200 feet thick and forms a very characteristic member between the Oneida conglomerate and the succeeding rock, which is the fossiliferous Lower Helderberg Limestone. From the position of the red shale and its highly ferruginous character, I am

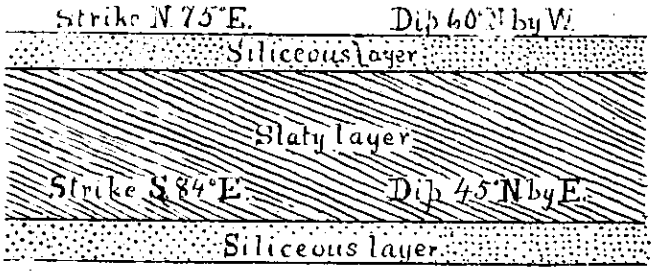


Fig. 23.

inclined to consider it the equivalent of the Medina Group. Another bed of red shale outcrops along the west border of the Bearfort mountain, near Uttertown, and other points, and in traversing the gorge through this mountain, northwest of West Milford, it is found to be interbedded with the lower portion of the red conglomerate. This, therefore, is quite distinct from that previously described and there are slight lithological differences between them.

Fossiliferous Limestone.—This rock, which is most prominent at Upper Longwood and southwest of Newfoundland, is at least 200 feet thick, and, as already stated, by its fossils is shown to be of Lower Helderberg age. Its extent on the Cobb property, between Newfoundland and Green pond, is much greater than has been hitherto reported. It occurs along the south bank of the stream which traverses the Cobb place, for a distance of 200 yards from the road, and also on either side of the road, in the fields, for 200 yards south of the stream. It is, moreover, plainly evident for nearly a mile in the sides of the road which runs southeasterly across the

Copperas mountain. The fragments of limestone in the soil occur abundantly within 100 yards of the crest of the ridge, and fossils are especially numerous at the fork where the road from Green Pond meets the road in question.

WHITE SILICEOUS GRIT, AND CALCAREOUS CONGLOMERATE.—This bed, which has thrown such important light on the horizon of the upper members of the Green Pond mountain system, has been found, thus far, at Newfoundland, Upper Longwood, Petersburg and Pickatinny, but will doubtless be found at many other points when carefully searched for. The most important outcrop now known is on Mrs. Kimball's land, about $\frac{1}{4}$ mile east of J. P. Brown's hotel, at Newfoundland, immediately north of the road to Charlotteburgh, and at the south end of the low, elongated ridge over which the road to West Milford runs. This was referred to in the Geology of New Jersey, 1868, p. 84, as the red conglomerate, but examination shows that this statement was erroneous. The white quartzite or siliceous grit, which is probably the lower portion of the bed, is moderately coarse, the grains averaging from $\frac{1}{16}$ inch to $\frac{1}{8}$ inch in diameter, and contains many casts of brachiopods, the specific identity of which is not certain. A portion of the deposit in question is a loose grit, from which some calcareous cement appears to have been removed by solution, and which has furnished most of the fossils. Other details of this stratum have been given above; its thickness is not far from 50 feet.

GRAYWACKE.—This is a tough, gritty rock, consisting of a considerable amount of siliceous detritus, mingled with argillaceous matter. It seems to form the passage-bed between the siliceous grit and the argillite, and has a tendency to cleavage. It occurs about 100 feet northwest of Chamberlain's hotel, at the door of the house on the corner of the road to West Milford, and also in a small outcrop near Petersburg.

The thickness of this layer is perhaps 100 feet, but as there is no definite means of ascertaining it accurately, I have considered it together with that of the argillite.

BLUE SLATE, OR ARGILLITE.—This is the most prominent rock of the Longwood and West Milford valleys. It is quite fissile and

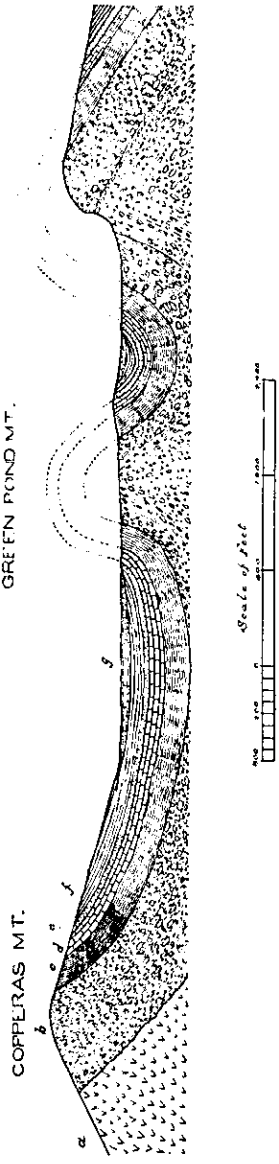


Fig. 24.

Section 1 mile south by west from Newfoundland.

a Archæan.
b Green Pond Conglomerate (Oneida).
c Red Slate (Medina?).
d Lower Helderberg limestone.
e Oriskany corniferous siliceous grit.
f Hamilton argillite.
g Alluvium.

separates into thin laminæ, which are usually at right angles to the bedding. In the Longwood valley it contains many fragments of crinoidal columns, and in it near Sylvester Corners, southwest of Petersburg, a Lamellibranch was found, which Prof. James Hall has pronounced to be probably a *Palæoneilo* and of Upper Devonian age.

From the exposures in the Longwood valley, and the valley 1½ miles north of Newfoundland, the thickness of these rocks may be estimated at 1,000 feet at least.

GRAYWACKE SLATES.—These rocks are well shown in the section at Clinton Falls, where the thickness exposed is somewhat over 700 feet. The total thickness is somewhat greater, as they form a ridge on the southeast border of the Bearfort mountain, but this region has not yet been fully studied.

In lithological aspect, the rock is an impure, gritty argillite, and occurs in continuation of the strike at Oak Ridge, which it underlies. The horizon of these rocks is shown to be above the argillite by direct contact. They make their appearance below Clinton Falls, at the foot of the lowest rapids, and form the material in which this beautiful series of cascades has been formed. No fossils have yet been discovered, but there seem to be traces of plant impressions in them, and they may correspond to the beds in Orange county, New York, which have yielded *Psilophyton princeps*, and other Devonian plants (Ann. Rep, 1884, pp. 54–55); that they are of Devonian age is beyond question.

STRATIGRAPHY.

A careful study of the region about Newfoundland shows that the rocks of the system have been subjected to a great amount of disturbance, in which the underlying Archæan rocks have been involved. The axis of this disturbance, southwest of the Pequannock river, has a trend of about N. 50° E., while between the river and Greenwood lake the trend is N. 40° E.

Of the anticlinal and synclinal folds in this system none of those within a radius of 5 miles of Newfoundland have been inverted or overthrown so that either of their sides has been carried against the vertical. At the north end of the western spur of the Green Pond mountain, at Newfoundland, the eastern slope of the anticlinal has a

dip of 70° S. E., while the other dips 30° N. W. At Woodstock the dip of the red conglomerate is 75° N. W. A section of the anticlinal mentioned is shown in Fig. 24.

The main ridge of the Green Pond mountain also has an anticlinal at its north end, which is first visible near the outcrop of red slate ¾ mile southwest of Newfoundland, and is indicated as the middle anticlinal (Fig. 24). The vertical faces which show themselves in this vicinity, on the southeast side of the Copperas and Green Pond mountain, were regarded by H. D. Rogers (final report on the Geology of New Jersey, 1840; see Ann. Rep., 1884, p. 30,) as the result of longitudinal dislocations, but in the case of the precipitous cliff shown in

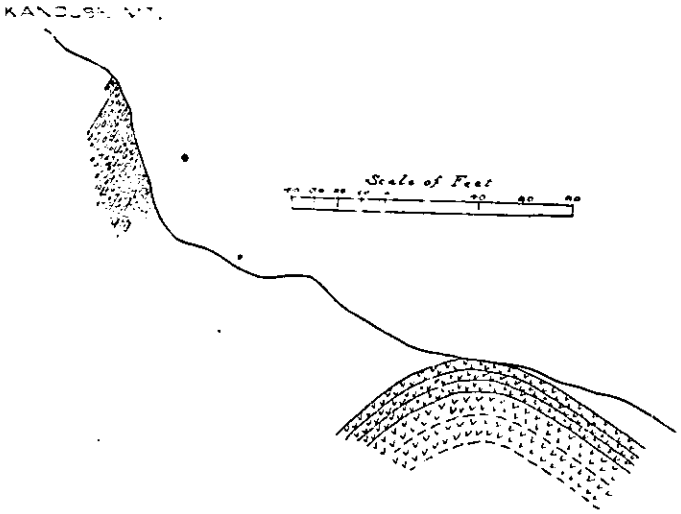


Fig. 25.

section at the right hand in Fig. 24, the weight of evidence indicates that the beds were folded in an anticlinal, as shown in the section. Since the conglomerate is a very unyielding material it could not conform to the extreme distortion which occurred on the east side of the axis, and must have been completely shattered.

It is not very surprising, therefore, that after the glaciation of this region, little or nothing remained of the eastern side of the fold. The escarpment, moreover, is gradually receding northwestward, as shown by the immense talus which conceals the lower part of the precipice, the jointed rock breaking away year by year. A complete anticlinal fold occurs at the north end of this mountain spur

southwest of the Newfoundland railroad station. From this and the evidence of the dip in the red slate ridge, it seems probable that the anticlinal continued the whole length of the ridge.

It should be remembered that we cannot claim that the bedding planes of the conglomerate ever assumed the exact curves above the land surface shown in the figure. From its brittle nature it was probably broken in every direction, and if the folding was gradual much of it may have been removed before the upheaval was complete. We are, however, justified in the conclusion that if the beds had all been flexible, as in the case of shales, the indicated curvature would have been assumed.

Along the eastern border of the Copperas and Kanouse mountains we have a precipitous face with no indications as to where the eastern continuation of these beds was after the upheaval. From the fact that an anticlinal occurs in the Archæan granulite at the southeast

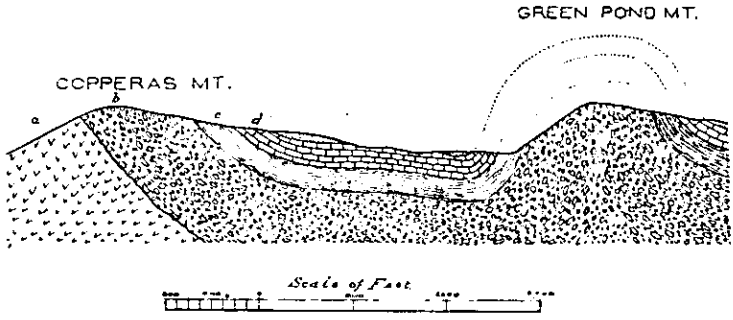


Fig. 26.

Section 1½ miles south by west of Newfoundland.

a Archæan.
b Green Pond Conglomerate (Oneida).
c Red Slate (Medina?).
d Fossiliferous limestone (Lower Helderberg).

corner of the Kanouse mountain (Fig. 25), the axis of which coincides in direction with the eastern border of the conglomerate, we know that a disturbance and an upheaval in the Archæan rocks were the causes of the Palæozoic uplift, but whether the conglomerate originally formed an anticlinal over this Archæan fold, or whether it was abruptly faulted along its line, is not yet known. There is some evidence of such Archæan folding about 1 mile northeast of the Green Pond Mines, near the contact of the crystalline rocks with the red conglomerate, and it seems quite probable that investigation will show the presence of an anticlinal at the north

end of the Copperas mountain similar to that at the north end of the Green Pond mountain and its outlying western spur. Another example of anticlinal folding is shown in the Bowling Green mountain, which is a fold of the conglomerate over the Archæan, with its axis inclined northeasterly about 45°. This structure, as well as the presence of a synclinal fold in the slate of the Longwood valley, is well shown in the section on page 83 of the Geology of New Jersey, 1868. In like manner the valley between the Kanouse and Bearfort mountains is in a great synclinal, which, however, is somewhat wrinkled along its axis so that one or more slight anticlinals occur in the slate.

Between the Green Pond and Copperas mountains, also, is a synclinal, illustrated in Figs. 24 and 26, the latter of which shows clearly the stratigraphical features of the rocks near Cobb's place. The synclinal structure indicated by the dip of the conglomerate is proven by that of the fossiliferous limestone as shown in the figure.

The region about Hanks' Pond has not been explored sufficiently to furnish data for plotting a section accurately, but it may be stated that the western ridge of the Bearfort mountain consists of the red Oneida Conglomerate and the eastern ridge, of the Upper Devonian graywacke slates, the intervening depression which is occupied by the pond at the south end of the mountain, lying along the edges of the Helderberg limestone, Oriskany-Corniferous grits and the Hamilton argillite.

As a final point in the discussion of the stratigraphy of this region, we have to mention the line of dislocation which crosses the system at right angles to its trend and along which the bed of the Pequannock river lies.

A peculiarity of this dislocation is that immediately southwest of it for a mile or two the conglomerate beds have a northeasterly pitch of about 10°, which diminishes farther southwest, and either disappears or inclines in the opposite direction. The throw was upwards on the northeast side of the fault line and here also the beds have a slight northeasterly pitch.

With this resumé of the work of the past season in this region I close my report, reserving for a future occasion the discussion of details which have not yet been sufficiently studied.

TRIASSIC.

The geology of the red sandstone and trap rocks of central New Jersey, appears to be plain and well marked, and in its characteristic rocks and their location and relations to each other, it is so. The well-known red color of the sandstones and shales, and of the conglomerates, enables the most careless observer to recognize them. The trap rock of the rough mountain ridges, which are so common in the red sandstone region, is also easily recognized in a general way by its gray or bluish-gray color, by its being hard and tough, and containing no crystals or grains of quartz. At first view it may be mistaken for granitic rock, but the entire absence of quartz grains from its mineral composition, reveals its true character. The strata in all the Triassic rocks of New Jersey generally have a gentle dip towards the northwest. The sandstones and shales are unquestionably of aqueous and sedimentary origin, and the trap rocks are of igneous and eruptive origin.

Beyond these plain and generally-accepted conclusions, there are difficulties in accounting for peculiarities observed in the structure of the rocky strata, and in the order of succession in which the geological changes in them took place. So interesting has been the questions upon the geology of the Triassic rocks east of the Alleghanies, that numerous papers have been published in regard to them. Prof. W. M. Davis, in Bulletin IX. of the Museum of Comparative Zoölogy, Cambridge, Mass., has given a list of 69 authors, and of 139 papers upon this subject. And yet the difficulties are not fully overcome. For the purpose of securing aid from the many observers who live upon this formation, and who, if properly imformed, can give help in solving these problems, some of the hypotheses which have been put forward are repeated:

I. In regard to the inclined portions of the strata, Prof. Rogers, in his final report on the geology of New Jersey, presented the idea that the strata were originally deposited in the position in which they are now found. It is difficult to understand what could have been the condition of agencies to produce such a deposition. The rocks upon the southeast, as well as the northwest borders of the formation, are formed of fragments of the older rocks which adjoin them, thus showing that the material for their formation has come from both sides,

which would not be likely to occur if it had drifted over to be deposited on the slope it now has. Besides, the upper surfaces of some of the strata are covered with the impressions of rain drops, which are round as if made upon a level surface, and other strata are covered with the tracks of animals, which tracks appear to have been made by the creatures walking about on the level, muddy surface of the deposit before it had become solid and strong. The conclusion is that the strata have been disturbed and thrown into their present inclined position, from their original horizontal deposit. It has been suggested that the change of level was going on while the deposit was forming; that the southeast border was rising, while the northwest border was stationary or sinking. The occurrence of pebbles or fragments of red shale in the rock, would indicate that the outcropping edges of the strata, which were being elevated, were worn off and carried forward to be redeposited in the strata which were still in process of formation. From the angle of dip, and the distance across the formation, calculations would give it a thickness of more than 10,000 feet. A well was bored in it at Paterson (Passaic rolling mill), to the depth of 2,100 feet, without finding bottom or any change in the quality or appearance of the rock.

Mr. I. C. Russell has advanced the theory that the New Jersey red sandstone and that of the Connecticut valley were originally of the same deposit, and have become separated by the upheaval of the country between the two, and the denudation of the middle and higher parts, and so leaving the parts left widely separated, as they are now found. This theory is consistent with the dip of the rock in both parts, as well as in similar isolated tracts in Virginia and North Carolina. The rock, the fossils, and the general character of the two formations, are the same; but the wide interval between, the enormous thickness that must have been worn away and no fragments left, and no ridges of trap rock in the intervening country, are all against the theory. It has been many times suggested that if there were longitudinal faults extending northeast and southwest through this belt of rock, there might be a means of explaining some of the marked peculiarities of structure of this formation. This was suggested very early by Prof. Dana, and faults observed have been published in the annual reports of this survey; Mr. Nelson H. Darton has spent much time in searching for and recording such faults as he has found, and Prof. W. M. Davis has, in the November number of *The American Journal of Science*, carried out in some detail the effects to be looked

for in such a system of longitudinal faults. It is easy to conceive that if there are such faults, and they are of sufficient magnitude, with the downthrow on the southeasterly side of the fracture and the upthrow on the northwesterly side, then the northwest dip can be explained, and the extraordinary thickness be reduced to more reasonable dimensions. The faults have not yet been found in sufficient extent, and the remarkable uniformity in the quality of the rock renders it difficult to detect them, or when found to determine the direction or amount of the offset. It is a plausible hypothesis to work upon, and should be pursued farther. If in crossing the formation from the southeast to the northwest, the same strata are passed over several times, the peculiar monoclinal structure is easy to be understood, and it is to be hoped that by calling the attention of a great number of observers to the points in question, facts may be obtained which will furnish the correct answers.

There is also a difference of opinion in regard to the relations of the trap rocks to the sandstone as to whether they came to their present location among the sedimentary strata, while the latter were being deposited, or have been intruded between the strata since the latter were deposited, and also whether the intrusion has taken place while the strata were horizontal, or since they have been at their present inclination. In the reports of the present survey, it has been assumed that the red sandstones were at their present inclination before the eruptions which forced the trap rocks up between the strata of the sandstones, and that the present elevation of the ridges above the surrounding country is caused by the trap rock resisting the action and wear of the elements, while the softer sandstones and shales have been worn away by them, until their surface is several hundred feet lower than the crests of the trap ridges. The reasons for this conclusion are found in the fact that the sandstones and shales overlying the trap are found altered in appearance and structure, as if affected by the melted rocks, which have been intruded underneath them. Instances of these are to be found along the western slope of the Palisades at different places, at Lambertville, on the west slope of Goat Hill, on the northwest slope of Sourland mountain, near Pluckamin, and also back of Plainfield on the First mountain. The overlying sandstone rock is very much changed, which would hardly have been the case if the trap rock were a simple overflow, which could have been hardened by exposure before any more rock would be deposited upon it. The heavy body of drift lying upon the northwest slopes of the

mountain ridges has hindered observations upon any sandstones which may lie upon the trap rocks there. That the trap has been intruded since the sandstones and shales were in their present positions seems to be almost a necessity, unless it can be proved that the successive parallel ridges are only repetitions of the same great sheet of trap rock, which has been broken by longitudinal fractures into long narrow strips and these strips thrown up on their southeastern border and thrown down on their northwestern border. This is not proved. There is a considerable transverse belt of country along the Raritan valley which is not crossed by any large outbursts of trap. There is a dyke of trap cutting across the strata at Blackwell's Mills, in Somerset county, which is well exposed there, and which can be traced on the surface for a mile or more towards the southeast, and others are to be seen on the Pennsylvania railroad, two miles southwest of New Brunswick. These are certainly of a more recent origin than the red sandstone.

Prof. W. M. Davis, in his late paper in the *Journal of Science*, discusses the known facts connected especially with the sandstones and trap rocks of the Connecticut Valley, which resemble ours very closely, and concludes that there the sandstones and shales, and the trap rocks are of contemporaneous origin, and that both were originally in horizontal layers; that the trap rocks, when erupted, in some cases overflowed the surface of the sedimentary rocks, in conformable layers, and in other cases were intruded between the sandstone beds; that the upheaval and tilting of the strata have taken place since that time; and that the tilting is due to a change of inclination and consequent narrowing of the belt of Archæan rocks, which underlies that of the Triassic period, and that the latter, having been traversed longitudinally by numerous fractures, has also yielded to the pressure, and the strips between these fractures have been tilted into the inclined position in which they now are; and, as a consequence, that in crossing the belt numerous repetitions of the same beds are met, and also repetitions of the same sheet of trap rock.

The conclusions of Prof. Davis are plausible and consistent with many ascertained facts, and they furnish a basis for further investigations in the same direction. But in the light of the facts thus far collected in New Jersey, we think it will be most profitable to work with the hypothesis—

1. That the sedimentary Triassic formation was originally deposited in beds which were nearly level.

2. That while some of the materials of which it is composed were drawn from the higher grounds surrounding it on all sides, the chief part of them came from the Archæan rocks on the southeast border.

3. That the eruptions of the igneous or trap rocks followed the upheaval of the sandstone.

4. That the trap rocks are necessarily intrusive, though they may overflow for short distances, from the outcropping edges of their intrusive sheets.

5. The curved lines in which the ridges of igneous rock run are due to the form and surface of the Archæan and Primitive rocks, which underlie the Triassic, and their convexity towards the southeast is due to the upheaval being on that side of the belt.

SURFACE GEOLOGY.

Leaving out of view the sand beaches on the seashore, the tide marshes which fringe the mainland, and numerous smaller fresh marshes and swamps lying along some of the streams, the Surface Geology of New Jersey may be described under two heads, viz., that of the *glacial drift*, and that of the *yellow gravel.*

The former characterizes the surface of the northern quarter of the State, and the latter the southern three-quarters. The southern edge of the great terminal moraine is the division line. It is a marked feature of the surface, and beginning on the eastern border of the State at Perth Amboy, is easily traced from there to Metuchen on the Pennsylvania railroad; to Netherwood and Fanwood on the Central Railroad of New Jersey; to Summit, New Providence, Madison, Morristown, Dover, south of Stanhope, and north of Hackettstown on the Delaware, Lackawanna and Western railroad; thence across the valleys and mountains almost direct to Belvidere.

The *glacial drift* will be the subject of study in another report.

Yellow Gravel.—To the south of this line, and thinly and unevenly scattered over the surface, are to be found numerous pebbles and gravel stones of a yellowish-white quartz. Most of them are solid and nearly pure quartz, but among them are found a few which, though rounded and water-worn like the rest, are silicified fossils, mostly Devonian shells and corals. The yellow color is due to oxide of iron, and where the gravel has been exposed to the organic acids

of swamps, and to wet and decaying vegetation, they are almost white. This gravel has not constituted any large proportion of the surface material, and now when it has been exposed for ages to the washing from torrents of rain, it has been left so as to be conspicuous on the higher grounds, while it has been buried on lower ground under the finer earth, which has been more easily carried down by the water, or has been entirely carried away. It has never been so thick, however, as to prevent it from becoming mixed with materials of the geological formations on which it lies, so that while we recognize the gravel, the soil upon which it lies is mainly characterized by the underlying earth or rock. Thus we have the red sandstone soils, the marl soils, and others, all lying in this area of *yellow gravel*. With most of these variations of soil there is not much difficulty in drawing the line of distinction. But in the Tertiary and Post Tertiary, which comprise the southeastern third of the State, the deposits are all earthy, and though dark colored when buried deep beneath the surface, they are, when near the surface, oxidized to various shades of yellow, so as to become very difficult to distinguish from each other or from the finer portions of the *yellow gravel*.

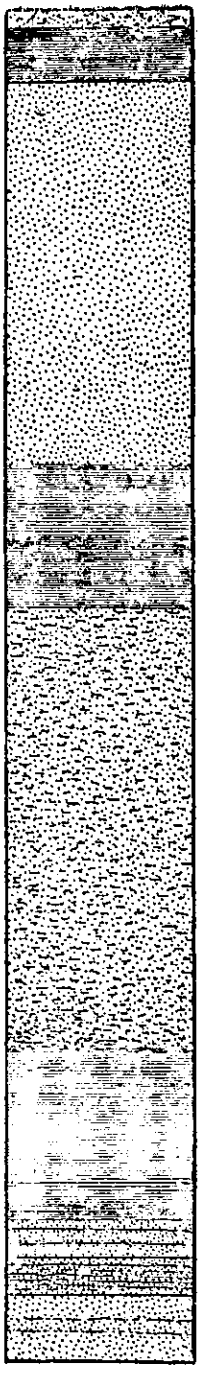


Fig. 27.

The geological structure of all Southern New Jersey is simple, consisting of a series of strata conformable to each other, and all descending with a uniform dip towards the southeast of from 40 to 20 feet per mile. From borings from artesian wells, corroborated by facts collected from other sources, we constructed the section shown in the Geology of New Jersey in 1868, which is here reproduced. Fig. 27.

The artesian wells at Seven Islands, in Great bay, and at Atlantic City, have shown a greater thickness of the black clay which overlies the glass sand, but otherwise the same general structure is seen.

The difficulty still presents itself of properly describing and locating the yellow gravel which, with its variously-assorted materials, constituted the upper and last surface deposits. It is so thin as to be scarcely recognized in many places, but in others it is many feet in thickness. There are large areas which are covered with a layer of clean white quartz sand several feet thick, others in which a light-colored sandy clay is found several feet thick; and still others in which the gravel is mixed with fine sand and clay to make a retentive and easily-cultivated soil.

In the report of 1878, Prof. Smock gave a detailed account of many localities where the light-colored clay had been dug, and in the same report an attempt was made to classify and mark out on the State map the portions where the sand was so light as to be fit only for the growth of pines, and others in which the sandy loams were sufficient to favor the growth of oak. The proportion of the latter is by far the greater in the extreme southern portion of the State.

Some better and more distinct system of classifying and describing these formations is desirable, and now that the maps are done we have the basis prepared upon which to conduct and locate our studies; they may be pursued with more hope of success. The work has been put in charge of Assistant F. J. H. Merrill, who was engaged last year in examining the formations along the seaside, and the changes which they are undergoing. This year he has devoted his time in all the earlier part of the season to the examination of the yellow gravel and its associate materials.

The following is his report:

YELLOW GRAVEL.

This name is applied to a superficial deposit, consisting of quartz pebbles and fragments of fossiliferous limestone more or less silicified,

together with sands of varying fineness, clay or clayey matter mingled with the sand and ferruginous matter rich in plant-food.

In general terms the Yellow Gravel may be said to occur *chiefly* over that portion of the State of New Jersey southeast of the northwest boundary of the Cretaceous formation, which would be approximately represented by a line drawn from Elizabethport to Trenton; northwest of this line the extent of the formation has not yet been accurately determined, though it occurs at many points on the Triassic area south of the moraine.

The field-work of the past season has extended over the larger portion of Monmouth, Ocean and Burlington counties, southeast of the marl belt, and preliminary investigations have been made in Atlantic, Camden, Gloucester, Salem and Cumberland counties, along such lines as afforded the most promising exposures and sections of strata. Although the examination is not complete, certain facts and generalizations have been reached, which are here presented.

In the Annual Report for 1880, pp. 87–97, this deposit is discussed at some length under the head of "Preglacial Drift," and this year's work has mainly confirmed the results there recorded, although some points appear to be disproved, which will be considered in turn.

The *pebbles*, which are the prominent feature of the formation, are all rounded and vary from $\frac{1}{8}$ inch to 5 inches in diameter. They consist mainly of crystalline quartz or chalcedony, normally white, and are evidently derived chiefly from quartz veins and segregations. Fragments of chert are somewhat rare. The fossiliferous fragments previously described (Ann. Rep. State Geologist, 1880, pp. 91, 92), are mainly silicified, and have come from beds varying in age from Lower Helderberg to Corniferous. Many specimens were collected during the past summer, but nothing especially new was discovered.

The yellow color which characterizes the gravel and sand is due to the hydrated peroxide of iron, which has come from some source not yet well known, and stained them after their deposition.

The *sands*, which occur interstratified with the gravel in the more recent deposits near the sea-coast and Delaware shore, or mingled with it throughout most of the southern portion of the State, consist of sharp, angular quartz grains, varying in size from $\frac{1}{100}$ inch up to $\frac{1}{16}$ inch.

With these sands is mixed frequently more or less clayey matter, and at many points layers of reddish or yellowish clay occur inter-

bedded with the sand or even enclosing some of the pebbles. Where the clay occurs in distinct beds it frequently serves, or has served, for the manufacture of a medium quality of brick. Instances of this may be seen at Asbury Park, Manchester, between Whitings and Manchester, &c. As a final constituent of this series, which deserves consideration, is a certain proportion of ferruginous matter, rich in *plant-food,* which has been unequally distributed over Southern New Jersey, and of which the presence is mainly to be recognized by the character of the vegetation it supports. By plant-food is meant those inorganic compounds, which, when present in the soil, supply vegetation with the elements necessary for its support. They comprise chiefly salts of potash, lime, magnesia and iron, together with phosphoric, sulphuric and nitric acids.

The absence of this plant-food is abundantly shown in the East and West Plains, lying partly in Ocean county, but chiefly in Burlington.

Here, as is well known to all who have visited the region, the soil is so deficient in plant-food that even pine trees cannot attain a greater height than five or six feet, while most of them are lower than this; at many other points it is lacking in greater or less degree. Its presence is manifest on the other hand to all familiar with the agricultural capabilities of the region under consideration. The more fertile lands, near Toms river, Forked river and Tuckerton, are examples of the presence of the factor in question.

The plant-food is discussed as a separate constituent, since at many different points, where the fertility of the soil is very unequal, its physical appearance is practically the same, there being perhaps a trifle less iron in the more barren soils.

In studying attentively the distribution and local aspect of the yellow gravel, one is struck with the fact that the pebbles are most abundant, coarsest and unmixed with sand on the highest ground. Typical examples of this will be seen on Beacon, Telegraph and other hills in Middletown, where the gravel is from 10 to 15 feet thick; on the hills near Perrinesville and Clarksburg, in Millstone township, Monmouth county, and again on Apple Pie, Governor's and Bear Swamp hills, near Shamong, Burlington county. At all of these localities the gravel is but slightly mixed with clay or sand, and is very nearly white. The silicified fossils are also very abundant in these places. Again, the higher portions of the East and West

Plains are covered with gravel of similar character. Again, on the lower grounds, we do not find the gravel in a super-incumbent layer of 5, 10 or 15 feet in thickness, but we find it mingled with clay or sand and stained a deep yellow by oxide of iron. There are very many places, however, on low ground, where there is no gravel and

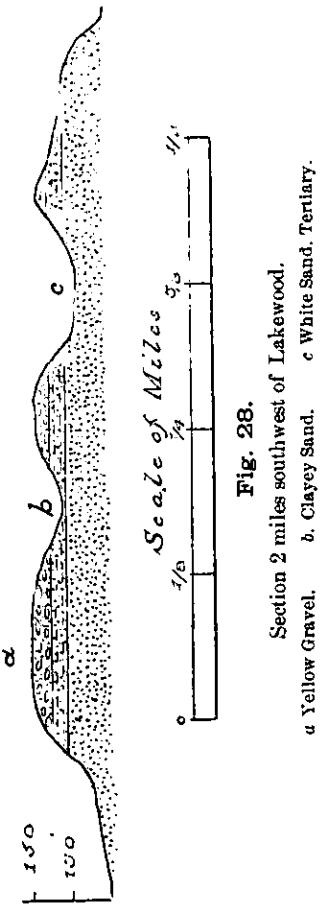


Fig. 28.

Section 2 miles southwest of Lakewood.

a Yellow Gravel. *b*. Clayey Sand. *c* White Sand. Tertiary.

where the surface-material is a white sand forming a barren soil. To appreciate these differences, we must consider the strata lying under the series in question.

The relations of the gravel and the clayey material containing plant-food to the upper Tertiary beds is shown in Fig. 28.

In estimating the age of the yellow gravel, we are not guided by

any paleontological evidence. It overlies, however, unconformably, all the Mesozoic and known Tertiary beds, and is immediately overlain in turn by the glacial drift where it occurs north of the moraine. The only question is, then, Shall it be called Tertiary or Quaternary? The upper members of the Tertiary in New Jersey, as we know them, are the miocene marl, the glass-sand, a deposit of coarse, white sand referred to below, and perhaps a series of beds of blue or light-colored clay which are very prominent at Winslow, near Wheatlands, Mount Misery, Vineland and Millville, and many other localities mentioned in the Annual Report for 1878. Whether these clays are upper Pliocene or Post-pliocene is uncertain, but the Yellow-gravel series overlies them all, and, as it were, forms a mechanical base for a new cycle of deposition parallel to the Potsdam sandstone or the Oneida conglomerate. From this evidence, the yellow gravel may be provisionally considered as Post-pliocene.

The division of the Quaternary from the Tertiary is based upon the presence in strata of the latter age, of a certain proportion of fossils of extinct species, while in the Quaternary beds, all the fossils are of existing species.

Now the glacial period has been assumed by common consent at home and abroad, to be the beginning of the Quaternary, and on that basis, any deposit which was preglacial would be older than the Quaternary age. There are, however, abundant proofs in the Post-pliocene deposits of Gardiner's Island, Suffolk county, New York,* that strata of considerable thickness were deposited in the Quaternary previous to the arrival of the Ice-sheet. On Long Island, the Yellow gravel attains a thickness of upwards of 100 feet, and these also seem to be distinct from what may be considered as Tertiary beds.

Besides the Miocene marl and the glass sands of New Jersey, there appears to have been another important deposit formed in Tertiary time, of which but little remains in its pristine condition. This was a bed of coarse white sand of upwards of 100 feet in thickness, and which forms the base of the highest hills southeast of the marl belt. It may be noticed in the Hominy hills east of Freehold, and also in Apple Pie, Bear Swamp and Governor's hills, as well as in the high ground of the plains, and especially near Lakewood, as shown in Fig. 28, and in the Forked River mountains.

These are all hills of denudation. The gravel, which is abundant

*See Annals N. Y. Acad. Sci.

on their summits, is wanting on their slopes, and the succession of the various beds below it is clearly shown.

In their original condition, the pebbles of the Yellow Gravel were apparently water-worn fragments of the harder portion of the rocks of the region from which they came, that is to say, they were derived from the quartz veins of Archæan and Palæozoic rocks. Such veins are not uncommon in the crystalline rocks of Morris county, where they are frequently met with in the iron mines, and the argillites of the great valley, west of the Archæan, also have an appreciable amount of vein quartz distributed through them.

The silicified fossils have not yet been traced to their source, or rather no limestones of Helderberg and Corniferous age have been found in which they occur. Still the Corniferous limestone along the Delaware river, northeast of the Water Gap, has not yet been thoroughly searched for them, and a study of the Green Pond Mountain region shows that an immense extent of Helderberg and Corniferous strata has been removed by erosion. Moreover, a loose mass of silicified *Favosites*, pronounced by Prof. Jas. Hall to be probably of Helderberg age, was found at the head of Green pond. As there is an extensive outcrop of fossiliferous Helderberg limestone only two miles farther up the valley, and the spot where it was found is or was underlain by the same rock, it would seem unnecessary to assume that its sources were very far distant, or that it was quite foreign to the region.

The character of the Yellow Gravel indicates that in its primitive condition, before it was distributed over southern New Jersey, it was a product of sub-aerial and fluvatile erosion. Practically nothing remains except the quartz, which, from its hardness, resistance to chemical action and lack of cleavage, has withstood the vicissitudes to which it has been subjected. The material is not a direct product of glacial action, since no fragments of compound rocks, such as granites, gneisses, traps, &c., occur in it. Possibly for a very long time there had been no such violent agent of erosion and transportation, as an ice-sheet, and the rocks had slowly been decomposed and dissolved by atmospheric and other natural agencies, leaving as remnants, to be rounded and transported by running water, the quartz of the veins and the fossils of which the forms had been hardened by pseudo-morphous silicification. Whatever the region from which these pebbles came such were probably the conditions under which they were formed.

III.
ECONOMIC GEOLOGY.

MINING.

The mining of iron and zinc ores has been prosecuted with considerable industry during the past year. There has been raised during the year:

	Tons.
Iron ore	500,501
Zinc ore	43,877

This, in the case of the iron ore, is over 50 per cent. more than in 1885, but it is still much below the product of our mines in 1882, when it reached 932,762 tons. The trade in iron has improved during the year, and the product from the mines shows plainly that whenever there is sufficient demand for the ore it can be produced in as large quantity as ever. Some notes in regard to mines which have been worked during the year are here appended. As the structural geology of the iron-bearing rocks is more fully described, there will be better opportunity for systematic and intelligent mining, and these notes are intended to help the work in that direction, and the attention of miners is called to them with the hope that they may contribute facts relating to the ores and associated rocks which can be combined with those collected by others and used in studying the general subject and its details.

The amount of zinc ore mined in 1885 is about 14 per cent. more than last year, and there is no difficulty in mining all that the market demands.

The mines noted are arranged alphabetically.

ALLEN MINE, Rockaway township, Morris county.

Has been idle throughout the year.

Geology of New Jersey, 1868, pp. 583–587; Ann. Rep., 1873, p. 35; 1879, p. 55; 1883, p. 110; 1884, p. 87; 1885, p. 101.

BAKER MINE, Mine Hill, Morris county.

Joseph Wharton, owner; Chase Stryker, superintendent.

The old workings north of the road to Dover have been abandoned and a new slope sunk on the ore-body, 100 feet south of this road. This slope is now over 200 feet deep on the foot-wall, which dips 61° S. E. The ore at the bottom is 6 feet thick. A new engine-house and dump have been built, and engine, pump and compressor put in position. There is said to be a longitudinal fault in the mine. The ore contains very little mica and hornblende. The rock is Granulite. Some exploration has been done at a shaft at the base of the hill (in the swamp); there is here a Bessemer ore.

Geology of New Jersey, 1868, p. 575; Ann. Rep., 1879, p. 52; 1880, p. 106; 1883, p. 104.

BEACH MINE, Rockaway township, Morris county.

This mine adjoins the Hibernia property on the southwest. It is controlled by the Andover Iron Company, but has not been worked during the past year. An offset of 22 feet to the southeast is reported near the line of the Lower Wood mine property.

Geology of New Jersey, 1868, p. 560; Ann. Rep., 1873, p. 47; 1879, p. 56; 1885, p. 103.

BEACH GLEN MINE, Rockaway township, Morris county.

This mine has been idle during the past year. It is owned by the J. Couper Lord estate. General J. S. Schultze is manager and Joseph Richards, of Port Oram, superintendent. It was last worked in 1884. The dip, as shown at the southwestern workings, is 75°–80° N. W.; farther northeast it changes to 70° S. E., but this appears to be local, and the general inclination of the ore-bed is steeply northwestwardly. The pitch, as indicated on the walls, is about 15° N. E. The enclosing rocks are granulite and hornblendic granulite. The ore-body itself is very heavily charged with dark brown or black mica, and

contains also some oligoclase and disseminated grains of Apatite. The richest ore in the present excavations is along the foot-wall, in a band one to two feet in width, but there are from five to eight feet of micaceous and feldspathic ore in addition. The workings consist of a tunnel over 1,600 feet long, run as an adit-level on the course of the bed, a shaft which intersects this tunnel at 104 feet below the surface and 1,100 feet from its mouth, and which has been sunk 60 feet below the tunnel level; at the bottom of this shaft is an incline 75 feet long, the deepest point in the mine being about 200 feet below the surface. The ore is lean, averaging only 41.11 per cent. metallic iron, but it is a Bessemer ore. Experiments on dressing this ore have recently been made under the direction of Mr. George W. Maynard, of New York, with very satisfactory results. About 19 tons of the ore were crushed and jigged at the dressing works of the Chateaugay Ore and Iron Co. The crude ore yielded chemical analysis as follows:

	Per cent.
Metallic iron	41.75
Phosphorous	0.0643
Phosphorous calculated in pig	0.1534

The concentrates gave:

	Per cent.
Metallic iron	65.50
Phosphorous	0.0224
Phosphorous calculated in pig	0.0342

The tailings from the jig held 24.92 per cent. of metallic iron, and those from the sluiceway 21 66 per cent. These analyses show that the percentage of iron was increased by over one-half, and that of phosphorus was decreased by nearly two-thirds in concentration. The phosphorus is mainly in the Apatite, which is in large part jigged out. The results of this experiment were so encouraging that there is a good prospect of the erection of extensive concentration works at the mine. Mr. Maynard points out that on the basis of the above analyses there will be required 2.73 tons of crude ore to yield one ton of 65.5 per cent. concentrates.

For our information regarding these experiments we are indebted to Mr. Maynard.

Geology of New Jersey, 1868, pp. 554–556; Ann. Rep., 1879, p. 57; 1883, p. 118; 1884, p. 91.

BEEMER MINE, Chester township, Morris county.

Operated by Cooper, Hewitt & Co.; S. W. George, superintendent.

This mine is opened just southwest of the Skellenger mine, and thus lies between it and the old workings of the Leake mine. Two shafts are being sunk, which in September had reached depths of 60 and 35 feet. Work was commenced April 1st, and from 200 to 300 tons of ore have since been raised per month; this is shipped from a switch on the Chester Branch of the Delaware, Lackawanna and Western railroad to Pennsylvania points. This ore averages 4–5 feet in thickness, and contains considerable hornblende and black mica. The enclosing rock is hornblendic granulite, dipping 55° S. E., and pitching 20° N. E. Several shoots are known, connected by stringers of ore.

BRYANT MINE, Randolph township, Morris county.

Owned by D. L. Brant, Esq.; John D. Evans, superintendent.

This mine was re-opened in August, the machinery from the Woodhull mine being moved here in May. The old No. 1 slope is being used. The foot-wall dips 40°–60° S. E.; the pitch is 33° N. E. There are five ore-shoots known, one above the other, probably all expansions of the same bed; these reach six feet in thickness. The slope was 185 feet deep in September. There are three small offsets known in the mine. The rock is granulite, containing scattered magnetite grains. There is very little hornblende or mica in the ore.

Geology of New Jersey, 1868, p. 566; Ann. Rep., 1880, p. 104; 1883, p. 98.

CAREY MINE, West Milford township, Passaic county.

These openings are on the land of James Carey, Esq. The rock is hornblendic granulite with a nearly vertical dip. The ore-body is reported to be seven feet thick. There is here a great deal of pyroxene in the ore and much epidote; the shaft is 27 feet deep and the open-cut 30–40 feet long; 50–75 tons of lean ore on the dump. No work has been done recently.

CHARLOTTEBURG MINE, Charlotteburg, Morris county.

Cooper, Hewitt & Co., owners; Edward George, superintendent.

A small amount of ore has been mined during the year, but very little shipped. The ore-bodies are five in number, lying nearly parallel, with a dip of 75° S. E., and pitching to the northeast. They are not known to come together at any point. The enclosing rock is mainly granulitic, but in the hanging-wall of the central ore-body there is the curious bedded diabase described in the notes on lithology in this report. The ore contains much black mica, hornblende, pyrite, plagioclase, feldspar and hard, dark-colored serpentine. Near the southern end of the pond all the ore-bodies are said to be cut sharp off—apparently by a fault. They have the appearance of lenticular shoots. 45 feet east of the most eastern ore-body an exploration shaft has been sunk to a depth of 48 feet—40 feet through loose material and 8 feet in rock—in hope of finding more ore. So far the effort has been futile.

Geology of New Jersey, 1868, p. 596; Ann. Rep., 1873, p. 49; 1879, p. 60; 1880, p. 108; 1883, p. 115.

CHESTER HIGHLAND MINE (formerly known as the CROMWELL MINE), Chester, Morris county.

Leased by the Chester Highland Mining Co., and subleased to Mr. W. F. Potter till July 1st, 1887.

The mine is 210 feet deep, the first 40 feet vertical, the rest on a slope of 60°, which is about the dip of the foot-wall to the southeast. There are three ore-shoots known, pitching about 40° N. E.; these are connected by little stringers of ore, and vary from 3 to 12 feet in thickness. The ore is not being roasted. It contains 2 per cent. sulphur, 50–53 per cent. metallic iron. About 750 tons were being raised per month and shipped to Edge Hill, Pa., and to the Chester furnace. No offsets are known in the mine. The rock of the walls is hornblendic granulite, and there is much hornblende and black mica in the ore We are indebted to Mr. Potter for most of the above information.

Ann. Rep. 1883, p. 78; 1884, p. 92.

COOPER MINE, Chester township, Morris county.

This mine has been idle all the year, and most of its machinery has been removed.

Ann. Rep. 1879, p. 47; 1880, p. 103; 1883, pp. 93, 94; 1884, pp. 78, 79; 1885, p. 99.

DE HART MINE, Randolph township, Morris county.

Owned by Keiper & Boyer, 62 Liberty street, New York City; S. M. Keiper, superintendent.

The mine was re-opened in May, 1886. Work has mainly consisted in sinking. The depth reached in September was 65 feet, vertically. The rock dips steeply to the southeast, and the pitch is northeast.

Geology of New Jersey, 1868, p. 559; Ann. Rep. 1873, p. 40; 1879, p. 49; 1880, p. 104; 1883, pp. 96, 97; 1884, p. 81.

DICKERSON MINE, Mine Hill, Morris county.

Operated by the Succasunna Iron Mining Co.; A. Pardee, manager; James Benny, superintendent.

Work on this mine during the past year has consisted in finishing the new shaft, which has now reached a depth of 814 feet with an "underlay" of 90 feet on the foot-wall at the bottom, and in erecting a new engine-house to carry new engines for hoisting and pumping and for compressing air for the drills. This shaft is divided vertically into three compartments, two for hoisting and the other for the pump. No ore has been raised from the deep workings, which are about as reported in 1884. A small amount of ore has been taken from the caved-in workings of the "Cow Belly" mine; 35,000 tons have been shipped from the dump. The new shaft is placed so as to meet the bottom of the old slope on the "Big Vein." No offsets are known in these workings. The pump in the old slope is kept going. The dip of the several ore-bodies varies from 50°–75° S. E., and the pitch from 28°–45° N. E. The rock of the walls is granulite, containing magnetite grains. There is much black mica in the ore, and this appears to be especially abundant along the walls.

Geology of New Jersey, 1868, pp. 570–574; Ann. Rep. 1879, pp. 51, 52; 1880, pp. 105, 106; 1883, pp. 100–103; 1884, pp. 83, 84; 1885, p. 99.

Doland Mine, Mount Pleasant, Morris county.

Has lain idle during 1886, with the exception of finishing the new pump, and sinking the slope 25 feet; the dip is 60° S. E. The ore contains much phosphate of lime, and averages 1.5 per cent. phosphorus. The rock is hornblendic granulite.

Annual Report, 1873, p. 46; 1879, p. 55; 1883, p. 107; 1884, p. 85; 1885, p. 100.

Ford Mine, Jefferson township, Morris county.

Operated by the Musconetcong Iron Company; A. Pardee, agent.

Mining has been continuous throughout the year, with an output of about 1,000 tons per month. A new boiler was put in position during the autumn. The ore-shoot pitches about 38° N. E., and the rocks dip 85° S. E. to vertical. The shoot is about 15 feet wide, and pitches under the shoot worked as the Scofield mine (see Fig. 17), which is probably another thickened portion of the same ore-bed. The lean ore is broken in a crusher, and the rock culled out. The rock is granulite with considerable coarse feldspar. The two ore-bodies in this mine, which were reported as separated by nine feet of rock in the report for 1884, are now reported as united. The ore is very fine grained, and contains considerable pyrite.

Geology of New Jersey, 1868, pp. 614–616; Ann. Rep., 1873, p. 66; 1879, p. 72; 1880, p. 113; 1883, p. 131; 1884, p. 99; 1885, p. 105.

Green Pond Mines, Rockaway township, Morris county.

All this group of mines were idle when visited in September. The enclosing rock is granulite, somewhat hornblendic, with beds of a more hornblendic rock. The dip varies from 45°–52° S. E., and the pitch is 20°–25° N. E. The coarse Green Pond Conglomerate is met with a few hundred feet west of the mines, forming the crest of Copperas mountain, and dipping 50°–55° N. W.

Ann. Rep., 1873, pp. 48, 49; 1874, pp. 23–25; 1879, pp. 58–60; 1880, p. 108.

GULICK MINES, Chester township, Morris county.

Controlled by Cooper, Hewitt & Co.; S. W. George, superintendent.

The shafts north of the road from Chester to Hacklebarney, worked last winter, were abandoned in May. About August 1st, work was begun on a shaft just on this road, which in September had reached a depth of 20 feet, and showed 6 feet of ore. Here the dip is 65° S. E. The rock is a very hornblendic granulite, and the ore contains pyrite and hornblende.

Ann. Rep., 1873, p. 36; 1879, p. 49; 1883, pp. 89, 90; 1884, p. 76; 1885, p. 98.

HACKLEBARNEY MINES, Hacklebarney, Morris county.

Owned and operated by the Chester Iron Mining Company; Richard George, agent; Reuben Rowe, superintendent.

These great deposits of ore have been worked continuously during the year. There are three shafts operated on top of the east hill, and the open cuts at its southern base are also worked. Here the dip averages 60° S. E., and the pitch 20° N. E. There are numerous offsets, all throwing the several parallel ore-bodies into the *hanging-wall*, that is, to the southeast; there are so many ore-beds, that it is very difficult to exactly locate the faults and ascertain the amount of throw. Besides these, there is a great fault in the valley of the Black river, which separates the east hill from the west hill, and has dislocated the ore-bodies at least 200 feet—those in the east hill being at least that amount southeast of the continuation of the strike of those in the west hill.

The ore-beds may be seen to good advantage in the excavations on the west hill; here at least five offsets are known, all throwing the ore into the *foot-wall*, or towards the northwest. The dip and strike average about the same as in the east hill. The belt of ore-beds appears to be about 200 feet wide, through which space there are many alternations of ore and rock. The rock of all this system of ore-beds is a very hornblendic granulite. Towards the outcrops this is very greatly decayed. The ore contains considerable black mica and a chloritic substance which is known as "blue slate;" there is also some tremolite in the deposit. Pyrite is very abundant, and in its decomposition yields much copperas. About 1,400 tons of ore are shipped per month, and this is all first roasted to drive off the 3 per cent. of sulphur which it contains when mined.

Geology of New Jersey, 1868, p. 557; Ann. Rep., 1873, pp. 35, 36; 1879, pp. 47–49; 1880, p. 104; 1883, pp. 87–89; 1884, p. 76; 1885, p. 98.

HIBERNIA MINES, Hibernia, Morris county.

The Glendon Iron Company has worked the Glendon, Scott, De Camp and Upper Wood lots during 1886; the Lower Wood and Willis mines have been idle. The rocks and ore pitch about 30° N. E.; on the Glendon lot the dip is 70° S. E., but at the Upper Wood mine this is changed to 82° N. W., and near the surface this northwestern dip continues to the Willis mine. The rock is mainly granulite, but varies to a poorly micaceous gneiss. To the east of the Willis mine, however, there are fine outcrops of a remarkably coarse quartz syenite, which contains black hornblende crystals six inches long, and the strata are very greatly contorted and broken. The Willis mine is said to be cut off by an offset at its northeastern end; the bed has not been found beyond this point, and as there is considerable massive granulite exposed, it is very probable that an upthrow fault has thrown the bed one way or the other. The ore of all these mines is much mixed with black mica.

Geology of New Jersey, 1868, pp. 561–564; Ann. Rep., 1873, p. 47; 1879, pp. 56, 57; 1880, p. 108; 1883, pp. 116, 117; 1884, pp. 90, 91; 1885, pp. 103, 104.

HIGH BRIDGE MINE (formerly Taylor mine), High Bridge, Hunterdon county.

Operated by the Thomas Iron Company.

Work was commenced October 1st, in sinking a new shaft between the old open-cut and the deep hoisting shaft, and in prospecting. This shaft shows 4 feet of ore at a depth of 30 feet, and there are other smaller ore-beds alongside of this, separated by rock. The surface rock and ore are greatly decayed. The dip is 72° S. E.; the pitch, as indicated on the walls of the open-cut, is from 40°–47° N. E. The rock is a hornblendic granulite, locally containing some black mica, and there is some hornblende and mica in the ore.

Geology of New Jersey, 1868, pp. 617, 618; Ann. Rep., 1873, p. 29; 1879, pp. 43, 44; 1880, p. 102.

HOWELL MINE, Rockaway township, Morris county.

This is situated just southwest of the Kitchell, or Wild Cat mine. It has been idle throughout the year. There is here considerable schistose gneiss overlying the ore-body; the dip is here 50° S. E.

Ann. Rep., 1879, p. 60; 1880, p. 108.

HUFF MINE, Port Oram, Morris county.

Owned by the heirs of the Huff estate; Robert Oram, superintendent and lessee.

This mine was worked in the early part of the year, being shut down about August 1st; about 200 tons were raised per month while it was operated. It is about 200 feet deep; dip 60° S. E. Ore is said to average not more than 45 per cent. metallic iron, but was dressed up to 55 per cent. before shipment. In September there were several hundred tons of ore on the dump; this is mixed with black mica and hornblende. The enclosing rock is granulite.

Geology of New Jersey, 1868, p. 597; Ann. Rep., 1873, p. 46; 1879, p. 54; 1880, p. 106; 1883, p. 107; 1884, p. 84; 1885, p. 100.

HURD MINE, Hurdtown, Morris county.

Operated by the Glendon Iron Company; George Richards, of Dover, agent.

This old mine is still worked vigorously and looks as well as ever. The slope is now over 2,600 feet in length, descending to the northeast with the pitch of the ore-body and its enclosing granulites, at an angle of 26°–31°. The vertical depth is thus about 1,200 feet. The dip remains very nearly vertical at the bottom of the present workings. The width of ore extracted is about 30 feet and the vertical height of the "shoot" is from 60 to 90 feet, the deposit being thus oval in section. Work during the past year has been confined to the main shoot, nothing having been done on the bed lying parallel to this to the northwest. There is very little mica in this ore, and none in the enclosing rock. East of the mine, on the hill, the rock appears perfectly massive, but at points 200 feet west of the Ogden Mine railroad it is poorly bedded, dipping 80° S. E., while along this railroad, 500 feet northeast of the road-crossing the dip is 60° N. W., pitch 26° N. E., the rock coarse granulite, with scattered grains of Magnetite. It would appear from these observations that there is an anti-

clinal fold of the massive rocks just east of the mine, and a tightly compressed synclinal of the Magnetite-Bearing Series on the eastern side of this low hill, between the massive rock and the railroad. The fault across this mine has been described in former reports. No other great offset has been encountered. A longitudinal section through the present workings and the old ones on the Sparta turnpike, modified from the illustration on page 67 of the report for 1883, is given on another page of the present report. The deposit now worked appears to lie against the northwestern side of the anticlinal above described. In the old workings the two beds appeared connected as shown in the Geology of New Jersey, 1868, and page 59 of the report for 1883, forming a synclinal fold with horses of rock separating the western part into three. Both beds were cut off by the fault, and the western one has not been worked to the northeast of it.

Geology of New Jersey, 1868, pp. 606–610; Ann. Rep., 1875, p. 65; 1879, p. 72; 1883, pp. 129, 130; 1884, p. 98; 1885, p. 105.

HURD MINE, Port Oram, Morris county.

The New Jersey Iron Mining Company, owners; L. C. Bierwirth, of Dover, agent.

This mine has been in operation during part of the year. The slope dips 52° S. E. The rock of the walls is granulite. It is one of the Irondale group of mines.

IRONDALE MINES, Irondale, Morris county.

With the exception of the Hurd mine, above noted, no mining has been done on this property during the year.

Geology of New Jersey, 1868, pp. 575–578; Ann. Rep., 1873, p. 43; 1879, p. 52; 1880, p. 106; 1883, pp. 104, 105; 1884, pp. 85, 86; 1885, p. 100.

KISHPAUGH MINE, near Danville, Warren county.

Owned and operated by the Musconetcong Iron Company. A. Pardee, general manager; W. G. Thomas, superintendent.

The present workings are about 450 feet deep. The dip is from 38°–45° S. E., and the southwest pitch, noted in former reports, is persistent. No offsets are known. Shipments have varied from 700 to 1,000 tons per month.

Ann. Rep., 1873, pp. 82–84; 1879, pp. 83, 84; 1880, p. 117; 1883, p. 142; 1884, p. 107; 1885, p. 106.

KITCHELL, or WILD CAT MINE, Rockaway township, Morris county.

The Kitchell Mining Company, owners; John George, superintendent.

Some work in exploration has been done during the year, and a small amount of ore obtained. Like other mines in the vicinity, this will be favored by the completion of the new railroad now in process of construction from Port Oram northward to the Piccatinny Powder Reservation, and thence to Denmark and Charlotteburg; 60 or 70 tons of ore have been shipped to Chester. The present workings consist of an open-cut and a 40-foot tunnel. Near the outcrop one of the beds containing some Magnetite is greatly decayed, forming a true gossan with much Limonite. The foot-wall of this bed is very smooth and rolling. The dip is 40° S. E., and the pitch 22° N. E. In the tunnel the ore-bed is two to four feet thick, and the ore is very bright. It contains some Pyrite, Hornblende and black Mica. There is a vein of Calcite one inch thick in the tunnel; this appears to have formed along the line of a fault; 300 feet northwest of the mine opening the rock is massive granulite.

Ann. Rep., 1879, p. 60; 1880, p. 108.

LANGDON MINE, Chester township, Morris county.

Owned by S. W. Langdon, Esq., and the estate of Hanford Nichols; leased by W. J. Taylor & Co.; W. J. Langdon, superintendent.

Work on the old portion of the mine was stopped September 1st, and begun several hundred feet farther northeast, where a bed 7–14 feet thick is exposed in the excavations. The dip is 45° S. E., and the pitch 15° S. W. It is not known that the ore of the two workings is in any way connected. There is said to be little attraction between the two. A narrow-gauge railroad over a mile in length has been constructed to Hacklebarney, whence the ore will be transported over the High Bridge branch of the Central railroad. The product is about 1,400 tons per month. The ore contains some black Mica and Hornblende, with a little Pyrite.

Ann. Rep, 1883, pp. 85, 86; 1885, p. 97.

MEADOW MINE, Port Oram, Morris county.

Owned by the J. Couper Lord estate; Joseph Richards, superintendent.

Has been in operation throughout the year, producing 300 tons per month. The dip is about 60° S. E. Worked through a vertical shaft which struck the ore-bed at 108 feet in depth; the workings extend 450 feet northeast of this shaft.

MOUNT HOPE MINES, Mount Hope and Hickory Hill, Morris county.

Owned and operated by the Mount Hope Mining Company (Lackawanna Coal and Iron Company). Matson Williams, superintendent and manager.

Work during the past year has been continued on some of the beds cut by the tunnel, most of the ore having been taken from the "Jugular vein," where a shoot of ore 30 feet 4 inches wide is being taken out; this has pitch 30°–40° N. E.; all the rocks in the mines reached by the tunnel dip 70°–75° S. E. except in the Side Hill vein, where the dip is more nearly vertical. The shoot above mentioned is just above a "pinch," which reduced the width of ore to about 18 inches; above the shoot there is another pinch, and above this another shoot, the deposit being alternately wide and narrow; it is not entirely cut out at any point yet reached.

An old shaft on the "Teabo vein," near the southern base of Hickory hill, was re-opened during the autumn, and the ore found to be ten feet thick.

The great fault between Mount Hope and Hickory hill, by which the ore-beds on the southeastern side of the latter have been thrown 160 feet to the southeast, has already been described.

The magnetite-bearing rocks on the southeastern side of Hickory hill, rest on massive granulite and quartz syenite, which outcrop near its summit. To the west of these the strata dip 80° N. W., enclosing some thin beds of ore, indicating an anticlinal fold in the massive series. Whether this structure occurs in Mount Hope or not is not yet ascertained, owing to the absence of outcrops on the latter.

All the ores of these mines contain considerable black mica and hornblende, but very little mica is to be found in the enclosing rocks.

Geology of New Jersey, 1868, pp. 588–595; Ann. Rep. 1873, pp. 45, 46; 1879, p. 56; 1880, p. 107; 1883, pp. 112, 113; 1884, p. 88; 1885, p. 102.

MOUNT OLIVE MINE, Mount Olive, Morris county.

This mine was shut down last May. During the winter a new slope, 175 feet long, was sunk on the ore-body. The dip is quite flat, averaging only 35°–40° S. E. There are three parallel ore-beds, which perhaps unite below; several offsets were encountered in the workings. The ore contains a great deal of Pyrite, but little Hornblende or Mica.

Geology of New Jersey, 1868, pp. 599–601; Ann. Rep., 1873, p. 59; 1879, p. 71; 1883, p. 127; 1884, p. 97.

MOUNT PLEASANT MINE, Mount Pleasant, Morris county.

Owned by the J. Couper Lord estate; Gen. J. S. Schultze, 59 Wall street, New York, manager; Joseph Richards, superintendent.

There are no special developments of interest in this mine not already reported. It has been in continuous operation throughout the year. It may be remarked that, in addition to the several faults across the bed, there is a system of longitudinal offsets, of various throws, in one place amounting to 35 feet. The ore of the "Teabo vein" is reported as containing 66 per cent. of iron and 0.196 phosphorus. The greatest depth reached is about 800 feet, on a slope of 55½°, which is about the dip to the southeast. The ore contains considerable black Mica and a little Hornblende. The enclosing rock is granulite. The pitch is northeastward.

Geology of New Jersey, 1868, pp. 578–582; Ann. Rep., 1873, p. 44; 1879, p. 55; 1883, pp. 107–109; 1884, pp. 86, 87; 1885, p. 100.

ORCHARD MINE, Port Oram, Morris county.

Owned by the J. Couper Lord estate; Gen. John S. Schultze, 59 Wall street, New York, is manager, and Mr. Joseph Richards, superintendent.

This mine had lain idle since the spring of 1884 till January of the present year, when the water was pumped out and work of breaking and raising ore was re-commenced. Two new boilers have been put in position. The output has been about 1,500 tons per month, which is not the entire capacity. The mine is 600 feet deep, on a slope of 57°, which is about the dip of the ore-bed; this averages 5 feet in thickness, but varies considerably. The pitch is about 30° N. E. No great shoots of ore have been encountered. The ore aver-

ages 58 per cent. metallic iron and 1½ per cent. of phosphorous. One hundred and seventy-five feet northeast of the hoisting shaft, and thus nearly under the Rockaway river, the ore-bed is cut off by a fault which is supposed to have thrown it 150–200 feet to the southeast, where the old Washington mine is opened. Explorations beyond this fault line in the Orchard mine revealed no ore. The rock is granulite, with scattered grains of magnetite. The ore contains Hornblende and a little black Mica and Apatite.

Geology of New Jersey, 1868, p. 578; Ann. Rep., 1879, p. 54; 1880, p. 106; 1883, p. 106; 1884, p. 86; 1885, p. 100.

OXFORD FURNACE MINES, Oxford Furnace, Warren county.

Mining has been continuous during 1886. There are no new developments to be recorded regarding these productive mines.

Geology of New Jersey, 1868, pp. 637–640; Ann. Rep., 1873, pp. 60, 61; 1879, pp. 74, 96; 1880, p. 113; 1883, p. 133; 1884, p. 101; 1885, pp. 105, 106.

PARDEE MINE, Rockaway township, Morris county.

Is idle, and filled with water. The dip of the ore-body appears in the open cut to be nearly vertical, but varies to 75° S. E.; the pitch is 25° N. E. There is considerable black mica and hornblende in the ore, and interstratified with it is a very heavy, black, fine-grained rock, which splinters readily under the hammer. Microscopical examination of thin sections of this rock shows that it is almost entirely composed of minute grains of magnetite, cemented together by chalcedonic silica. (Field No. 725.) 200 feet northwest of this mine the rock is very massive, hornblendic granulite, and just northwest of this the Green Pond Conglomerate of Copperas mountain rests on the Massive rock, dipping 50° N. W. (See figure on a preceding page of this report.)

Ann. Rep., 1873, p. 48; 1880, pp. 122, 123; 1884, p. 89.

RICHARD MINE, Mount Pleasant, Morris county.

Owned by the Thomas Iron Company; Reese Jenkins, superintendent.

This has been one of the most productive mines in the State during the past year, averaging about 5,000 tons per month. It is worked through three shafts; the most southwest of these (No. 1) is sup-

posed to be on the continuation of the bed worked in the old Baker mine; here the dip averages 60° S. E.; 470 feet northeast of this slope a fault occurs, throwing the bed 40–50 feet into the hanging-wall (that is, towards the southeast); the surfaces of rock along this fault line were very smooth; it has a very steep hade to the southwest. No. 2 shaft is 525 feet northeast of this offset, and is sunk vertically. No. 3 shaft is about 700 feet northeast of No. 2, and is also vertical at its upper part, but below is on the foot-wall; 334 feet northeast of No. 3 shaft is another fault, running across the strike of the ore and rock; it has a hade of 85° N. E. Just beyond this offset a drift has been run 80–90 feet southeast, and another 15 feet northwest, neither of them meeting the ore-bed. On the fourth level a drift has been run 66 feet in continuation of the level through the offset; at the northeastern end of this drift a cross-cut was driven 13.6 feet northwest and again a drift 26 feet northeast, in hope of finding the ore again. These explorations are on the Allen mine property, and were conducted by the New Jersey Iron Mining Company. No ore was found. At the extreme northeastern end of the exploration drifts the rock is well-bedded gneiss, dipping 48° S. E. This offset has been met in all the levels of the mine which have been worked up to it. The pitch of the Richard mine is in general northeast. The ore contains some granulite in places and a few vugs of Quartz and Calcite, with which there is a little Pyrite.

Geology of New Jersey, 1868, p. 583; Ann. Rep., 1873, p. 45; 1879, p. 55; 1883, p. 109; 1884, p. 87; 1885, p. 101.

Ringwood Mines, Ringwood, Passaic county.

Owned and operated by Cooper, Hewitt & Co.; Philip George, superintendent.

The Peters mine was the only one worked during the past season, and a new slope has been sunk northeast of the old workings, known as the "New Peters." The ore-bodies are in the form of shoots, pitching 40°–50° N. E., while the dip is 60°–75° S. E.; the enclosing rock is stratified hornblendic granulite. West of the mines and forming the mass of the mountain are rocks of the Massive Group, which underlie the Iron-bearing rocks. The ore contains some black mica. There is an immense quantity of ore in stock; little has been shipped during 1886.

Geology of New Jersey, 1868, pp. 546–550; Ann. Rep., 1873, pp. 52–54; 1880, p. 109; 1883, pp. 92, 93.

SCOFIELD MINE, Jefferson township, Morris county.

Operated by the Crane Iron Co.; David Jenkins, of Mine Hill, agent.

Has been in operation throughout the year, producing some 900 tons per month. A gravity road, several hundred feet in length, has been constructed to convey the ore to the tracks of the Ogden Mine railroad, and will save much expense in handling it. This has an inclination of 6° 45′. The shaft is about 475 feet deep. All the mining now done is on the Ford shoot, which pitches under the Scofield shoot proper (see Figure) at an angle of 38°, which is also about the pitch of the Scofield. No offsets have yet been encountered. The dip is 85° S. E. to vertical. There is still much ore in the Scofield shoot held as a reserve; this averages 10 feet in thickness and 62 per cent. of metallic iron. The Ford shoot averages 54 per cent. of iron.

Geology of New Jersey, 1868, p. 615; Ann. Rep., 1879, p. 72; 1880, p. 113; 1883, p. 131; 1884, pp. 99, 100; 1885, p. 105.

SOLOMAN MINE, Mount Olive, Morris county.

Owned by Mrs. Nancy Soloman; operated by the Wynokie Iron Mining Co.; G. M. Miller, superintendent.

This property adjoins the Mount Olive mine to the northeast, and the ore-beds of the Mount Olive extend into it. A slope on the middle one of these, 75 feet deep, was being worked in September, and a drift from it driven northeast on a 5-foot ore-body. The dip is 42° S. E., the pitch about 10° N. E. About 300 tons per month have been raised and shipped from Flanders' station, about three miles distant.

SWAYZE MINE, Chester township, Morris county.

A little work was done on this mine in the spring, but it has since been idle.

Ann. Rep., 1873, pp. 33–35; 1879, p. 47; 1883, p. 92.

TEABO MINE, Rockaway township, Morris county.

Owned and operated by the Glendon Iron Company; George Richards, manager.

Has been working during the year; No. 4 shaft only has been used. This is 400 feet deep vertically, and then 200 feet on a slope of about

75°, which is nearly the dip at that point. Production has been about 1,200 tons per month.

Geology of New Jersey, 1868, pp. 587, 588; Ann. Rep., 1873, p. 45; 1879, p. 56; 1883, p. 111; 1884, p. 88; 1885, pp. 101, 102.

WANAQUE, or WYNOKIE MINE, Pompton township, Passaic county.

Leased by the Wynokie Iron Company; G. M. Miller, superintendent.

This mine was re-opened in March, 1886, and has since been worked. The slope is over 100 feet deep, and there is a drift 50 feet long at the bottom of the slope, running N. 40° W., for the ore-body and enclosing rocks have this strike. The ore is 6 feet thick. The product during the autumn was about 300 tons per month. The dip of the ore-body worked is 55° N. E. It appears to have another arm which has a northerly strike, and the appearance of the workings suggests a steeply-pitching synclinal fold, though at the time of our visit they were not far enough advanced to determine this definitely; 150 feet northwest of the slope there is a shaft 25 feet deep, from which some ore has been taken. There is much black mica and hornblende in the ore. The rock is hornblendic granulite. South of the workings are outcrops of very massive rocks. The ore is shipped from Midvale station on the Greenwood Lake railroad.

Geology of New Jersey, 1868, pp. 545, 546; Ann. Rep., 1873, p. 52.

WELDON MINE, Jefferson township, Morris county.

The mine was worked by the Miller Brothers, of Weldon, during the early part of the year. In September it was idle.

Geology of New Jersey, 1868, pp. 610–612; Ann. Rep., 1873, p. 65; 1879, p. 72; 1880, p. 112; 1883, p. 130.

WEST END MINES, Valley Station, Hunterdon county.

Operated by the West End Iron Co.; G. M. Miller, superintendent.

Work has been in progress here throughout the year, and much ore has been raised.

Ann. Rep., 1883, p. 123; 1884, p. 94; 1885, p. 104; see also earlier reports.

WINTER MINE, Rockaway township, Morris county.

This is about 1,200 feet southwest of the Davenport mine. It has not been operated the past year, and water has been allowed to flood the workings.

Ann. Rep., 1873, p. 48; 1880, pp. 122, 123; 1884, p. 89; 1885, pp. 102, 103.

WOODHULL MINE, Chester township, Morris county.

During last winter a shaft was sunk south of the road and some ore taken out. In September the mine was idle.

HEMATITE MINE ON MARBLE MOUNTAIN, WARREN COUNTY.

Several years ago some red hematite ore was taken from pits sunk on the top of the southern end of Marble mountain, about two miles north of Phillipsburg, on property owned by Mr. Henry Fulmer, of Easton, Pennsylvania. During the past autumn the property has been purchased by the Iron Mountain Mining Company, whose office is at 239 South Sixth street, Philadelphia, and work in exploring the deposits was commenced about November 1st. Mr. Daniel R. Kelly is the contractor and James McQuillen, of Phillipsburg, is superintendent. The old workings consist of numerous open pits, none of them more than 20 feet deep, and a tunnel driven in the western side of the mountain near its summit. The position of the property is indicated on Sheet No. 2 of the new topographical atlas.

The present owners have done considerable prospecting and opened several new trial-pits. The largest of these, and the one which it is proposed to sink, is located some 500 feet northeast of the old tunnel, is 20 feet in depth and about 25 feet square. This excavation has disclosed considerable red hematite; the stratification of the enclosing Gneisses and Talcose Schists is not well shown at this point, but appears to be about 15° S. E. The vertical thickness of the bed as exposed is about 11 feet; this is not all rich ore, however, there being some rock in it, and much red talcose matter containing more or less hematite. There is some impure limestone of feebly crystalline nature associated with the ore; both rock and ore contain considerable Pyrites. On the eastern side of this pit is a well-defined face of rock which has strike N. 50° E., and dips 60° toward the

southeast; this has been regarded by some as a hanging-wall, but is almost certainly a fracture-plane, and many more of these may be seen in the other excavations.

The superintendent estimates the amount of ore on the bank on November 27th at about 1,000 tons. This was cobbed from three or four times that quantity of lean ore and rock. Boilers and hoisting machinery are now being put in position; a chute leading several hundred feet down the western slope of the mountain will soon be completed, and will deliver the ore at the tracks of the Belvidere branch of the Pennsylvania railroad; a pipe line nearly a mile in length is being laid to bring water from the low ground east of Marble mountain.

It appears that the hematite lies in beds enclosed by the ordinary rocks of the mountain, and that these beds are in the synclinal fold which exists at the top of the mountain at this point. This structure is indicated from the fact that at points 200 feet southeast of the excavation above described, the dip is from 10° to 40° to the northwest, while at the tunnel 500 feet southwest, the dip averages 20° southeast. At the outcrops to the southeast of the excavation there is considerable hematite interbedded with the Gneisses, &c., and these may perhaps mark the eastern side of the basin.

While there is certainly considerable hematite in these rocks it remains to be seen whether it will be found available in sufficient quantity to make the enterprise a financial success. Its occurrence in this mountain is peculiar and not quite paralleled, we believe, anywhere in the State. The ore is very red, compact and shining, and not at all like the hematites which come from the magnesian limestones at Reigelsville and elsewhere. It is very similar in appearance to that of Rossie, New York.

GREENSAND MARLS.

The great economic value of these marls has become thoroughly demonstrated in New Jersey. Calls are frequently made for information in regard to them, and as the reports upon them are all out of print, the following from the report of the State Geologist to the State Board of Agriculture, in 1876, is here reprinted:

GEOGRAPHICAL EXTENT.

The part of New Jersey in which these marls are found is included in a belt or strip of country which stretches obliquely across the State from Raritan bay and the Atlantic ocean on the northeast to the head of Delaware bay on the southwest.

Its northwest border can be traced from the shore of Raritan bay, a little south of Chesquake's creek, in a southwesterly direction, in a line passing north of the village of Morristown, and just south of Jacksonville; thence across the country by the house of the late Parker Brown to the little village called Texas, on the Matchaponix creek; and from thence directly on, passing about a mile south of Jamesburg station, and crossing the Camden and Amboy railroad near Cranbury station, it passes about a half mile north of Hightstown, and thence in a line a half mile north of the railroad to the mouth of Crosswicks creek, on the Delaware, near Bordentown. It follows the bank of the river to Kinkora, from which place it is extremely difficult to trace it with accuracy, the marl-beds being entirely hidden by superficial deposits and soil, except in the banks of the streams. Guided by these marks, the line can be drawn. It follows near the line of the railroad east of Florence; a half mile east of Burlington, crosses the Rancocas a mile above Bridgeborough and the Pensauken, some distance above the Cinnaminson bridge; it comes to the bank of the Delaware again at Gloucester City; it passes back of Red Bank, crosses Woodbury creek a mile above its mouth, Mantua creek near Paulsboro, and Raccoon creek a mile above Bridgeport; thence it continues in the same direction to the Delaware, near Penns Grove.

From Penns Grove to Salem the line follows the Delaware river, which in this distance runs across the belt. Heavy beds of alluvium cover the borders of the marl at places along the river.

The southeastern boundary of the formation is much more difficult to define. There is no rock, the surface is uniform, and the soil and subsoil are everywhere more or less sandy. While the line drawn cannot be far from the true location, its exact place has frequently been a matter of doubt.

The line runs a mile south of Salem City and within half a mile south of Woodstown, near Eldridge's hill and Harrisonville, two miles and a half southeast of Mullica Hill, two miles southeast of

Barnsborough, half a mile southeast of Hurffville, half a mile southeast of Blackwoodtown, through Clementon, near Gibbsborough, Milford, Chairville, Buddstown, two miles southeast of Pemberton, two miles southeast of New Egypt, thence to the Manasquan a mile above Lower Squankum, to Shark river just above the village, and to Corlies' Pond and the seashore at Deal.

The extreme length of the formation from the Highlands of Navesink to the Delaware, at Salem, is one hundred miles. Its breadth at the northeast end, from near the mouth of the Chesquake creek to Deal, is nineteen miles, and at the southwest end, from the mouth of Oldman's creek to Woodstown, it is nine miles. The area included in this formation is not far from one thousand two hundred and fifty square miles.

The general surface of the country is smooth and uniform, being south of the deposits of boulder earth, and its slight inequalities of elevation have been produced by denudation. Along the middle of the State the country rises to a height of near two hundred feet, and maintains this elevation from the north line of Monmouth quite down to Cumberland county. On the east, the surface descends gradually to the seashore, and on the west it falls off with like uniformity to the Delaware. A chain of hills, extending from the Highlands of Navesink westward across Monmouth county, rises somewhat above the general level of southern New Jersey.

GEOLOGICAL STRUCTURE.

The greensand formation consists of a series of beds or *strata*, lying conformably upon each other, and all having a gentle descent or *dip* towards the southeast. The strata differ from each other in mineral composition, but they are all earthy in form, except at a few detached points, where the material of the strata has been cemented, by oxide of iron, into a kind of sandstone or conglomerate. They appear to have lain without disturbance in relation to each other ever since their deposition from the ocean; having no folds or curves in them, but lying smooth and parallel, like the leaves of a book. As the dip of the strata is towards the southeast, their edges show themselves upon the surface in northeast and southwest lines. If the country were level, these lines would be straight; but, owing to inequalities in the *surface*, they present irregularities of greater or

less extent, curving to the northwest on high ground, and to the southeast on low or descending ground. The lowest strata have their *outcrop* farthest to the northwest.

These explanations will be better understood after an examination of the following tabular arrangement of the strata, and also of the sections:

TABLE OF THE DIVISIONS OF THE GREENSAND FORMATION, IN THE ORDER OF THEIR OCCURRENCE.

DIVISIONS.	SUBDIVISIONS.
Upper Marl-Bed	Blue Marl. Ash Marl. Green Marl.
Yellow Sand	Yellow Sand.
Middle Marl-Bed	Yellow Limestone and Lime-Sand. Shell Layers. Green Marl. Chocolate Marl.
Red Sand	Indurated Green Earth. Red Sand. Dark Micaceous Clay.
Lower Marl-Bed	Marl and Clay. Blue Shell Marl. Sand Marl.
Clay Marls	Laminated Sands. Clay containing Greensand.

The section from Jacksonville, in Middlesex county, to Shark river, in Monmouth county (Fig. 1), which is here inserted, shows all the beds in the order of their occurrence, as seen when looking northeast. *a* is plastic clay; *b* is the clay marl and the laminated sand; *c* is the lower marl-bed; *d* is the red sand; *e* is the middle marl-bed; *f* is the yellow sand; and *g* is the upper marl-bed.

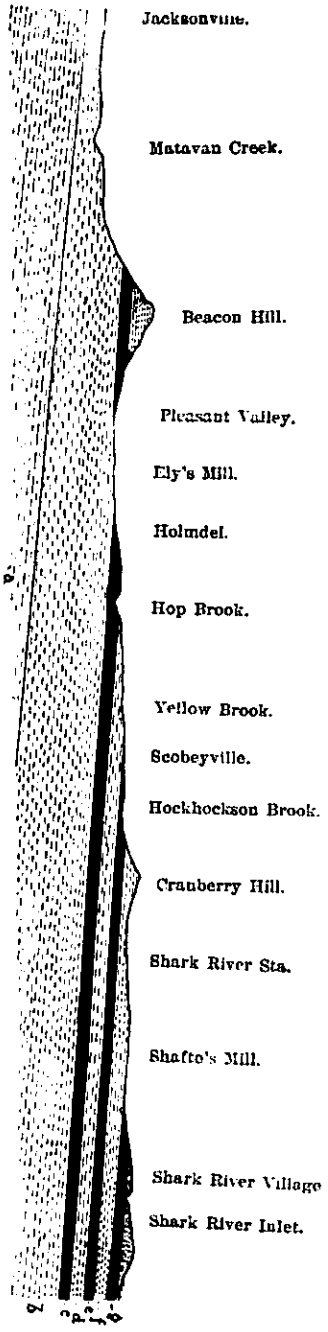


Fig. 1.

Figure 2, on page 159, is a columnar section, showing all the beds of the greensand formation as they would appear if piled one on top of another, throughout, and in the order of their succession. It also shows their comparative thickness, its scale being one hundred feet to one inch, vertical.

1. CLAY MARLS.—These marls lie immediately southeast of the plastic clays, and are separated from them by a line which is easily recognized. It can be traced upon the map almost straight from just north of Chesquake creek on Raritan bay, to Bordentown on the Delaware. From thence down the Delaware to near Salem, its northwest border is parallel to the river. The material of which the clay marls is composed is chiefly a dark-colored clay, with greensand grains sparingly intermixed.

2. LOWER MARL-BED.—This is a stratum of greensand marl, which is largely used in agriculture. It lies along the southeast border of the clay marls, and can be well seen in Middletown, Marlboro, Holmdel, Freehold, Cream Ridge, Arneystown, near Mount Holly, near Haddonfield, Carpenter's Landing, Batten's Mill and Marshallville.

3. THE RED SAND.—The material lying over, and to the southeast of the first marl-bed, is composed mainly of a reddish sand, having more or less clay intermixed at both its upper and lower

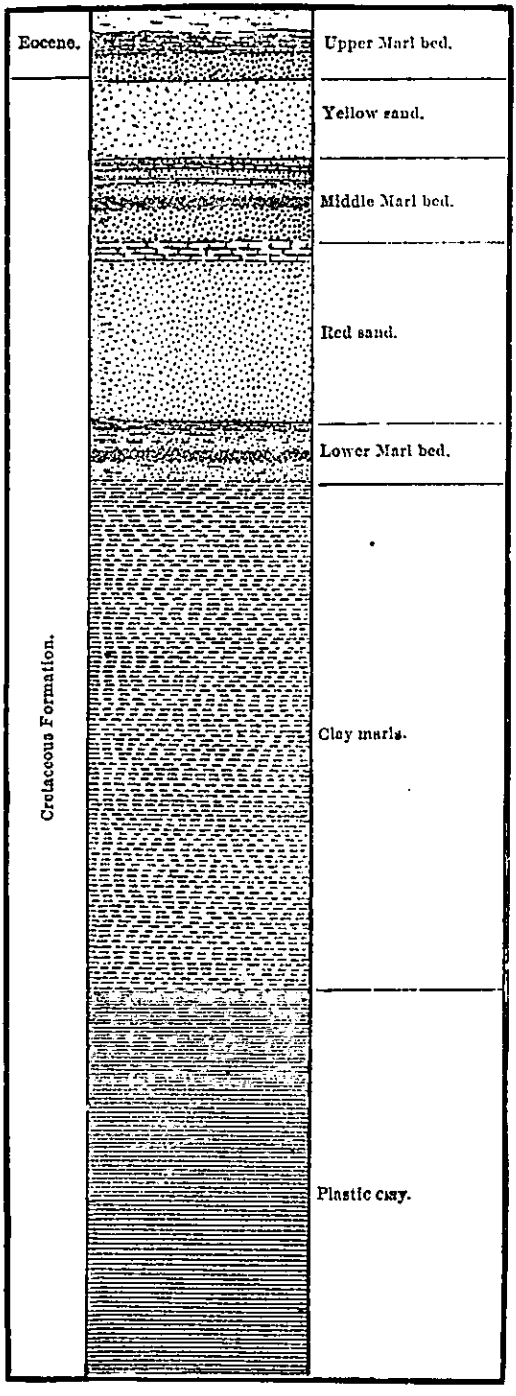


Fig. 2.

parts. Its characteristic appearance is well seen at the Navesink Highlands, at the Red Bank hills in Monmouth county, just west of Freehold, in the Red hill south of Shelltown, in the mount at Mount Holly, at Mullica Hill, and in many other places.

4. THE MIDDLE MARL-BED.—With this bed of greensand belong yellow limestone and limesand, the marls near Eatontown, those near Blue Ball, north of New Egypt, at Pemberton, at Vincentown, Medford, Marlton, White Horse, Barnsboro, Mullica Hill, Woodstown, Salem and other places.

5. THE YELLOW SAND.—This material lies immediately on the Middle Marl-Bed, and is not well characterized, though everywhere found.

6. THE UPPER MARL-BED.—This bed consists of greensand disposed in layers, which are paralled to those

already mentioned, and it lies immediately to the southeast and upon them. It is well seen in the marls of Poplar, Shark river, Squankum, New Egypt, northeast of Pemberton, and at Clementon; southwest of which this bed has not been identified. The cross-section (Fig. 1) shows their relative positions, and the columnar section (Fig. 2) gives the thickness of the members and their subdivisions.

The direction or *strike* of the strata has been obtained by taking two points in the Lower Marl-Bed, which are at tide-level and on opposite sides of the State, and then drawing a straight line between them. It touches the Lower Marl-Bed at tide-water on Sandy Hook bay, opposite Red Bank, near the mouth of Hop Brook, at Mount Holly, Clement's bridge, Carpenter's Landing and above Sculltown, at Marshallville, Salem county, and St. Georges, Delaware. The distance from St. Georges to Sandy Hook bay is one hundred and six miles, and finding the marl at intermediate points on the same level, and in the same line, proves that there is no important change of direction in the strike for the whole distance. The true bearing of this line is S. 55° W. It is evident, from an inspection of the map, that the belt of country in which this formation lies narrows towards the southwest.

The inclination, descent, or, as it is technically called, *dip*, is at right angles to the *strike;* of course, if taken from the strike of the Lower Marl, its bearing will be S. 35° E. The amount of the dip is about thirty-eight feet in a mile. The pits of John M. Perrine, north of Freehold, are one hundred feet above tide and three miles northwest of the tide-level line above discribed; this gives thirty-three feet per mile descent. This marl bed is considerably too high at Cream Ridge and at Arneystown for the usual dip, and there is either an elevation of the marl here or a curve to the southeast. From this point on towards the southwest, the bed is too little exposed to furnish accurate data from which to calculate its dip, but enough has been ascertained to show that it continues nearly the same.

In the Middle Marl-Bed, the bottom of the marl at Mullica Hill is seventy-one feet above tide; at Stratton's marl-pits, nearly two miles up the north branch of Raccoon creek, the bottom of the marl is twenty-nine feet above tide, giving a descent of twenty-one feet per mile; the hill at Red Bank, Monmouth county, is one hundred and twenty-two feet; at Parker's creek, two miles southeast, the bottom of marl is at tide-level; the descent here is sixty-one feet per mile. The old road from Keyport to Holmdel, at its summit on Big Hill,

just touched the bottom of the second marl-bed, at the height of three hundred and two feet; eight and a quarter miles southeast of this the marl is at tide-level. This gives a descent of nearly thirty-seven feet per mile. Marl on the east side of the road from Freehold to Blue Ball, is at top one hundred and twenty-three feet above tide. Shepherd's marl, south of Blue Ball, is eighty-four feet above tide; the distance between them, measured in a southeast direction, is about one and one-eighth miles, giving a descent of a little over thirty-four feet per mile. At Mount Holly, the marl in the mount is one hundred and fifteen feet high; at the Pemberton Marl Co.'s pits it is only twenty-six feet above tide. The two places, measured on the line of dip, are three and a half miles apart, which gives a descent of twenty-five and three-sevenths feet per mile.

At Winslow, which is twelve and a quarter miles southeast of Clementon, and at about the same elevation, the marl was struck at the depth of three hundred feet. If this is the Upper Marl-Bed it gives it a descent of twenty-five feet per mile. Other levels of the Upper Marl-Bed have been taken at New Egypt, Squankum, Shark River and Deal, but the distances in which the marl is exposed, are so short that the results can be given only approximately.

From the borings of several artesian wells at Asbury Park and other places on the seaside; at Lakewood, in Ocean county, and at Greenwich, in Cumberland county, the conclusion is reached that the dip of the marl-beds towards the southeast is thirty-seven feet per mile. The upper layer of the Upper Marl-Bed has a dip of only twenty-eight feet per mile.

THICKNESS OF THE FORMATION.

We are obliged to measure the different parts as they are exposed in gullies, hillsides or artificial openings in different places, and add them together. The results are given in the following table, and details are given in the description of the various strata and the results have been verified:

	Feet.
Clay marls	277
Lower Marl-Bed	80
Red Sand	100
Middle Marl-Bed	45
Yellow sand	43
Upper Marl-Bed	37
Total thickness	532

GEOLOGICAL AGE.

This formation is all included in the Cretaceous Period,* excepting the upper layer of the Upper Marl-Bed, which belongs to the Eocene portion of the Tertiary. Of the three modes of determining Geological Age, viz., by superposition, mineral composition, and organic remains, the latter is principally relied on in the present case.

The name "Cretaceous" was given to this formation in England, on account of the white chalk which is there a conspicuous member of it. The name is retained among geologists even when the chalk is wanting, as is the case in this country. The mineral substance greensand, is found in rocks of many different ages, but nowhere else so abundantly as in the Cretaceous rocks of Europe, and of the United States. This common characteristic is not without weight in determining the age of the formation.

The organic remains of the formation are very abundant and furnish satisfactory evidence upon the question of Geological Age. The bones of enormous crocodiles and other saurians are found in immense numbers in the clay-marls, and in the beds of greensand; they are usually found scattered, a single one in a place, but sometimes almost a whole skeleton is found together. They have been collected in many places. The Academy of Natural Sciences, at Philadelphia, has probably the best collection of them. There are a good many in the museum of the Geological Survey, at Trenton, and in the cabinet of Rutgers College, and public and private collections in all parts of the country contain specimens. These saurians have not been found in any age in such numbers since the Cretaceous.

Fossil shells are more abundant and better preserved than any other animal remains. Being so much less perishable than others, the entire series of them, in all geological periods, is more complete; and from them inferences regarding the condition of the earth at that time can be drawn with more safety than from any other kinds of organic remains. The fossils of this formation have been extensively collected as objects of scientific interest, and the greater portion of them have been described in the transactions or journals of

*Messrs. Meek & Hayden, who have explored and studied the Cretaceous Formation in the region of the Upper Missouri, having visited localities in New Jersey, and inspected the results of the late Geological Survey, pronounce our greensand marls to belong to the Later Cretaceous. [See Proc. Acad. Nat. Sci., 1857, p. 127; 1861, p. 426.]

learned societies. T. A. Conrad, Esq., of Philadelphia, prepared a "Synopsis of the Invertebrate Fossils of the Cretaceous Formation of New Jersey," which will be found in Appendix C of the Geology of New Jersey. The remains of fishes, especially the teeth, are very common, but there are no satisfactory descriptions of them. The reptilian remains have lately been made the subject of a Monograph, by Prof. Joseph Leidy, of the University of Pennsylvania. It is published in one of the volumes of the Smithsonian Contributions to Knowledge. A complete description of all the invertebrate fossils is now being published by the Geological Survey, in 1886–8.

CLAY MARLS.

That part of the Cretaceous Formation which is designated by the above name, lies immediately upon the *Plastic Clays* (see Figure No. 2), and its outcrop is seen in the belt of country adjoining those clays on the southeast. They have Raritan and Sandy Hook bays on the northeast; on the northwest they follow a southwest line almost straight from Chesquake to Bordentown, and thence onward in a nearly direct line to the bend of the Delaware, below Pennsgrove. On the southwest they border on the Delaware river, and on the southeast they join the Lower Marl-Bed, which is fully described farther on.

Their outcrop is characterized by two very distinct varieties of soil, which originate from the strata underneath them. Along the northwestern side, and for nearly half the breadth of the formation, the soil is generally heavy, but retentive and susceptible of a high degree of improvement. The remaining part, being the southeastern portion, is a sandy loam. This soil is admirably adapted to the growth of early crops and market-garden products. Some of the most productive parts of Monmouth, Burlington, Camden, Gloucester and Salem counties are upon this formation.

DESCRIPTION.—In the banks of streams or ravines, on steep side-hills, or in cuttings of roads and railroads, where this formation has been long exposed to the weather, it is everywhere characterized by reddish crusts of oxide of iron. Deeper beneath the surface, or where it is always moist, it is composed of beds of dark-colored clay and sand, with more or less of lignite and iron pyrites, but also containing small quantities of greensand irregularly scattered through the clay. The grains of greensand are smaller than grains of gunpowder, the

most of them passing through a sieve with meshes 1-150 of an inch in diameter. These grains may vary from black to olive-green upon their surface, but when crushed upon the nail they always show a light-green color. And the same color is always strongly developed in digging, the grains being crushed with the spade.

The formation is well displayed in the cuts on the New York and Long Branch railroad north of Matavan creek, along the bank at Matavan Point, where there is an exposure of the dark clays and lignite for nearly a mile along the bay-shore. Following the bay-shore below Keyport and Union City, beds of clay marl are indistinctly exposed. Farther on, at the base of the Highlands, the clay containing greensand is entirely wanting, and in rising on the slope up to the Lower Marl-Bed, the material passed over is sand, thinly laminated by films of clay. Computing from the breadth of country passed over and the dip of the strata, the formation is two hundred and seventy-seven feet thick, of which the clay and greensand strata make up one hundred and seven feet, and the laminated sands the remaining one hundred and seventy feet. At the shaft sunk in searching for coal east of Jacksonville, the dark clay containing grains of greensand was passed through for fifteen or twenty feet before reaching the white sand of the lower formation. It is also exposed in a ravine on the farm of Enoch Hardy, near the same place. Here and at a number of other places in the vicinity it has been dug for marl. At Ten Eyck Brothers', near Matavan bridge, on turnpike to Old Bridge, a section is exposed in the side of the road descending to the bridge. From the house downwards for thirty feet the material is clayey, but the strata not plainly exposed; then there is a bed of greensand and clay intermixed, five feet thick; next five feet of chocolate-colored clay; below which there is seventeen feet of a black micaceous clay, which descends to the creek.

On the straight road from Hightstown to Cranbury, near the Millstone river, it crops out in the road. At Bordentown, near the railroad shops, the dark clay containing greensand is well exposed, and is seen resting on the white sand of the lower formation. It is seen very finely also at the Kinkora brick-yard, three miles below. At Shelltown, on Crosswicks creek, the clay and greensand are seen in the south bank by the roadside, while immediately south of this, and along the road up the slope of Red Hill to the Lower Marl-Bed, only the laminated sands are to be found. Farther to the southwest,

the surface of the country is such that the meeting of the strata of different kinds is not exposed, but there are openings in many places where one or the other of these characteristic strata is exposed. No interest has been attached to the laminated sands, except as the basis of a warm soil suitable for early crops; but there have been many experiments made with the clay and greensand layers, to test their usefulness as fertilizers.

LOCALITIES.—The clay marls have been dug as fertilizers by Enoch Hardy, of Jacksonville; Ten Eyck Brothers, of Matawan; at Texas, east of Jamesburg; Daniel Prest, of Strong's Mills; Charles Craig, in Manalapan; J. J. Ely, 2 miles west of Perrineville; Henry Taylor, west of Imlaystown; at Waln's Mill; by Miller Howard, at Shelltown; by J. D. Conover, 1½ miles southwest of Newtown, Mercer county; at Jacksonville, Burlington county; Charleston, Centreton and Irish Wharf, on the Rancocas; by John E. Hopkins, of Haddonfield; C. Grover and Wesley Budd, near Mount Ephraim, Camden county; and Benjamin C. Tatem, below Woodbury, Gloucester county.

The laminated sands can be best seen along the base of the Navesink hills, on the bay side. They can also be seen on the northwest and lower slopes of the Mount Pleasant hills, on the Freehold and Jamesburg railroad from Englishtown to the battle-ground, and on the west slope of Red Hill between Monmouth and Burlington counties.

FOSSILS.—Shells and casts of mollusks are found in this formation, though from the much fewer excavations in it, they are not so commonly seen in collections as those from the marl-beds. The Ammonites Delawarensis, Baculites ovatus, Scaphites ———, Gryphea vesicularis, and some others have certainly been found in it.

MARL-BEDS.—The series of strata comprised under this name include those beds of greensand which have obtained so high a reputation, under the name of *marl*. The district in which they have their outcrop is widely known as the Marl Region, and occupies a strip of country from six to fifteen miles wide, and stretching from the ocean below Sandy Hook to Salem, on the Delaware. The soil over this district is more or less sandy, remarkably free from stones and boulders, and in most parts in a high state of cultivation and very productive. When exposed in natural or artificial sections

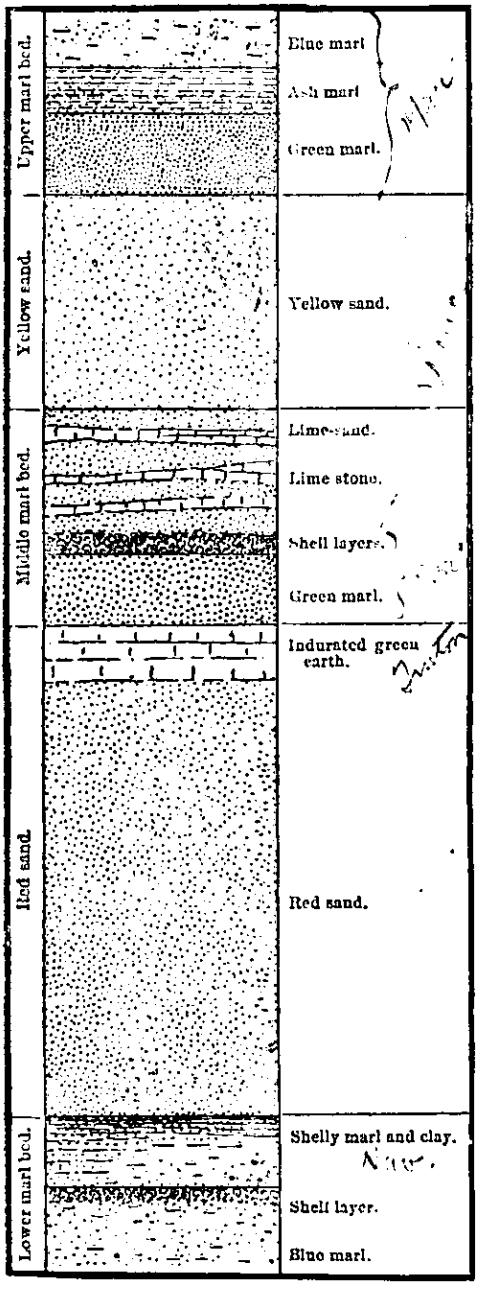


Fig. 3.

several well-marked beds and layers can be characterized, as detailed in the accompanying columnar section, Fig. 3.

These several beds having a strike of S. 55° W. and a dip to the southeast of thirty to forty feet per mile, have their outcroppings in the order of their occurrence, that which is lowest appearing farther to the northwest, and that which is higher in the series farther to the southeast.

Those parts of the bed which are thirty feet above tide appear a mile northwest of the same bed at tide-level. Those which are sixty feet above, two miles northwest of those at tide-level, and so on. The same principle holds true of the Middle and Upper Marl-Beds; their exposure on the surface is in a very irregular line; it is, however, easily explained, being caused by an inequality of heights of the surface in different places, while the dip and strike of the beds are uniform. Wherever the country slopes towards the southeast the outcrop is broad;

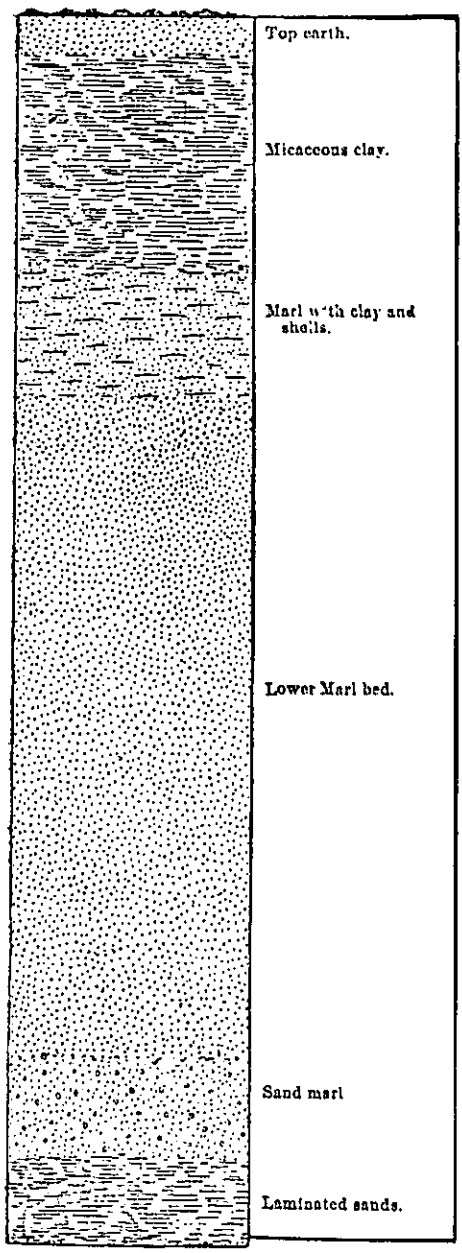


Fig. 4.

when towards the northwest it is narrow.

DETAILED DESCRIPTION OF THE OPENINGS IN THE LOWER MARL-BEDS.

The subdivisions of the Lower Marl-Bed are plainly marked in all the eastern part of the State. The columnar section, Fig. 4, on this page, shows these subdivisions fairly. It was made from a measured section at the Highlands, on Sand Hook bay.

SAND MARL.—A layer of open sand with scattering rounded grains or small pebbles of quartz, and a small percentage of greensand. It contains numerous fossil shells, and some phosphate of lime. It is a very distinct layer, and the lines of division between it and the laminated sands below and the blue marl above it are clearly marked. It is from two to four feet thick.

BLUE MARL.—This constitutes the chief part of the bed. It consists of greensand mixed with a grayish and very fine earth, which makes from 10 to 30

per cent. of the whole. Much of this earth is carbonate of lime. It effervesces strongly with acids. In places where it is worked for marl, and horses or mules are obliged to stand in its mud, it is said to take off the hair from the animals' legs; and I am assured by those who have seen it, that surfaces smeared with the muddy and fresh-dug marl give off a pale phosphorescent light. In places where the bed has been exposed to the action of decomposing iron pyrites, the carbonate of lime has been entirely removed, and much of the marl has become black in color and very astringent.

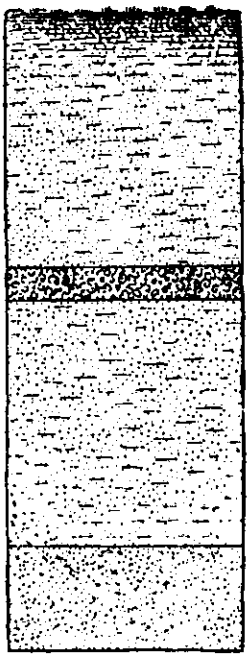


Fig. 5.

This layer is about sixteen feet thick. Very near the middle of it is a shell-bed of from six to twelve inches thick, which is composed almost entirely of valves of *Gryphea vesicularis*. The substance of the shell is still thick and firm, and the shells closely packed in the mass. This layer is a very characteristic feature in the marl-pits about Marlboro in Monmouth county, and it is also plainly seen in some of the pits near Red Bank in the same county, ten miles east of the former place. It has also been recognized in the western part of the State. Fig. 5, on this page, shows the bed with the shell-layer in it, as seen at Uriah Smock's marl-pit at Marlboro, Monmouth county.

MARL AND CLAY LAYER.—The blue marl at its upper part passes gradually into a layer of a darker color, containing many scales of mica and some dark-colored sandy clay. It also has some shells, particularly the *Ostrea larva*, in thin, flaky scales. This layer is ten or eleven feet thick, and at its upper part contains scarcely any greensand grains. It is frequently found very astringent, or acid, from the presence of sulphate of iron (copperas) in it. The change in this layer is very gradual from the bottom to the top; the lowest being a pretty good fertilizer, while the upper is scarcely more than a black sandy and micaceous clay.

LOCALITIES.—The following series of marl exposures in the Lower Bed is presented to verify the general statements made above, in regard to structure, and to exhibit the line or belt of country in which the outcrop of the marl occurs. There are a great number of others which are opened, and it is possible to increase the number until they actually join each other, and the whole distance from Sandy Hook bay to the Delaware river, near Salem, becomes one great marl-pit.

At the Highlands, on the shore of Sandy Hook bay, the following section was measured—reddish-yellow, or ferruginous sand of great thickness, lying over the marl.

9 feet of black, micaceous and astringent clay.
5 feet of black clay as above, with some thin and flaky shells.
25 feet of marl, greensand; the upper part, for three or four feet, mixed with the clay over it, the rest almost free from clay, and consisting of marl grains, fine carbonate of lime, shells, and a little sand.
3 feet sand and small gravel, with marl grains and shells.

42 feet total thickness.

At the old North American Phalanx pits, on Hop Brook, in Atlantic township, Monmouth county, the black clay is seen overlying the marl, but not in its full thickness. The following series of specimens, obtained at the different depths mentioned, were presented by Mr. Charles Sears:

At 6 feet the sample is an average, and is a micaceous clay, dark-colored, and containing some thin and tender shells, and a few marl grains.
9 feet specimen similar to the preceding, but with more marl.
12 feet clay, with large percentage of marl grains.
15 feet marl without clay, but with some fine carbonate of lime, bluish-gray color.
18 feet same as at 15 feet, but of a little darker color.
21 feet same as last specimen.
24 feet lighter-colored marl than the preceding, and containing a large percentage of fine carbonate of lime.
28 feet same as the last specimen.
30 feet similar to the last, but a shade darker.

32 feet more of a bottle-green color, and the marl grains finer.
34 feet same as preceding.
36 feet same.
38 feet same.

From 21 feet down the specimens were obtained by boring; the boring terminated in marl.

At the pits at Hartshorn's Mill, a mile and a quarter north of Freehold, the following measurements were obtained:

Near these pits the overlying black clay was found to be 11 feet. At the pits, commencing at the surface—

3 feet dark micaceous clay, containing shells.
4 feet clay, with shells and numerous marl grains.
6 feet marl, gray, and containing shells and fine carbonate of lime.
15½ feet marl, like the last, though varying slightly in color, some parts being darker and others lighter.

The last distance was bored, and ended in sand, for which, if we add 3 feet, we have a total of 42½ feet.

In Monmouth county, on McCleas creek, Peter J. McCleas digs 20 feet of marl.

Opposite Red Bank, and on the north shore of the Navesink river, Wm. V. Conover digs 3 or 4 feet of grayish and rusty marl, under which he has dug 21 feet in greensand.

In Nut Swamp, Mr. Wm. Smith says that he digs 20 feet in marl; the upper a dry and gray marl, and the lower part is black and astringent.

At Middletown a fine exposure of the unchanged blue marl is to be seen in the pits of Azariah Conover. He has dug 25 feet in it without finding the bottom.

Along the north slope of the Mt. Pleasant Hills pits are opened from above Middletown to near Marlboro. The marl is mostly somewhat changed by atmospheric agencies, and by leaching.

At Mt. Pleasant, J. S. Whitlock has marl pits at which a fine section is exposed. Over the marl 14 feet dark micaceous clay, then 4 or 5 feet dark clay and some greensand, 9 feet black marl, 2 feet shells, 7 feet marl to sand-marl.

Near Holmdel, on the farm of the late Peter R. Smock, the blue

marl is very finely exposed, and the layer is dug into for 15 or 16 feet, and the best of marl obtained.

On the slope along the north side of Hop Brook, Rev. G. C. Schank has marl exposed, in a section of which 10 feet at the top is a gray marl, then 14 inches of a solid mass of shells; then 9 feet 9 inches of blue marl, under which is 4 feet of sand marl.

At Marlboro, Monmouth county, Uriah Smock has marl-pits in which he digs 2 feet top-dirt, 2 feet reddish-gray marl, 7 feet blue marl, 2 feet layer of solid shells, 10 feet blue marl, and 3 feet sand marl.

On road from Freehold to Englishtown, near the old Monmouth battle-ground, Dr. J. Conover Thompson has pits in which he digs 3 feet of reddish-gray marl, then 7 feet black marl, and 4–5 feet blue marl.

On the Manalapan creek, at Black's mills, J. R. Perrine opens the marl layer about 20 feet in thickness.

At Manalapan village several persons dig into the marl 3 to 6 feet, and then into the sand marl and underlying sand from 4 to 8 feet.

At Perrineville, Wm. H. Mount's pits showed the following measured section: 2 feet top-dirt, 2 feet sand and reddish-gray marl, 5 feet black marl, 4 feet sand marl.

Near Imlaystown, Michael Taylor, in digging his well, penetrated the marl.

Nimrod Woodward's pits at Cream Ridge, expose about 12 feet of blue marl, and the sand marl underneath.

At Arneystown, on the Province line road, and on bank of small stream, the blue marl is dug by G. Lawrie and T. Wiles.

From this part of the bed towards the southwest, the marl is not so highly prized as a fertilizer, the openings into it are much fewer, and consequently the observations and measurements in relation to it much less complete or satisfactory.

On the stream, three-quarters of a mile northwest of Jacobstown, Burlington county, the marl is dug by Michael Rogers and others; it is said to have been penetrated 27 feet.

This marl bed is opened at Georgetown.

On the Rancocas, a half mile below Mt. Holly, Daniel G. Lippincott digs marl from 7 to 20 feet.

At Hainesport, the marl is opened by Barclay Haines; 7 feet sand, greensand and light-drab clay; 7 feet black micaceous marl; then light-colored sand.

A mile and a half south of Moorestown, John T. Davis finds 2 to 3 feet very pure greensand, 5 to 6 feet of sandy gray marl.

On the Pensauken creek, in Camden county, on the Moorestown and White Horse road, David Davis and Joseph Githens find marl 10 feet deep, the lower 3 feet, being full of large and solid shells.

Bridge Kay finds marl on south branch of Cooper's creek, 2 miles from Haddonfield; layer is penetrated 10 to 15 feet.

On the Camden and Atlantic railroad, a mile and a half southeast of Haddonfield, J. Gill's marl-pits are located.

At Clement's Bridge, on the Almonesson creek, Gloucester county, the marl has been dug.

The marl has also been dug at Carpenter's Landing.

On Repaupa creek marl-pits have been sunk.

On Raccoon creek, above Swedesboro, the marl has been opened by several persons.

Dr. Charles Garretson's pits, 10 feet in marl.

The marl at Batten's mill has been dug into 16 feet by Zebulon Batten.

John W. Davidson has dug the marl on Church Run 9 feet above level of pond and 16 feet below; marl sandy and of uniform quality.

The bed is opened on Indian Run and other small streams, between Swedesboro and Sculltown.

At Auburn, Salem county, N. Lippincott's marl is exposed for 20 feet above tide-water, and 10 feet below tide.

On the Salem and Auburn road, and on banks of Two-penny Run the marl is dug by Samuel Borden and others.

On lands formerly of Joseph Basset and Wm. Slape, near Marshallville, the marl is dug. It is covered by about 5 feet top-dirt, then 12 feet marl, and then sand.

RED SAND BED.

Red Sand.—This name is applied to the bed of sand, with its subordinate members, which lies immediately over the Lower Marl Bed. In the Geological Report of 1854 it was named the Ferruginous Sand Bed, but as that name has formerly been applied to all the sands of the Cretaceous Formation, this more specific and characteristic name has been substituted. It is from one hundred to one hundred and ten feet thick. The mass of the bed is composed of a very ferruginous and red sand. At some former time this sand must have

been almost white, for in many places nodules or tubes of stones are found, which on the outside have the usual red color, but on breaking them open they are found filled with white sand. Indeed, all the circumstances indicate that at some time since its deposition water, containing some salt of iron in solution, has filtered through it everywhere and discolored it, except in those places where the iron solution has absolutely cemented the sand into stone, and so formed a protecting coat for those parts which had not before been penetrated.

The lower part of this bed, from ten to twenty feet thick, is a dark-colored, sandy and astringent clay. The coloring matter of this portion of the bed is protoxide of iron, and it only needs to be changed to a peroxide to become as strong a red in color as the rest of the bed, and, in fact, such a change has taken place in many localities, so that this part of the bed cannot be distinctly traced.

The upper portion of this bed, which lies immediately under the Middle Marl-Bed, is composed of a greenish indurated earth, in many places firm enough to be considered as rock. In some places in the southwestern part of this formation it is not indurated, and, being green in color and containing some phosphoric acid, farmers have used it as a fertilizer with profit. Where exposed, it varies in thickness from ten to twenty-five feet. It is separated by a well-defined line from the Middle Marl-Bed, but below it passes insensibly into the Red Sand layer. (Fig. 6.)

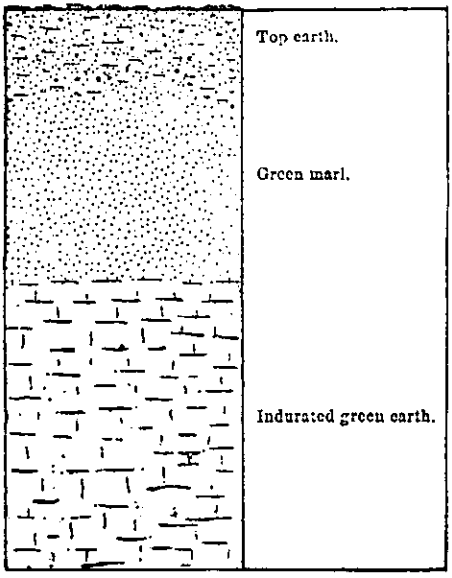


Fig. 6.

LOCALITIES.—Navesink Highlands, on shore of Sandy Hook bay, Monmouth county; hills near Red Bank; deep cut on the New York and Long Branch railroad, and on the New Jersey Southern railroad; deep cut on Holmdel and Keyport turnpike; Beacon and other of the Mt. Pleasant Hills; Sugar Loaf Hill; Freehold;

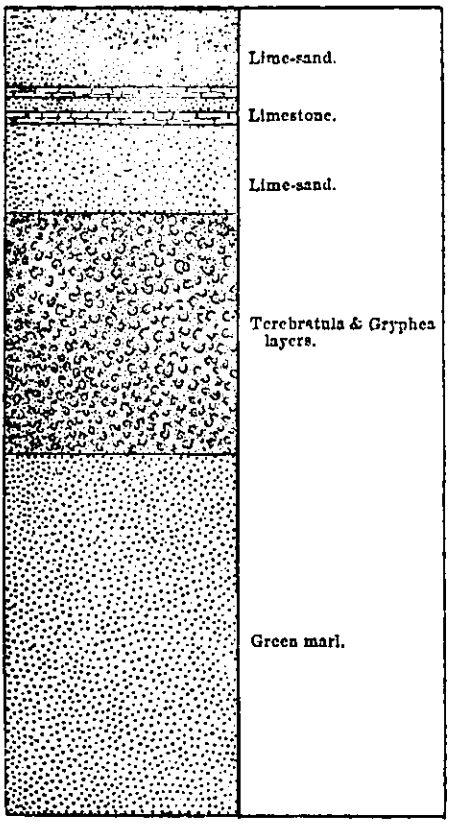


Fig. 7.

Timmons Hill; Cream Ridge; Red Hill, between Shelltown and Arneystown; Arneys Mount and the mount at Mount Holly, Burlington county; banks of Big Timber creek, near Chew's Landing, Camden county; banks of Mantua creek, above Carpenter's Landing, Gloucester county; Richards Hill; Mullica Hill; banks of Oldman's creek, above Auburn; and the banks of Salem creek, below Sharptown, Salem county.

The black micaceous sandy clay which constitutes the lower part of this bed has been sufficiently referred to in the localities of the Lower Marl-Bed.

The Red Sand Layer, which is the principal member of the Red Sand Bed, is to be found in all the localities given in the preceding list.

The Indurated Green Earth was dug for a fertilizer by J. P. Lafetra, near Shrewsbury, Monmouth county; it forms the ledge over which the water flows at Tinton Falls; the rocky masses at the deep cut on the Holmdel and Keyport turnpike are of this layer; it is the green clay south of West Freehold, at Clarksburg, on the Province Line road below Arneystown, near Jacobstown, Burlington county; what is called "green land" in Camden, Gloucester and Salem counties, is the outcrop of this layer. Mr. Benjamin Lodge, near Carpenter's Landing, digs this indurated earth as a marl. The solid masses of large shells imbedded in green material, seen at the roadside on Richards Hill and in the bank at Mullica Hill, are also of this layer. It is softer in substance, and is dug as a fertilizer by Mr. Robinson, on Major's Run above Sharptown.

Fig. 6, on page 173, shows this green earth as it is dug by some of the farmers along the brook above Tinton Falls, in Monmouth county. The green marl overlying it is the bottom of the Middle Marl-Bed.

DETAILED DESCRIPTIONS OF OPENINGS IN THE MIDDLE MARL-BED.

The bed of greensand to which this name is applied, is composed of three distinct layers. Its section is well shown in Fig. 7, p. 174.

GREEN MARL LAYER is an almost pure greensand, containing but few white shells, though casts of shells, fossil-bones, etc., are not uncommon. Where it has not been worn away by denudation, it is fully fifteen feet thick. At bottom it terminates in the most part of Monmouth county upon the indurated green earth of the Red Sand Bed. Farther towards the southwest it terminates in a chocolate-colored earth or clay, into which it gradually passes. At the upper part it terminates in a layer of white shells, mixed with greensand, which constitutes the

SHELL LAYER. In a few places these shells have been dissolved out by the action of sulphate of iron, or other agency, and only the impure greensand is left, when the line between this and the preceding layer is difficult to determine. When unchanged this layer is white with shells, principally those of the *Gryphea vesicularis* and *Terebratula Harlani*, which are so thickly imbedded in the greensand as to make half the substance of the mass. It varies from four to seven feet thick with an average of five feet. The lower two-thirds consist of the *Gryphea*, with scarcely any other shells intermixed. The upper third is almost entirely composed of shells of the *Terebratula*. This remarkable and plainly distinguished layer is found developed for the whole hundred miles in which this bed is exposed in New Jersey.

The YELLOW LIMESTONE, or LIMESAND LAYER, is the upper layer of the Middle Bed. It is a mass of crumbled corals, sea-eggs, and other calcareous matters, with a small percentage of quartzose sand, and scattering grains of greensand. In Monmouth county it is always soft and crumbling, but in Burlington, Camden, Gloucester and Salem counties the lower part is in layers of a stony hardness, with layers of the softer materials interposed. This was called the

Yellow Limestone by Prof. Rogers, and is much more fully developed in the States farther to the southwest. In Salem county it has a thickness of 25 feet, but has not been seen quite so thick in any other place.

LOCALITIES.—In Monmouth county, on the beach at Long Branch, masses of the cemented corals and other calcareous matter, also masses of cemented greensand, are almost always to be found. At the Turtle mill, between Eatontown and Long Branch, the limesand and part of the shell-layer are dug into eight or ten feet. Peter Casler, of Townneck, has a pit in the green marl which he has dug into for eighteen feet. The limesand is dug on Mr. Wolcott's land, on the road from Eatontown to Shark River; near Eatontown Geo. A. Corlies digs ten feet, and has bored seven feet deeper—shell-layers about two feet thick and four feet below the surface, then eleven feet of green marl, without finding bottom; at Tinton Falls, Pierson Hendrickson digs ten feet into the marl; Robert W. Cooke digs from four to six feet deep of the bottom of the green marl. About half a mile south of Colt's Neck the marl is dug by several individuals; John Van Mater digs twelve feet in it; at Pyle's Corner the green marl layer is dug into thirteen feet. About a mile southwest of Blue Ball several pits are open; J. Shepherd digs ten feet in green marl; H. Brinckerhoff digs about five feet in shell-layer, and thirteen or fourteen feet in the green earth; John and Thomas Strickland have pits in which a part of the limesand, the shell-layer and the top of the green marl are exposed. The bed is opened at Smithville and at Burnt Tavern.

Near Prospertown, on the Lahaway creek, Ocean county, the following section was measured in the pit of Van Hise: two feet top-dirt, four feet reddish marl, one inch iron-stone, one to three feet black marl, ten to twelve feet hard green marl; at Hornerstown, John Goldy's pits have three feet top-dirt, one foot reddish marl, and eleven feet green marl, chocolate marl at bottom. At the bank on Samuel Horner's estate, at New Egypt, there are exposed two feet top-dirt, nine or ten feet of limesand, seven feet of shell-layers, and fourteen feet of green marl. The limesand is opened at Cookstown; at Messrs. Black's, in Springfield, the marl is dug fourteen or fifteen feet deep; at Juliustown the bed is opened in several places; the marl pits of the Pemberton Marl Company are situated at Pemberton; they dig three or four feet top-dirt, three feet gray marl, eleven feet black marl, eight feet green marl. chocolate marl to bottom. Along the

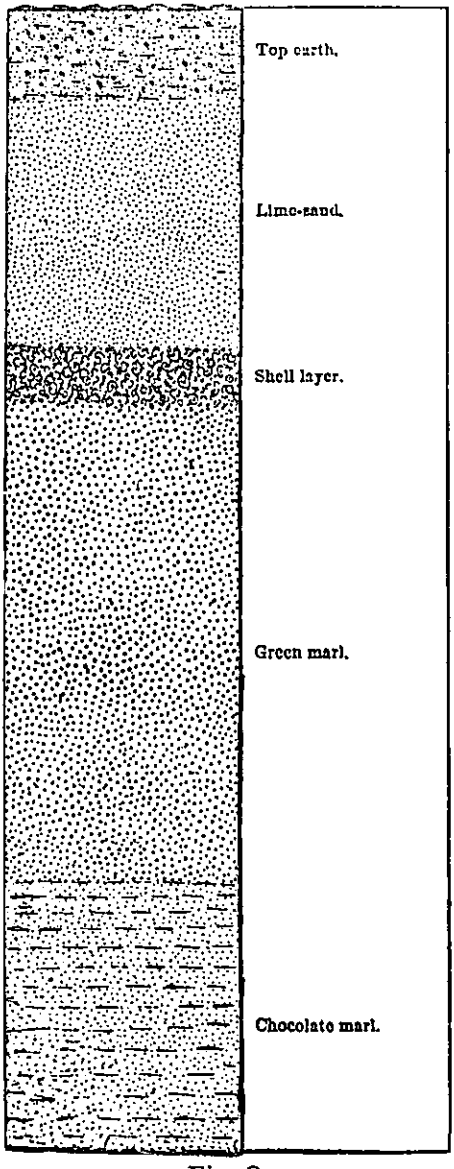


Fig. 8.

south branch of the Rancocas the whole bed is exposed in the successive openings between Vincentown and Eayrstown, the limesand and yellow limestone in the pits farthest up stream, the shell layers in the next pits below, and the green marl in the pits farthest down the stream; the same order of layers is also seen along Haines' creek. West of Medford, along Sharp's run, there is also a very fine exposure of the marl, from fifteen to sixteen feet of the green layer having been dug into; at Marlton, the pits of Samuel Brick, in which the green layer for thirteen feet and down to the chocolate marl is exposed, give a good example of the openings in that vicinity. Passing the openings on every stream between Marlton and White Horse, in Camden county, at the latter place, in the pits of Minor Rodgers, six to thirteen feet of green marl are passed through, and the chocolate marl reached. On the north branch of Big Timber creek the marl is dug at Brownsville, and at Laurel Mill Ephraim Tomlinson has in his bank full thirty feet of the bed—the limesand and yellow limestone above, then the shell-

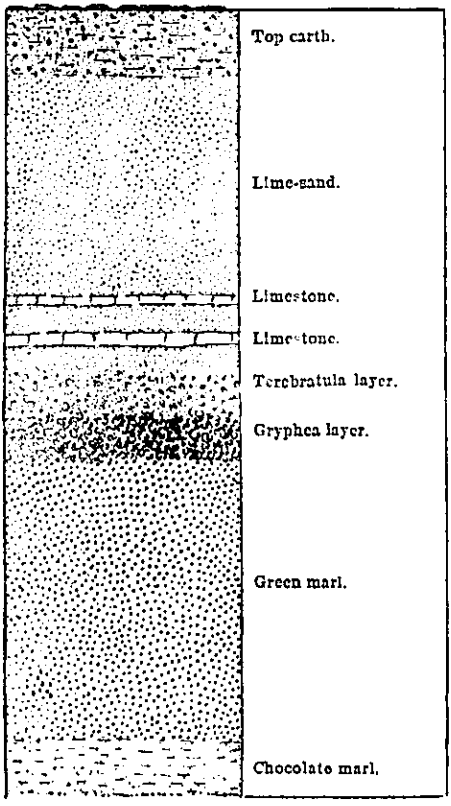


Fig. 9.

layers and the green marl. At Blackwoodtown the whole bed can be seen, by going along up the stream from Good Intent towards the southeast; David E. Marshall's pits, shown in Fig. 7 (page 174), are good examples of the bed, having on top six to twelve feet red or gray marl, seven feet pale-green marl, and from eighteen to twenty feet of green marl, and then chocolate marl. On Mantua creek there is an unusually fine exposure of the whole bed; in the long line of pits of the Messrs. Heritage (Fig. 9), at Hurffville, they show this section:

	Feet.
Top-dirt	2–6
Limesand	9
Yellow limestone	3
Terebratula layer	2
Gryphea layer	2
Green marl	13
Chocolate marl	...

Southeast of Barnsboro, in Gloucester county, on the south branch of the Mantua creek, are important marl-pits, one of which is worked by the West Jersey Marl Company, in a layer containing twelve feet of green marl. Along both branches of Raccoon creek the marl is also well exposed in the several layers.

N. T. Stratton's pits here show the following sections:

	Feet.
Gray calcareous marl	3
Gray limestone	½
Gray calcareous marl	¾
Gray limestone	½
Gray calcareous marl and greensand	3
Shell-layers	4
Pale-green marl	6
Best green marl	12–16
Chocolate marl	...

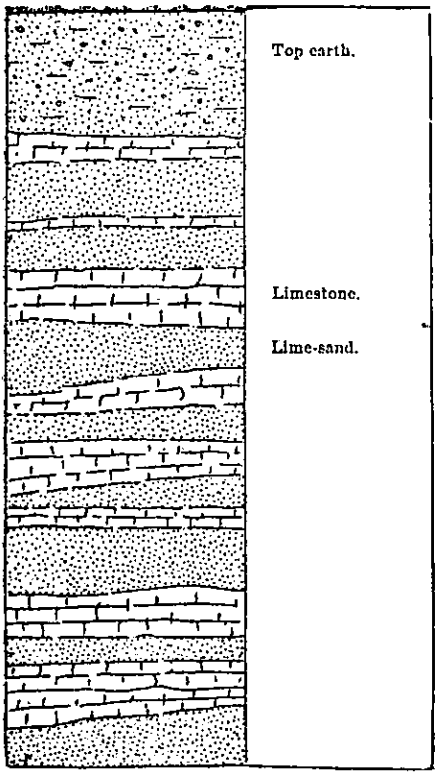


Fig. 10.

At Harrisonville, on Old-man's creek, there are good sections of the layer shown and worked; in Salem county, on branch of Old-man's creek, near road from Woodstown to Mullica Hill, the layers of limesand, yellow limestone, shell-layers, and the green marl, are all finely shown in a thickness of 28 feet; along Salem creek, at Woodstown, the marl has been worked very extensively; on Nikomus Run, the whole bed is exposed and worked by many persons. The following section is shown: 9 feet limesand and yellow limestone, 4–6 feet shells, 15 feet green marl, chocolate marl; along Major's Run there is a similar section exposed, and the chocolate marl was found to be 8 feet thick in Samuel Prior's pits; Messrs. Pettit and several others dig marl along Mannington creek and its branches; a section in Pettit's marl measured in greensand 18 feet, in shell-layers 4 feet, and in limesand 20 feet; William Barber's yellow limestone quarry exhibits the finest exposure of this

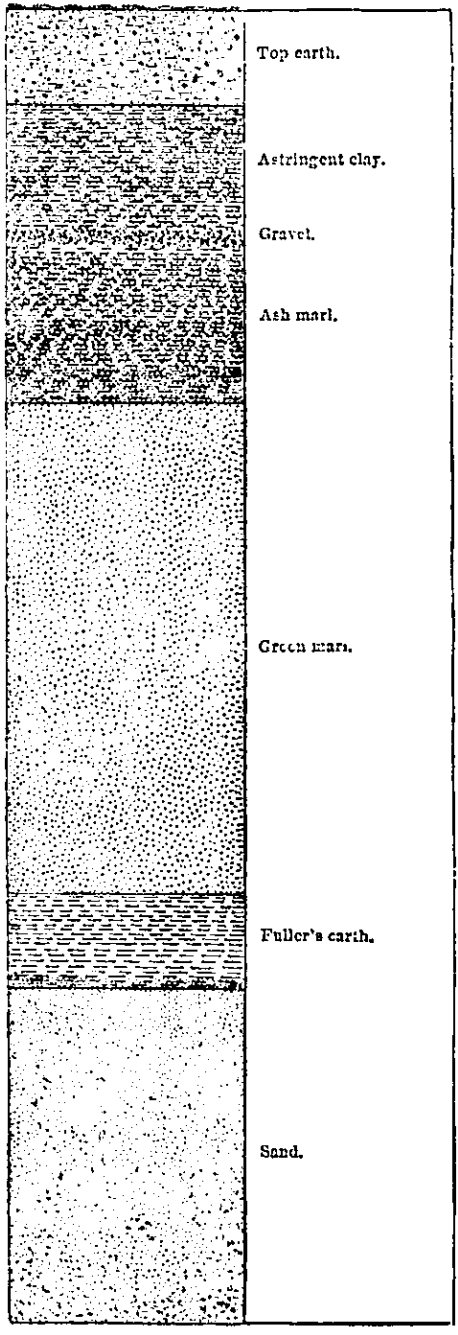


Fig. 11.

layer in the State; he has dug 25 feet in it without finding bottom; it is made up of alternating tabular masses of limestone and limesand (Fig. 10), the stone from 4 to 12 inches thick, and the limesand from 8 inches to 2 feet; beyond these, marl has been found in various places quite to Salem, but as yet in limited quantity.

YELLOW SAND BED.

The limesand layer of the Middle Marl-Bed, at its upper part, becomes more and more mixed with quartzose sand, and finally changes into the Yellow Sand Bed. This contains, in many places, a very slight sprinkling of green-sand granules; and in a few places in Eastern Monmouth it has been observed to have just enough of a greenish clay to make it pack well and form an excellent material for road-making. Generally, however, only the sand is to be found, and as fossils have not been found in it, there is no means of identifying it except by its relation to the Middle

Marl-Bed. In the eastern part of Monmouth county this bed is between 40 and 50 feet thick; but in Camden county, which is its southwestern extremity, as far as determined, it is only from 10 to 20 feet thick.

LOCALITIES.—Along the beach, between Long Branch and Deal, in Monmouth county, sand, with a small percentage of greensand granules, is found; near Oceanville, William P. West has dug 2 feet greenish clay and 25 feet sand of pale-green color, under which is sand just like that of the sea-beach; Rulief P. Smith digs it as a fertilizer; the very sandy green clay near Maps' Mill, on Whale Pond creek, is of this layer; the same quality of clay is found at the brick-yard south of Tinton Falls, on land of William Marshall; beneath the marl-layer of the upper bed at Shark river, sand, with a little greensand intermixed, is found; at the pits of the Squankum Marl Company, after digging through the marl and fuller's earth, dug 6 feet and bored 16 feet, all in sand, containing green and dark-brown grains. Fig. 11 shows this section at the Sqankum Marl Company's pits. In the central portion of the State the superficial deposits of a recent date, together with the unsettled country, render it difficult to trace this layer accurately.

Near the Ocean county line, at the end of the bridge on road south of New Egypt, and 1 mile from that place, the yellow sand is found; near Pemberton, Burlington county, this sand is also to be found, and is dug into for marl; at Medford, in the marl-pits along the brook the Upper Marl-Bed is dug through, and after passing the fuller's earth, a layer of sand with grains of marl is found.

DETAILED DESCRIPTION OF THE UPPER MARL-BED.

This bed of greensand is about 37 feet thick and is composed of 3 very distinct layers.

THE GREEN MARL.—The Squankum marl of Monmouth county is a good sample of this layer; it is 17 feet thick, and is almost all pure greensand, containing but few fossils and only a small percentage of clay. At the bottom it terminates in a kind of white earth called white marl or fuller's earth. It is overlaid by the ash-colored marl.

THE ASH MARL is not a greensand; it is composed of very fine sand mixed with a greenish-white clay, stratified and flaky in structure; it is very uniform in composition; scarcely any fossils are known in it. The heaps of this marl look much like heaps of ashes, hence its name.

THE BLUE MARL.—This layer lies directly on the ash marl, without any well-marked line of division, and it is terminated above by surface sand and loam, or by what is called *rotten-stone;* it is 11 feet thick; it is a mixture of greensand and light-colored earth; the upper 2 or 3 feet are quite hard and stony, so much so that it sometimes takes 2 or 3 years' exposure to bring them to a proper degree of fineness for agricultural purposes. It lies unconformably on the layers beneath, its fossils are quite distinct and are pronounced by paleontologists to be of the Eocene division of the Tertiary Age.

LOCALITIES.—In Monmouth county, at Deal, between the seashore road and the ocean, there is a series of marl-pits in which all these layers are exposed; beginning at the north and going south, Rulief Smith's pits are in the green marl, G. Hendrickson's in the ash marl, and Abner Allen's in the blue marl, 8 feet. Along Poplar Brook the green marl is extensively worked; J. Gardner dug into it 16 feet, and it is of nearly equal thickness in the pits of J. Howland and others. The blue marl is found 8 feet thick south of Poplar, about the head of Long Pond; and west on lands of S. Kirby and others. The ash layer is 10 feet thick. Along Shark river the bed is cut by the stream and the several layers exposed. Hugh Hurley digs 18 feet in the green layer; George W. Shafto has dug 10 feet in the ash layer; J. T. L.

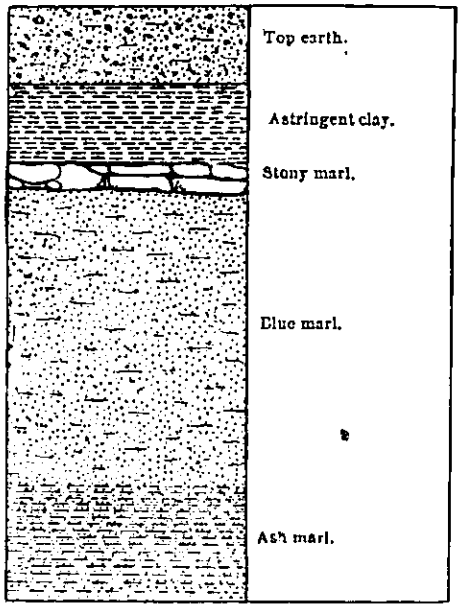


Fig. 12.

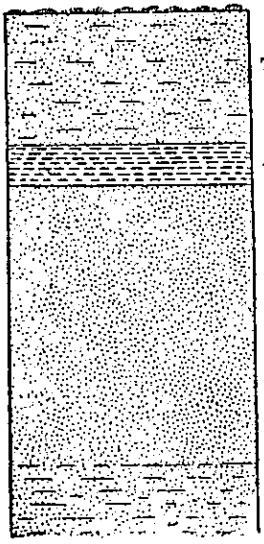


Fig. 13.

Tilton has 9 feet of the blue marl. Fig. 12 is a section of Tilton's marl-pits. It shows the stony layer which lies at the top of the blue marl, and separates it from the miocene or astringent clay which lies on it. Along the Mingumhone, at Farmingdale, the whole green layer, to a depth of from 12 to 15 feet, is opened in the pits of the Squankum and Freehold Marl Company; farther down the stream the ash marl is opened and dug through to reach the green layer below. On the Manasquan river are located the diggings from which most of the noted Squankum marl has been taken; on the north side, J. B. Williams, E. K. Johnson, W. Johnson, Benjamin Reed are on the green marl; Mrs. Allaire on the ash marl; on the south side, Messrs. Johnson, T. Longstreet, D. Longstreet, C. Matthews, T. Windsor, dig in the green marl, and J. S. Forman and Mrs. J. P. Allaire in the blue and ash marls; the whole green marl is from 13 to 15 feet, the ash marl 8 to 12 feet, the blue marl 12 feet. On Timber Swamp, at the Old Manasse Mill, are located the diggings of the Squankum Marl Company, where the section is from 4 to 10 feet top-dirt, from 4 to 6 feet ash marl, 15 feet of green marl. From the Manasquan river to New Egypt, in Ocean county, this bed of marl has not been opened. The country is mostly uncleared and the ground elevated, so that the bed is not so easily reached as in other sections.

The outcrop of this bed is about 2 miles southeast of New Egypt; only the green marl is found. Diggings are opened on the Wiles, Irons and Bussem farms, and the bottom, when reached, is in fuller's earth; at Poke Hill, in Burlington county, Samuel E. Emley and others dig marl in this bed, finding the green and ash marls. Mr. Emley, digging 12 feet green marl (see Fig. 13 for Emley's pits), and Joseph Emley, at Hockamick Mills, dig through the ash marl. The bed is opened in a large number of places along the head-waters

of the streams which form the Rancocas; above Pemberton it is well seen in the pits of J. Forsyth, S. Shinn and B. Shreve; along the creek both the ash marl and the green are exposed in the pits of Dr. J. P. Coleman, Isaac Hilliard and others; above Vincentown the marl is found on the several branches which unite to form the south branch of the Rancocas; the Vincentown Marl Company's pits are in this bed; along the Jade Run both the ash layer and the green marl are dug, and also on Ash Run, where the most extensive diggings are made; near Chairville it is worked in the green layer; on Haines' creek, at Medford, and up to Oliphant's and Christopher's saw-mills, the green marl is worked; it is from 8 to 15 feet thick, and terminates in fuller's earth; at Clementon is the most southwesterly exposure of the bed which has yet been found; it is in the pits of Hamilton Adams, George Lippincott and James Tomlinson, and has been dug 6 or 7 feet.

COMPOSITION OF THE GREENSAND MARLS.

MECHANICAL ANALYSES OF GREENSAND AS TAKEN FROM THE MARL-BEDS.—Under this head are given the results obtained by washing and sifting marls so as to determine the percentage of greensand grains, of clay and mud, and of sand and gravel. The work was done by stirring up the marl thoroughly in water, and then pouring off the turbid water and leaving the washed grains of marl with the sand and gravel. The water was left to settle and the sediment was dried and weighed. The washed marl was also dried, and the gravel and sand sifted out or picked out by hand and the two parts weighed separately.

Examination of six samples of marl from the Lower Marl-Bed.

	1	2	3	4	5	6
Greensand.....	58.4	75.0	65.0	52.5	40.8	25.6
Clay, etc., (sediment).....	33.6	25.0	15.6	25.0	32.0	36.0
Quartz sand.....	6.6	.....	2.5	18.7	27.2	38.4
Iron crusts.....	0.7	.....	.....	.....	.....	.....
Shells, in pieces.....	0.7	.....	.....	.....	.....	.....
Chocolate-colored clay....	.....	.....	16.9	3.8	.....	.....
	100.0	100.0	100.0	100.0	100.0	100.0

1. From Rev. G. C. Schanck, Marlboro, Monmouth county—a carefully averaged sample.

2. From John R. Perrine, Manalapan.

3. From John R. Perrine, Manalapan.

4. Wm. H. Mount's marl, Perrineville—an average sample.

5. From Marshallville, Salem county, pits of the late Jos. Basset—an average sample.

6. N. Lippincott, Auburn—an average sample.

Examination of thirteen samples from the Middle Marl-Bed.

	1	2	3	4	5	6	7
Greensand.....	82.0	81.2	84.2	90.3	88.5	71.4	77.3
Clay, etc.....	17.2	17.2	15.8	7.8	11.5	28.6	21.1
Quartz.....	0.8	1.6	.....	1.9	.....	.....	.....
Iron crusts.....	.....	.....	.....	.....	.....	.....	1.6
	100.0	100.0	100.0	100.0	100.0	100.0	100.0

	8	9	10	11	12	13
Greensand.....	91.3	89.0	71.1	28.7	86.6	74.3
Clay, etc.....	7.8	11.0	28.9	17.2	12.5	21.8
Quartz.....	0.9	.....	.....	50.0	0.9	3.9
Iron crusts.....	.....	.....	.....	4.1	.....	.....
	100.0	100.0	100.0	100.0	100.0	100.0

1. From Robert W. Cooke, Tinton Falls, Monmouth county—average.

2. From Charles Bennet, Blue Ball, Monmouth county.

3. From Charles Bennet, Blue Ball, Monmouth county—red marl.

4. From S. R. Gaskill, Pemberton, Burlington county—average.

5. From Lawrence W. Jones, Medford, Burlington county—average.

6. From Inskip's Bridge, Burlington county—average.

7. From Minor Rodgers, White Horse, Camden county—average.

8. From W. J. Marl Company, Barnsboro, Gloucester county—average.

9. From Thomas J. Heritage, Hurffville, Camden county—average.

10. From David E. Marshall, Blackwoodtown, Camden county—average.

11. From David E. Marshall, Blackwoodtown, Camden county—average, red.

12. From N. T. Stratton, Mullica Hill, Gloucester county—average.

13. From Dickinson's pits, Woodstown, Salem county—average.

Examination of two samples from the Upper Marl-Bed.

	1	2
Greensand	67.6	16.6
Clays, etc	28.8	33.6
Quartz	3.6	49.8
	100.0	100.0

1. From J. & S. Butterworth, Vincentown, Burlington county.

2. From George Lippincott, Clementon, Camden county.

Examination of three miscellaneous samples.

	1	2	3
Greensand	73.4	66.6	31.9
Clay, etc	26.6	32.0	20.3
Quartz	.....	1.4	47.8
	100.0	100.0	100.0

1. Chocolate marl, John Brown, Bally Ridge, Burlington county.

2. Substance used as marl by John P. Craig, Glendale, Camden county.

3. Substance used as marl by Joseph Robinson, Sharptown, Salem county.

MARL GRAINS,

Mineralogically known as Greensand, or *Glauconite*, which is found in considerable quantity in all the marl-beds and in the clay marls, is a mineral substance in the form of irregular rounded grains, of a green color, varying from almost black through olive to a light green. Some of the grains seem harder than others, but any of them can be easily crushed between the thumb-nails. The powder produced by crushing is always light green. As the marls are found, they are

mixed with clay, fine carbonate of lime, quartz-sand, small pebbles, fossil-shells, etc. To examine the grains more carefully, samples of two pounds each were taken, one from the Clay Marls, one from the Lower, one from the Middle, and one from the Upper Marl-Bed. The sample of clay marl was taken from near Ten Eyck Brothers', at Matawan, Middlesex county; that from the Lower Bed from the marl-pits of O. C. Herbert, at Marlboro, Monmouth county; the Middle Bed sample was taken from the marl-pit of David E. Marshall, of Blackwoodtown, Camden county; and that of the Upper Bed from the pits of E. K. Johnson, of Squankum, Monmouth county. They were thoroughly stirred up in water and the muddy fluid decanted. This operation was repeated until the washing water was no longer turbid. The water from each was allowed to stand until it had settled clear, when it was poured off, and the muddy sediment was dried and weighed. The washed greensand was also dried and then sifted through a sieve with meshes one-thirtieth of an inch square. This took out quartz grains, lumps of marl, fragments of shells, etc. The sifted portion was again sifted in a sieve with meshes $\frac{1}{100}$ of an inch square. That which passed this sieve was then separated by a sieve with meshes $\frac{1}{150}$ of an inch square; that is, the whole marl was sorted into

1. Fine mud.
2. Grains less than $\frac{1}{150}$ of an inch in diameter.
3. " between $\frac{1}{100}$ and $\frac{1}{150}$ of an inch in diameter.
4. " " $\frac{1}{30}$ and $\frac{1}{100}$ " " "
5. " more than $\frac{1}{30}$ " " "

Percentage of fine sediment and of different sized grains obtained by washing:

	1	2	3	4	5
	Mud.	Grains less $\frac{1}{150}$ of an inch.	Between $\frac{1}{100}$ and $\frac{1}{150}$	Between $\frac{1}{30}$ and $\frac{1}{100}$	More than $\frac{1}{30}$
Clay Marl yielded.....	73.	22.	4.	.5	5.
Lower Marl yielded.....	31.	6.	11.	48.	4.
Middle Marl yielded.....	22.	1.	7.	67.	3.
Upper Marl yielded.....	22.	19.	32.	25.	2.

CHEMICAL ANALYSES OF GREENSAND MARLS.

The following analyses show the composition of the different grades of marl as they are dug out of various pits, and as they are applied to the soil. The greensand or glauconite in them is of nearly uniform composition: but there is mixed with it carbonate, sulphate and phosphate of lime, quartz-sand, clay, sulphate and phosphate of iron, shells and other fossils, etc. The differences in the kind and quantity of these substances cause wide differences in the appearance of the marl containing them, as well as in its composition and properties.

The first table of analyses shows the composition of typical specimens of marl from the different beds. The remaining analyses are arranged in the order of the several beds, beginning with the lowest and presenting the samples from each in succession from the northeast towards the southwest.

	1	2	3	4	5	6	7	8	9	10
Phosphoric acid...	1.14	1.33	1.02	2.24	2 69	2.56	3.58	3.87	2.58	2.30
Sulphuric acid.....	0.14	.00	.27	.39	.26	0.22	0.97	0.31	1.89	.00
Silicic Acid and Sand.....	38.70	46.03	50.23	50.80	49.40	51.50	53.15	54.75	59.80	57.67
Carbonic Acid.....	6.13	.....	.....	.....	.....	.....	.....	.....	.....	.....
Potash.....	3.65	5.67	6.32	5.18	6.31	4.62	3.75	4.11	4.25	3.53
Lime.....	9.07	2.01	1.40	2.13	2.52	1.26	3.27	5.46	2.97	1.26
Magnesia.....	1.50	3.47	3.45	3.54	3.24	3.95	1.75	2.99	2.00	3.67
Alumina.....	10.20	7.86	7.94	8.77	8.90	6.01	8.79	6.46	6.00	10.10
Oxide of Iron.....	18.63	25.23	20.14	17.63	17.11	21.04	15.94	15.20	11.98	14.16
Water.....	10.00	8.40	9.00	9.66	9.10	7.39	8.98	6.85	8.32	7.25
	99.16	100 00	99.77	100.34	99.53	98.55	100.18	100 00	99.79	99.94

No. 1 is an average of the variety of marl most largely used in eastern Monmouth. It is from the Lower Marl-Bed, not particularly rich in phosphoric acid, but remarkable for containing from 10 to 20 per cent. of carbonate of lime in fine powder. In the neighborhood of the marls, where it costs little more than the cartage, a great deal is used which is much poorer than this; but there is no trouble in finding

millions of tons of this quality. It is used in larger quantities than the other varieties and is remarkable for the permanent improvement it makes in the soil.

Nos. 2, 3, 4, 5 and 6 represent the green marls of the Middle Bed.

2. Marl from the Cream Ridge Marl Company, Hornerstown, Monmouth county. The analysis was of an average specimen, collected by E. H. Bogardus. This marl belongs to the Middle Bed.

3. Marl from the Pemberton Marl Company's pits, Pemberton, Burlington county. The sample was an average, prepared by J. C. Gaskill, superintendent. This is in the Middle Marl-Bed.

4. Marl from Kirkwood, Camden county, and from the Middle Marl-Bed. There is abundant supply of this marl to be had, and it is the source from which it can be easiest sent to all of Atlantic county, and the country along the Camden and Atlantic railroad.

5. Marl from the Middle Bed, as opened in the pits of the West Jersey Marl and Transportation Company, near Barnsboro, Gloucester county. Several hundred tons of it are sent over the West Jersey railroad every day, to supply the wants of farmers in all the country which is reached by that road and its branches.

6. An average sample of the green marl of the Middle Bed, as dug at Dickinson's pits, at Woodstown, Salem county. From 10,000 to 15,000 tons are carted annually from these pits to the neighboring farms.

Nos. 7, 8, 9 and 10 are analyses of representative specimens of the Upper Marl-Bed.

7. An average of five analyses of Squankum marls, from as many different marl-banks, near Farmingdale (Squankum), Monmouth county. Each specimen analyzed was an average of the marl dug at the pit.

8. An average sample taken from a heap of 100 tons sent by the Squankum and Freehold Marl Company to New Brunswick. A sample of the green layer, carefully averaged at the pits of this company by E. H. Bogardus, yielded on analysis 4.58 per cent. of phosphoric acid.

9. An average sample of marl dug at the pits of the Squankum Marl Company, near Farmingdale. This is a mixture of the *green marl* and the *ash marl* of the Upper Marl-Bed, both of which are here dug. The ash layer contains more clay. The mixture makes a good fertilizer. This marl is sent to all points on the line of the New Jersey Southern railroad.

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

CLAY MARLS.

	1	2	3	4	5	6
Phosphoric acid.....	1.15	0.58	0.18	0.24	0.18	1.28
Sulphuric acid.....	1.28	.....	3.42	2.22	0.36	.....
Silicic acid and sand...	34.50	45.40	67.26	65.00	64.70	74.10
Potash	1.54	3.79	5.16	2.49	2.52	1.19
Lime.....	2.52	1.51	0.62	0.39	1.40	1.34
Magnesia.....	2.15	2.20	1.94	0.85	0.90	1.72
Alumina.....	6.00	5.80	4.36	6.76	6.20	6.61
Oxide of iron.....	31.50	24.50	10.27	10.86	12.35	6.49
Water.....	18.80	15.40	5.70	5.80	10.66	8.25
Organic matter.....	.....	.....	.....	5.35	.....	.....
	99.43	.....	98.91	99.96	99.27	100.98

1. Analysis of a sample from the stratum near Ten Eyck Brothers', at Matawan, Middlesex county: *

2. Analysis of a sample from the farm of J. B. Johnson, on the Matchaponix creek, three miles south of Spottswood, Middlesex county.

3. Analysis of a sample from the land of Miller Howard, Shelltown, Burlington county.

4. Analysis of a sample from the land of Benjamin C. Tatum, near Woodbury, Gloucester county.

5. Analysis of a black clay of this formation.

6. Analysis of *marl* from the land of John E. Hopkins, Haddonfield, Camden county.

Nos. 1, 2, 3 and 4 are clay marls, and have been used as fertilizers. They are slightly acid from the sulphate of iron in them, and need care in applying them to the soil. They contain much less phosphoric

* This specimen was carefully washed to separate the grains of greensand from the clay, and was found to contain twenty-seven per cent. of greensand grains. The mass is somewhat like clay in consistency, though when exposed in piles it falls into sandy powder. It is greenish in color, and changes to a rusty red on exposure to the atmosphere.

acid than the marls of the several marl-beds. Wherever applied they have been found beneficial. The Messrs. Ten Eyck, and many of their neighbors near Matawan, have used them satisfactorily. Enoch Hardy, near Jacksonville, showed a remarkable growth of clover from the application of clay marl. Mr. Craig, near Englishtown, has dug and used it with good results. It has been used by Mr. Waln, at Waln's Mills; by Mr. Howard, at Shelltown. In Burlington county, along the Rancocas, it has been used in many places; also in Camden and Gloucester counties, and with profit. When found upon the farm, so that the hauling is short, it is better economy to use it than to purchase the richer but more expensive marls found at a distance. With these marls and lime to alternate, land can be kept in first-rate condition; and they deserve to be much better known than they now are.

No. 5 is a specimen of the dark clay which is very common in the formation.

No. 6 is called a *marl*, and has been used as a fertilizer with good success. Some portions of it contain a good deal of white carbonate of lime from decaying shells. With the exception of the phosphoric acid, No. 6 is an average of the laminated sands.

MARLS FROM THE LOWER MARL-BED.

Samples from the Navesink Highlands, shore of Sandy Hook bay.

	1	2
Phosphoric acid	1.51	1.77
Sulphuric acid	2.40	.....
Silicic acid (soluble)	36.89	52.70
Silicic acid (insoluble) (sand)	18.80	
Potash	5.27	4.30
Lime	0.65	1.51
Magnesia	0.79	2.10
Alumina	6.61	6.20
Oxide of Iron	21.63	23.27
Water	8.85	7.26
	102.40	99.11

No. 1 is a black marl; No. 2 is a marl rich in phosphoric acid. The top marl found in this finely exposed bank is more sandy than these specimens whose analyses are here given.

Marl from the bank of Wm. V. Conover, north shore of the Navesink river, at Red Bank, Monmouth county.

Phosphoric acid	1.14
Sulphuric acid	0.14
Silicic acid and sand	38.70
Potash	3.65
Lime	9.07
Magnesia	1.50
Alumina	10.20
Protoxide of iron	18.63
Water	10.00
Carbonic acid	6.14
	99.16

A sample of the best marl of this bed. It contains about fifteen per cent. of carbonate of lime. In this bank also, at the top, there is more quartz-sand and less lime in the marl than in the specimen analyzed.

Samples from the marl-bank of Rev. Garret C. Schanck, on Hop Brook, near Marlboro.

	1	2
Phosphoric acid	2.18	2.08
Sulphuric acid	.....	0.76
Silicic acid and sand	43.70	56.30
Potash	3.82	4.92
Lime	8.85	trace.
Magnesia	2.33	1.70
Oxide of iron	25.00	17.38
Alumina		8.20
Water	9.21	8.05
Carbonic acid	5.40	.....
	100.49	99.39

No. 1 is a carefully selected and averaged sample of the whole bed as dug, twenty-one feet. No. 2 is a black marl; it has evidently been changed by sulphate of iron, and all carbonate of lime dissolved out.

Blue marls dug at Marlboro, Monmouth county.

	1	2
Phosphoric acid	1.14	1.60
Sulphuric acid	0.31	.....
Silicic acid and sand	38.70	41.50
Potash	4.47	.....
Magnesia	1.21	2.37
Oxide of iron and alumina	30.67	30.12
Carbonate of lime	13.91	11.47
Water	11.22	9.91
	99.63	.....

1. A good sample of the blue marl dug at the pits of Richard Laird.

2. This is an analysis of a carefully averaged sample, for a depth of 18 feet, at the pits of O. C. Herbert, and they represent fairly the large amount dug annually at the pits of Uriah Smock, O. C. Herbert and others, near Marlboro. Certain layers, as for example the *shell-layer* in these pits and in some of the marl-banks of Holmdel and Middletown townships, contain more carbonate of lime. As much as 23 per cent. has been found in some specimens, but the average of the whole blue marl layer is fairly given above.

Marl from the northwest slope of the Mount Pleasant hills.

Phosphoric acid	0.84
Sulphuric acid	0.12
Silicic acid and sand	52.07
Potash	6.46
Lime	1.01
Magnesia	1.53
Alumina	6.96
Oxide of iron	21.55
Water	9.31
	99.85

This marl was from Morgan's bank, near Mount Pleasant.

It is a fair sample of what are termed hill marls. Soft water has penetrated them to some extent, and then draining out, takes the carbonate of lime and changes the protoxide of iron to a peroxide.

Such marls are dug on the northern slope of this range of hills, from Middletown to Marlboro. In many localities the marl is dry, but still retains its original percentage of lime. The marls on the southern slope of these hills are generally of this latter character.

Sand marls from the sand marl layer of the bed.

	1	2	3
Phosphoric acid	0.85	0.94	0.76
Sulphuric acid	2.25	4.22	0.35
Sand and silicic acid	68.50	68.66	67.40
Carbonate of lime	0.26	1.73	0.95 (lime)

1. Sand marl from the pits of Richard Laird, Marlboro.

It has some value on account of its phosphoric acid.

2. Sand marl from Hartshorn's pits, north of Freehold.

3. Marl from the bottom of the bed, as dug in the pits of John B. Buckelew, near the Monmouth battle-ground.

Marls north of Freehold.

	1	2
Phosphoric acid	0.38	1.89
Sulphuric acid	0.20	0.18
Silicic acid and sand	53.10	53.91
Potash	3.78	.....
Lime	.....	2.62
Magnesia	0.70	.....
Alumina	6.30	.....
Protoxide of iron	15.39	.....
Water	8.64	.....
Carbonate of lime	12.10	.....
	100.59	.....

1. Blue marl from Hartshorn's pits.

2. Marl from the pits of Dr. J. C. Thompson. This is a changed marl, but rich in phosphoric acid.

Marls from Manalapan and Millstone townships, Monmouth county.

	1	2	3	4
Phosphoric acid	2.37	2.75	2.38	2.33
Sulphuric acid	.....	.....	.....	0.64
Silicic acid and sand	47.10	44.70	50.40	54.70
Potash	.....	.....	.....	4.15
Lime	2.52	2.69	2.52	1.40
Magnesia	2.44	.....	1.76	2.00
Oxide of iron Alumina	32.93	29.40	30.34	20.36 8.70
Water	8.90	.....	8.07	6.41
Carbonic acid	.....	.....	1.50	.....
	.....	.....	96.97	100.69

1 and 2. Marls from the pits of John R. Perrine, Black's Mills, Manalapan, N. J. They were sent to the laboratory by Mr. Perrine.

3 and 4. Marls from Perrineville, pits of Wm. H. Mount.

3 is an average of eleven feet depth of marl.

4. Marl taken from a heap near the pits.

Marls from West Jersey.

	1	2	3
Phosphoric acid	1.28	1.34	1.39
Sulphuric acid	0.73	.....	.87
Silicic acid (soluble) Silicic acid (insoluble sand)	74.60	65.60	20.20 49.92
Potash	1.41	.....	2 46
Lime	0.84	4.54	2.36
Magnesia	0.14	1.47	0.42
Alumina Protoxide of iron	13.69	13.89	6.10 8.32
Water	7.13	7.11	7.08
	99.82	.....	99.12

1. Marl from pits west of and near Carpenter's Landing, Gloucester county. This is not used extensively, although it is well exposed and accessible.

2. Marl from the bank of N. Lippincott, Auburn, Salem county. This marl is used to a large extent. Its phosphoric acid and seven per cent. of carbonate of lime make it valuable.

3. Marl from Marshallville, Salem county. This is a very good fertilizer. It is not acid in its reaction, but contains carbonic acid enough to effervesce with acids.

It will be observed, on comparing the analyses given above, that this bed is more sandy towards the southwest than in Monmouth county.

INDURATED GREEN EARTH.

Analysis of a specimen from Tinton Falls, Monmouth county, and Glendale, Camden county.

	1	2
Phosphoric acid	1.20	2.58
Sulphuric acid	.....	.....
Silicic acid and sand	36.70	44.30
Potash	3.10	.....
Lime	1.56	2.85
Magnesia	2.60	2.59
Alumina, Oxide of iron	43.58	33.24
Water	10.62	9.88
	99.36	.....

1. This is from the farm of Mr. Polhemus. It has been used to some extent as a fertilizer, and with good effect.

2. From J. P. Craig's farm, Glendale, Camden county. It is dug from under the marl, and is a good fertilizer.

MARLS OF THE MIDDLE MARL-BED.

Marls from the eastern part of Monmouth county.

	1	2
Phosphoric acid	0.19	0.64
Sulphuric acid	0.41	0.38
Silicic acid (soluble)	46.93	42.50
Silicic acid (quartz)	4.22	

Potash	7.08	5.71
Lime	0.49	0.78
Magnesia	2.02	1.47
Alumina	8.23	7.00
Oxide of iron	23.13	33.06
Water	6.67	9.91
	99.37	101.45

1. Marl dug near Entontown. This is a pure greensand, but rather poor, containing an uncommonly small amount of phosphoric acid.

2. A red marl from the Holmdel and Keyport turnpike, and from the top of cut in the Big Hill. This is greensand whose iron has been oxidized, or *rusted*, by long exposure to atmospheric agents. It has not been used as a fertilizer.

Marls from Blue Ball and vicinity, Monmouth county.

	1	2	3	4	5
Phosphoric acid	0.50	1.04	0.75	0.42	0.24
Sulphuric acid	0.34	1.44	.....	0.04	0.09
Silicic acid and sand	47.50	54.11	65.70	45.70	46.10
Potash	5.29	6.98	3.78	3.15	2.90
Lime	0 56	0.48	.....	*23.00	*20.50
Magnesia	2.70	3.79	1.80	1.00	0.70
Oxide of Iron	20.52	23.39	14.43	10.69	17.38
Alumina	8.60		8.40	7.70	7.20
Water	13.57	8.11	4.60	3.11	4.98
	99.58	99.34	99.46	99.81	100.09

1. Marl from the farm of Daniel Jones, southeast of Freehold. This is nearly pure greensand, but it is not active as a fertilizer.

2 and 3. These are good specimens of the green marls which are found at Covert's pits, south of Blue Ball. They are nearly pure greensand.

4 and 5. Gray marls, from the shell-layer of the Middle Bed, and from the pits of Henry C. Brinckerhoff, south of Blue Ball. They are valuable for the large amount of *carbonate of lime* which they contain.

* Carbonate of lime.

Marls from Upper Freehold, Monmouth county.

	1	2	3
Phosphoric acid	1.58	1.33	1.34
Sulphuric acid	2.27	traces.	0.00
Silicic acid and sand	49.77	46.03	46.82
Potash	5.78	5.67	5.59
Lime	2.56	2.01	2.02
Magnesia	2.79	3.47	3.10
Alumina	24.49	7.86	6.48
Oxide of iron		25.23	23.93
Water	10.49	8.40	9.70
	99.73	100.00	98.98

1. Green marl from near the top of the layer as dug at the pits on the estate of Samuel Horner.

2. An average sample from the Cream Ridge Marl Company's pits, collected by E. H. Bogardus in 1869.

3. Marl from the same locality as 2. An average collected in 1870.

Burlington county Marls.

	1	2	3	4
Phosphoric acid	1.02	1.28	1.79	2.16
Sulphuric acid	.27	1.37	.....	4.00
Silicic acid and sand	50.23	51.92	47.00	49.20
Potash	6.32	5.36	.....	.....
Lime	1.40	1.68	1.90	2.80
Magnesia	3.45	3.38	3.05	3.66
Alumina	7.94	5.40	30.11	26.64
Oxide of iron	20.14	19.82		
Water	9.00	8.70	8.44	.....
	99.77	98.91	.....	.....

1. Marl from the Pemberton Marl Company, from J. C. Gaskill, superintendent; sent as an average sample of the whole bank. This marl is well known for its extensive use.

2. Marl from the Pemberton Marl Company, collected by E. H. Bogardus in 1870.

3. Marl from Lawrence W. Jones' bank, along Sharp's Run near Medford. This is an averaged sample in a digging of 9 feet. It is extensively used and much liked.

4. Marl from Inskip's Bridge. This is an acid marl, but of good quality and much used.

Marls from Camden and Gloucester counties.

	1	2	3	4	5	6	7
Phosphoric acid.....	2.24	3.66	2.69	1.60	2.50	3.60	3.48
Sulphuric acid.....	0.39	0.62	0.26	.....	.....	.98	.....
Silicic acid and sand	50.80	49.94	49.40	51.10	47.30	46.66	49.80
Potash.....	5.18	6.31	6.31	6.46	.....	6.82	.....
Lime.....	2.13	2.37	2.52	2.13	2.97	2.86	1.68
Magnesia	3 59	2.71	3.24	3.85	2.69	3.09	3.50
Alumina.....	8.77	24.54	8.90	9.15	29.91	26.61	28.22
Oxide of iron.....	18.83		17.11	18.20			
Water.....	8.46	9.43	9.10	6.75	8.96	8.57	.....
	101.39	99.58	99.53	99.24	.....	99.19	.....

1. Marl from Minor Rodgers' pits, Kirkwood, Camden county. This is an average for fourteen feet. This marl is extensively distributed along the line of the Camden and Atlantic railroad, and is a good one.

2. An average sample from David E. Marshall's pits, Blackwoodtown, Camden county. It is an excellent fertilizer, and is largely used.

3. A carefully averaged sample of marl, from the West Jersey Marl Company's pits, Barnsboro, Gloucester county. It is from the green layer. It is extensively used and well known.

4. An average from the West Jersey Marl Company, collected by E. H. Bogardus, 1870.

5. Marl from Heritage's banks, Hurffville, Gloucester county. This is an average of the whole green marl layer. It is an excellent marl.

6 and 7. Marls from N. T. Stratton's bank, two miles east of Mullica Hill, Gloucester county.

6. A good sample of the green marl.

7. Is a carefully averaged sample of the whole bed. They are both good marls, and much used.

Marls along Oldman's creek, and marls of Salem county.

	1	2	3
Phosphoric acid	2.34	2.56	2.05
Sulphuric acid	0.21	0.22	.....
Silicic acid and sand	50.00	51.50	48.15
Potash	6.18	4.62	6.07
Lime	1 57	1.26	0.38
Magnesia	0.60	3.95	1.20
Oxides of iron	24.32	21.04	30.38
Alumina	6.15	6.01	4.56
Water	6.88	7.39	5.97
	98.25	98.55	98.76

1. Marl from Jesse Lippincott's pits, near Oldman's creek, Gloucester county. This is an average of the green marl of this neighborhood.

2. Marl from Dickinson's pits, west of Woodstown, Salem county. This is an average of the whole of the green marl layer which in these pits is fifteen feet thick. It has a high reputation and extensive use.

3. This is an average of four analyses of as many samples, from different layers in the pits of Messrs. Pettit, Mannington township, Salem county. In this marl the carbonate of lime seems to have been replaced by oxide of iron.

Limestone and limesand from the upper layer or member of the bed.

	1	2	3
Phosphoric acid	0.04	0.20	.....
Sulphuric acid	0.06	8.33	.....
Silicic acid	23.31	8.11	7.05
Magnesia	1.81	1.40	1.15
Alumina	0.91	0.86	4.90
Oxides of iron	3.07	3.56	
Carbonate of lime	69.61	84.73	80.40
Water	0.24	0.45	.....
	99.05	99.54	.....

1. Selected as a fair sample of the yellow limestone in Mannington township, Salem county. This limestone makes a lime almost free from magnesia, and in that respect is quite different from that made from most of our blue limestones.

2. Limesand from Swede's bridge, Mannington township. This is a sample of the loose variety of the limesand; it is gray in color, and contains many greensand grains.

3. Limesand from the vicinity of New Egypt. This is a good calcareous marl, though not much used.

"Chocolate Marls" underlying the green marl of the bed.

	1	2	3
Phosphoric acid	1.60	1.47	1.28
Sulphuric acid	.....	1.30	0.61
Silicic acid and sand	51.50	48.00	47.90
Potash	5.59	4.70	6.20
Lime	1.01	1.68	1.34
Magnesia	2.74	3.77	3.65
Alumina and oxides of iron	29.26	30.94	29.94
Water	9.13	9.41	9.11
	100.83	101.47	100.05

1. Chocolate marl from Belly Bridge, near Lumberton, Burlington county.

This is a specimen of the *chocolate-colored earth* found everywhere in Burlington county, immediately under the green marl of the Middle Bed. It is called *marl*, and is used as such with good results.

2. From the pits of the West Jersey Marl Company, near Barnsboro, Gloucester county.

It is an acid marl.

3. "Chocolate marl" from pits near Major's Run, southwest of Sharptown, Salem county.

This marl is acid in its reaction, but when carefully used it is a valuable fertilizer, and is liked by farmers.

UPPER MARL-BED.

Marls of Deal, Poplar and Shark river, Monmouth county.

	1	2	3	4	5
Phosphoric acid.....	1.70	4.16	1.28	6.87	3.73
Sulphuric acid.....	.....	0.04	1.47	3.12	2.44
Silicic acid and sand....	51.20	55.50	55.50	44.68	49.68
Potash.....	2.96	3.50	3.99	3.97	4.98
Lime	1 51	4.20	2.80	4.97	4.14
Magnesia.....	1.50	1.80	1.68	2.97	0.47
Oxides of iron.....	11.90	19.41	18.20	18.97	28.71
Alumina.....	23.67	3.70	6.70	6.04	
Water.....	5.53	8.39	9.25	8.63	5.54
	99.97	100.70	100.87	99.32	99.69

1. An average specimen from the green marl layer at the pits of J. Gardner, Deal.

2. Blue marls from the upper layer of the bed. Jacob White, Deal.

3. A *changed* marl from the same pits as No. 2. These samples were taken from the same level and but a few feet from each other. They illustrate the change in composition effected by air and moisture.

4. Marl from Howland's pits, Poplar. This sample was taken from a heap, and was better than the average. It was selected for its large percentage of phosphate of lime, the greatest ever found in our greensand marls. It was from the green marl layer.

5. A green marl from Hugh Hurley's pits, Shark river. Another specimen from the same pits had 2.58 per cent. of phosphoric acid. This marl is extensively used.

Squankum marls, Monmouth county.

	1	2	3	4	5	6
Phosphoric acid.....	3.23	4.54	3.97	3.59	3.87	4.67
Sulphuric acid.....	.....	0.43	.....	1.41	0.31	0.51
Silicic acid and sand...	50.70	51.16	56.50	51.40	54.75	52.70
Potash.....	3.02	4.27	3.97	.....	4.11	3.81

Lime	2.63	3.48	3.08	3.08	5.46	5.52
Magnesia	1.20	2.04	2.00	.....	2.99	2.70
Oxides of iron	22.77	17.67	11.68	28.32	15.20	15.92
Alumina	10.50	6.10	10.30		6.46	8.66
Water	5.51	9.13	7.92	7.19	6.85	6.40
	99.56	98.82	99.42	.....	.....	.....

These analyses are all of the green marls—the lowest layer of this bed.

1, 2 and 3. Marl from C. G. Bond's pits. The *green marl* of the Squankum Marl Company is like these.

4. Marl from Jas. Butcher's pits.

5 and 6. From the pits of the Squankum and Freehold Marl Company. The first is an average of 100 tons sent to New Brunswick; the last is an average sample, collected in 1870 by E. H. Bogardus.

	1	2	3	4
Phosphoric acid	1.20	0.88	2.58	2.18
Sulphuric acid	2.16	.....	.....	0.75
Silicic acid and sand	73.10	73.70	61.60	61.00
Potash	.....	2 39	2.58	2.54
Lime	1.62	0.61	0.87	1.85
Magnesia	.....	1.00	2.20	1.62
Alumina	12.60	5.20	7.70	19.67
Oxides of iron		5.89	14.24	
Water	8.26	9.31	8.53	11.20
	.....	98.98	100.30	100.81

1. Ash marl from the pits of the Squankum Marl Company.

2. Ash marl from the pits of Mrs. J. P. Allaire, on the southwest bank of the Manasquan river, near Lower Squankum.

These ash marls constitute the middle layer of this bed; do not contain any greensand, but are good fertilizers.

3. Blue marl from J. S. Forman's pits. This is the top layer of the bed.

4. *White marl*, or fuller's earth, from the Squankum Marl Company's pits, and at the bottom, under the green marl.

Marls from New Egypt and vicinity.

	1	2
Phosphoric acid	2.53	2.05
Sulphuric acid	2.26	.....
Silicic acid and sand	63.15	55.10
Potash	5.04	.....
Lime	2.63	2.29
Magnesia	1.00	2.66
Alumina	4.15	22.38
Oxides of iron	9.97	
Water	9.27	7.76
	100.0	.....

1. Marl from John Irons, southeast of New Egypt. This is from the green layer.

2. Marl from Samuel E. Emley's pits, Poke Hill, Burlington county; an average for 11 feet in depth. It is extensively used.

Marls from Burlington and Camden counties.

	1	2	3	4
Phosphoric acid	1.68	3.52	2.46	2.64
Sulphuric acid	0.96	.....	0 17	0.44
Silicic acid and sand	55.93	56.40	57.35	56.20
Potash	5.80	.....	4.47	5.37
Lime	1.64	3.25	3.36	1.98
Magnesia	1.01	1.72	2.99	1.61
Alumina	24.41	21.98	5.86	6.00
Oxides of iron			15.03	16.29
Water	8.84	8.60	8.20	9.28
	100.27	.....	99.89	99.81

1. A green marl from Joshua Forsyth's pits, near Pemberton; an average sample.

2. A carefully averaged sample of the green marl from Butterworth's pits, Stop the Jade creek, near Vincentown. This is a superior marl.

3. An average sample of green marl from the Vincentown Marl Company's pits, near Vincentown.

4. A green marl from Hamilton Adams' pits, Clementon, Camden county.

GENERAL STATEMENTS REGARDING THE USE OF MARL.

The marl has been of incalculable value to the country in which it is found. It has raised it from the lowest stage of agricultural exhaustion to a high state of improvement. Found in places where no capital and but little labor were needed to get it, the poorest have been able to avail themselves of its benefits. Lands which, in the old style of cultivation, had to lie fallow, by the use of marl produce heavy crops of clover, and grow rich while resting. Thousands of acres of land, which had been worn out and left in common, are now, by the use of this fertilizer, yielding crops of the finest quality. Instances are pointed out everywhere in the marl district of farms which, in former times, would not support a family, but are now making their owners rich from their productiveness. Bare sands, by the application of marl, are made to grow clover, and then crops of corn, potatoes and wheat. What are supposed to be pine barrens, by the use of marl are made into fruitful land. The price of land in this region was considerably below that in the northern part of the State forty years ago; now that the lands are improved, their prices are higher than those in the northern part of the State, though even there they are higher than anywhere else in the United States. In 1830 Thomas Gordon said of these lands:

"It would be difficult to calculate the advantages which the State has gained, and will yet derive from the use of marl. It has already saved some districts from depopulation, and increased the inhabitants of others, and may, one day, contribute to convert the sandy and pine deserts into regions of agricultural wealth."—*Gordon's History and Gazetteer of New Jersey, Part 2, p. 5.*

The reputation of New Jersey soils fifty-eight years ago is strongly stated in Morse's American Universal Geography, edition of 1819:

"SOIL AND AGRICULTURE.—The mountainous parts of the State have generally a strong soil, and form a fine grazing country. The farmers there raise great numbers of cattle for the markets of New York and Philadelphia. They also raise wheat, rye, maize, buck-

wheat, potatoes, oats and barley, enough for their own consumption. They keep large dairies, and make great quantities of butter and cheese. In the counties that are uneven and hilly the soil is likewise generally rich, and very productive of the various kinds of grain, particularly wheat and maize. A narrow tract of country on the Delaware, in Burlington and Gloucester counties, is rich and fertile, as are various similar tracts in the southern half of the State, on the small rivers and creeks. In Salem, Cumberland and Cape May, there are also very extensive tracts of salt meadow on the river and bay. In Gloucester and Burlington similar tracts have been recovered by sluices and moulds from the inroads of the sea, and are now rendered rich, fresh meadow. With these exceptions, the greater part, at least four-fifths of the six southern counties, or two-fifths of the whole State, are barren. They produce little else but shrub-oaks and yellow pines. The inhabitants raise a little maize, rye and potatoes, but subsist chiefly by feeding cattle on the salt meadows, and by fishing on the shores and in the creeks and rivers."

The six southern counties alluded to are: Monmouth (which then included Ocean), Burlington, Gloucester (which then included Camden and Atlantic), Salem, Cumberland and Cape May. In contrast with the above, the census report of 1880 shows that the highest price of land and the largest amount of agricultural products are from the six southern counties, and from those where marl is found.

THE AGRICULTURAL USES OF GREENSAND MARL.

In the winter of 1876–7, a series of questions was sent out to farmers in various parts of the State, with the request that they would return answers to them, giving their own practice and experience with marl. The inquiries were addressed to many, in order to get replies from enough to represent all the kinds of marls. And all the answers received are set down.

A few of the answers are here given:

We have improved land with marl that was so poor you could not raise anything on it, and now we can mow it and cut 2 tons of hay per acre, all by the use of marl. It will prevent sandy soil from burning up the crops and clay soil from baking, and insure crops on all kinds of land. My father bought the farm I now live on about 65 years ago. At that time marl was not much in use. He carted a few loads to try it, and said he could see it in the grass crops for

years after, where he had put it on, which made him think it was of great value. He commenced to improve the land by carting 2,000 to 3,000 loads a year—his land, excepting 15 out of 150 acres, being very poor, so that he could not raise corn or grass at that time. Now we can mow every acre, and all through the use of marl. The land in my neighborhood is a sandy loam. By the use of marl it has become one of the best agricultural districts.

The land in this vicinity, Holmdel, is a heavy loam, and has been brought up by the use of marl, together with the barn-yard manure made on the place, from quite ordinary condition, and in some instances by the present occupants, to as high a condition of fertility as any land in this State. We put on from 100 to 150 dump-wagon loads, containing from 12 to 15 bushels each, to the acre, at a cost of 12 to 15 cents a load for digging and carting, and at a further cost of $1.25 per 100 loads for spreading the marl. The marl we have here, and in this section, seems beneficial to all kinds of soil or crops, especially to the potato crops. An application of this marl has been known by me to show extraordinary results for 25 years.

The blue shell marl found along the Hop brook needs no lime. Wherever it has been used in sufficient quantity, lime shows no effect, as I have found from repeated trials. On new ground lime does good, appearing to decompose the roots and other woody fibre in the soil.

My first experience with marl as a fertilizer was with that on Sharp's run, near Medford, Burlington county. About the year 1824 my father came into possession of a farm of about 50 acres on Sharp's run. A considerable portion of this was in meadow, underlaid by marl from 18 inches to 3 feet beneath the surface. This meadow land had never, to my knowledge, been plowed. A large portion of it, particularly the higher ground, was covered with Indian grass and moss, and was not worth mowing. Some of the lower part of this meadow produced good grass, white clover and herd grass. We commenced using marl, spreading it in the fall and winter, at the rate of 15 to 20 tons to the acre, on this moss and Indian grass, and instead of them we had a heavy swath of white and red clover, and that without any seeding. This ground has ever since continued to produce good crops, excepting in very dry seasons, although it has had only light dressings of marl at intervals of 10 to 15 years.

How marl compares with barn-yard manure, I would say it is much cheaper, is better adapted to potatoes and grass, and lasts much longer. Our potato crop would not amount to much without marl, and without that crop our lands would be worth but little over one-half what they are with it. So you see I have a very high estimation of the value of marl; the fact is, our county has been doubled at least in value by its use.

All the *good* farmers adjoining us, who cultivate older lands, say that without marl they could not farm with profit, and this they prove by the great expense they are under to procure it, many hauling it 20 miles. They claim to be able to show, to a line, where it has been used.

In my mowing field, last summer, I noticed a strip of grass running the whole length of the field, that only cut about 1 ton per acre. The balance of the field cut 3 tons per acre. This field had had on it about 70 loads of muck per acre, which alone did no good until an application of limesand was given. Since then it has been very productive. The strip alluded to above had no limesand on it. The grass seed had been sown crossways of the strip, hence it had as much seed sown on it as the rest. All fertilizers applied on this field subsequent to the putting on the limesand had also been applied crossways this strip, hence the difference in the grass can only be attributed to the limesand. This limesand answers the place of burned lime as a fertilizer, and while it is equally effective it cannot possibly do any harm. I know of another case where limesand was applied to all of a field, excepting four corn middles, some 30 years ago. The advantage of the lime is still shown by an excess of at least 25 per cent. of grass on the limed part.

In 1824 I was induced to try the Squankum marl on an old, worn-out farm, much of which had not been plowed within the recollection of the oldest inhabitants. I applied 5 or 6 loads of 20 bushels each on an acre, for buckwheat or rye. The effect of it was so great that the use of it became general, and the farms increased rapidly in value, from $10 to $100 or more per acre. As the land increased in value, the amount of marl was increased to 20 loads an acre.

CONCLUSIONS.

From these letters, detailing the results of experience, together with the chemical analyses, the following conclusions may be drawn:

I. That the most valuable marls, and those which will best pay the cost of long transportation, are those which contain the largest percentage of phosphoric acid. The phosphoric acid is combined with lime, and is partially soluble in citrate of ammonia, and its value may be safely set down at 6 cents a pound, and it can be computed by multiplying the percentage of phosphoric acid by 20, which will give the number of pounds of that acid per ton, and that product by the price of reverted phosphoric acid; thus, if a marl contains 2 per cent. of phosphoric acid, a ton of marl will contain 20 times 2 pounds, which is 40 pounds, and that multiplied by 6 cents per pound will give 6 times 40, or $2.40 per ton for its value.

II. That the most durable marls are those containing carbonate of lime, the more the better. The carbonate of lime is in the form of a very fine white earth or powder, and is much more valuable than that in hard shells. These are found in the Lower Marl-Bed, and in the upper portion of the Middle Marl-Bed.

III. That the potash in the marls has but very little, if any, present value, it being combined with silica, and so insoluble.

IV. That greensands containing but little of either phosphoric acid or carbonate of lime, become active fertilizers when composted with quick-lime.

V. That marls which are acid and burning from containing sulphate of iron, can be rendered mild in properties and useful as fertilizers by composting with lime. A bushel of fine slaked lime if thoroughly mixed with an acid marl, is sufficient to neutralize the sulphuric acid in several tons. Its best effects are seen in wet seasons. It has produced the greatest increase of crops upon soils of rather heavy loam.

VI. That crops particularly improved by it are all forage crops—*grass, clover*, etc.; for these the green marl may be spread upon the surface in the fall, to the amount of from 100 to 400 bushels per acre. The crop is generally doubled, and in some cases quadrupled, by this application. Other marls must be used in larger quantities, but will produce good results. *Potatoes.*—For this crop marl seems to be a specific. It does not materially increase the growth of vines, and the

yield is not much greater, but the potatoes are smoother and fairer in the skin, and dryer and of better quality when boiled. The marl is put on the potatoes in the hill at planting; if not acid, it is thrown directly on the tuber; if acid, the potato is first covered by earth and the marl thrown on or beside that. From 5 to 30 tons may be used on an acre. *Buckwheat.*—Most remarkable effects upon this crop are produced by marl. Two and a half tons or 50 bushels to the acre, spread on after sowing, have caused an equal amount of buckwheat to grow on land which otherwise was not worth cultivating. *Wheat, rye, oats and corn* are improved by the use of marl, though not with the striking results seen on the crops before mentioned. It is applied as a top-dressing on the prepared ground, is spread on the surface before plowing, is worked in the hill or drill, or is composted with barn-yard manure and spread on the ground, according to the farmer's judgment. From 5 to 30 tons and even more may be used upon an acre.

With any kind of garden or field crop it may be used, and will be beneficial both to the crop and soil. It is free from the seeds of weeds, is dry, and convenient to handle—all of which recommend it to any good farmer. When first dug it may be somewhat lumpy, so as not to spread well, but after a few weeks' exposure to the air it spreads perfectly.

WATER-SUPPLY.

The subject of water-supply is still a prominent one in all parts of the State. In the cities of Newark and Jersey City, important movements have been made towards securing their supplies from the waters of the Passaic, in the wooded mountains of Passaic and Morris counties. The supply of water there is ample, of the best quality and capable of being delivered by gravity. The financial questions involved have delayed action, and the most feasible plans for collecting and conducting it down are still in discussion. Many particulars in regard to the streams and ponds from which an abundance of good water could be got, were given in our Annual Report for 1876, and in several of the reports since that time.

The Passaic river, at Belleville, from which the supplies for Newark and Jersey City are now pumped, is disgustingly impure, and is constantly liable to dangerous contamination. With sources of supply unquestioned in purity, and more abundant than those used for the

supply of Boston, New York or Philadelphia, and at a manageable expense, there is no justifiable excuse for longer delay in the introduction of this element so essential for health, comfort and cleanliness.

The Passaic river drains an area of 750 square miles above Little Falls, and it is capable of supplying more than 400,000,000 gallons of water daily, if proper provision were made for storing that which now runs to waste in storms and freshets.

All the water from this great area is collected in a single stream only 100 feet wide at Little Falls, and it is there at an elevation of 150 feet above mean tide, and only 14 or 15 miles from the Hudson river, at Jersey City. By going back a few miles farther into the mountains, streams of water can be secured which have never been where there could be a suspicion of any impurity, and reservoirs, from 200 to 500 feet above the sea-level, could be constructed to store the surplus waters of storms, and have them ready for the seasons of drought.

The supply from basins of limited area by impounding the water of streams and heavy rainfalls, is capable of such easy application, and so comparatively inexpensive, that it should be much better understood. The rain that falls on an acre of ground in the driest of years, is more than 800,000 gallons, or enough to supply 2,200 gallons a day the year round. Some of this is lost by evaporation, and more by soaking into the ground and so escaping, but engineers calculate that it is safe to estimate the daily supply from an acre, when held in an open reservoir, at two-fifths that amount, or 880 gallons a day. This is enough for several families. A square mile will yield a half million gallons a day, a sufficient supply for a town of 5,000 or more inhabitants.

Artesian wells along the sea-shore continue to supply a large amount of pure water, and are held in the highest estimation both by residents and summer visitors. A number of new wells have been bored at Asbury Park, Ocean Beach, Spring Lake, and other seaside resorts during the last year. In all these cases the water is drawn from the same sandy layer underneath the Lower Marl-Bed.

A well has just been bored at South Beach Haven, on Long beach, for James Holgate, Esq. An 8-inch pipe was sunk to a depth of 318 feet, of which the lower 8 feet were in clay. A 6-inch pipe was then sunk 107 feet further, and a flow of excellent water was obtained.

The quantity flowing is said to be 500 barrels a day, which is about 10 gallons a minute. It rises in a tube to the height of 14 feet above the surface.

This well is supplied from a layer of water-bearing sand, interposed between the layers of tertiary clay—probably the same layer from which the well at Seven islands is supplied. The latter is 403 feet deep, and that at South Beach Haven is 425 feet.

The artesian well at Seven islands, in Great bay, Burlington county, was bored on the easterly side of the most northerly of these islands, for Joseph Wharton, Esq. It is 408 feet deep and lined with iron pipe—188 feet of 6-inch; 147 feet of 4½-inch, 69 feet of 3-inch.

The material passed through was—

	Feet.
Sand, with salt water	279
Tough clay	5
White, pebbly sand	1
Clay, with seams of sand	50
Dark-blue clay	45
Sand and gravel	15
Compact dark-brown clay	8
Sand and fresh, pure water	....
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The flow of water was about six gallons a minute at first, but in the course of the first night it fell to two gallons a minute, and the pipe filled up fifteen feet with sand. This sand was taken out by the sand-pump. It was very fine, and the pump was worked until all the sand that would rise in the tube was removed. The water then flowed to the amount of seventy gallons a minute, and it continues to flow at nearly that rate, having fallen off but little in quantity. It rises to a height of 15 feet above the meadows, which are at the level of high tide.

Analysis showed the water to contain only $6\frac{88}{100}$ grains of solid matter to a gallon, and to be of excellent quality. Its temperature is 60° Fah.

The analysis by Messrs. Austen and Wilber is as follows:

	Grains per gallon.
Silica	1.557
Sesquioxides of Iron and Alumina	0.140
Lime	0.379
Magnesia	0.221

	Grains per gallon.
Soda	0.968
Potash	0.157
Sulphuric Acid (SO_3), as sulphates	0.408
Chlorine, as chlorides	0.408
Mineral Matter	4.238
Permanent Hardness, equivalent to grains calcium carbonate per gallon	1.394
Temporary Hardness	Trace

Organic Matter, very small amount.
The water is perfectly clear and odorless.

Notice was taken last year of an artesian well at the works of the Esterbrook Steel Pen Company, Camden. It was then 67 feet deep. The water contained some floating particles of fine clay. The attempt was made to overcome this difficulty by boring deeper; 10 feet of yellow gravel and stones were passed through, and then 10 feet of fine white sand and gravel. Water of satisfactory quality was found at that depth, but the quantity not being sufficient the boring was continued 13 feet further, or to the depth of 100 feet. At that depth a soft micaceous rock was struck, in which the boring was continued for 30 feet further, but with no increase in the flow of water.

This is evidently the gneissic rock which has been reached.

DRAINAGE.

The drainage of the Great Meadows, on the Pequest, in Warren county, has been eminently successful. The ground is dry and capable of cultivation in all parts. The clearing and cropping of the reclaimed lands are progressing every year. Large crops are grown upon the fields without any manure, and with the simplest and most inexpensive tillage. At the Garden City Stock Farm, of Arnold & Stevens, where they have now about 300 acres cleared and in cultivation, the corn crop has been about 70 bushels of shelled corn, 60 to 70 bushels of oats, 350 bushels of potatoes, 600 bushels of onions, 3 to 4 tons of timothy hay, 3 tons of Hungarian grass per acre and excellent crops of rye and barley, and also of garden vegetables and root crops.

Messrs. Swayze and Bulgin, of Danville, who now own a large

portion of the south end of the Great Meadows, report that, "There are now about 800 acres under cultivation, and the crops show how very rich the land is. I cannot tell you how much the yield of corn is to the acre, but it is more than double the average of the uplands adjoining. Dr. William I. Roe tells me, after 40 years' experience as a farmer, the yield is more than the best lands will produce, no matter how much manure you use. Timothy will produce 4 tons to the acre. Messrs. Arnold & Stevens gathered 34 loads from 7¾ acres. Twenty acres in rye was of such rank growth as to make the straw unfit for market—it being too coarse. As the grain has not been threshed, cannot give the yield, but the most profit has been realized from the cultivation of vegetables, especially onions. Messrs. Arnold & Stevens sold 800 bushels of onions from 2 acres. Mr. Bulgin had 12 acres of onions that averaged 600 bushels to the acre. Two and one-half acres gave 1,570 bushels. Potatoes yield over 300 bushels without manure. Mr. Bulgin had 3½ acres in celery, and it was as fine as ever grew. Next year at least 150 acres will be devoted to growing vegetables, as it has now been proven that a profit of at least $100 per acre can be made from vegetables. The ground grows blue grass naturally, and where it gets possession drives every other grass out, making a very heavy sod. Last spring a small lot was sown with clover and every seed seemed to have grown, as it came out in head last fall, and was a perfect mat. There is no more malaria than there is on the highlands, as it is perfectly healthy now. Cannot say how much there was before the drainage. Mr. Bulgin says the foggy mornings and evenings are much less than before the drainage. Some of the lands we bought last spring we have rented at $30 per acre for a year, and could have rented 50 acres more at the same price, for 5 years, but declined to do so."

Such land is in demand at good prices, and the crops produced are such as the best Warren county farmers will find it difficult to equal. The sanitary benefits are equally marked. Physicians report that there is no more malarial disease around the meadows than there is on the uplands, and that there are no more fogs in the valley than there are on the hills. This is very different from its former condition, as given in the Annual Report for 1877. In that the testimony of several physicians, who had practiced in the vicinity, was given.

Dr. William I. Roe, of Vienna, said "Nearly 30 years ago I was in practice for 2 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 into the neighborhood from a non-malarial district, seldom escaped the ravages of miasma in one form or another."

Dr. E. T. Blackwell, of Hackettstown, said "In 1849 I passed the year at Townsbury, and saw the influence of the Great Meadows. 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 blighting effect of these 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."

Dr. John S. Cook, of Hackettstown, said that "the valley of the Pequest during the preceding 30 years had been visited by several epidemics which assumed a malarial type, while our Musconetcong valley has been comparatively free from them. 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."

Dr. N. M. Hartpence, of Oxford, said "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 prevalent there."

November, 1886, Dr. John S. Cook, of Hackettstown, says "I think I can truly say there has been a great *decrease* in the malarial diseases along the course of the Pequest since drainage was accomplished. These diseases are no more prevalent than in any other well-drained county. My own experience, and the reports from other physicians, confirm me in making this report."

In the Annual Report for 1869, a statement was made of the need for drainage of a large tract of wet lands on the Passaic river and its branches, the Rockaway and Whippany, above the Little Falls. At the same time a plan for clearing out the obstructions in the stream, and so effecting the drainage, was presented. A law to provide for the drainage of lands was passed in 1871. Under this law, the following petition being presented, the Board of Managers prepared the plan of drainage and presented it to the Supreme Court, and asked for the appointment of commissioners to carry out the plan:

"*To the Honorable, the Board of Managers of the Geological Survey of the State of New Jersey:*

"The undersigned, owners of lands subject to overflow, bordering the Passaic river, between Chatham and Little Falls, respectfully ask that your honorable body examine the said lands, determine upon a system of drainage for the same, reporting the matter to the Supreme Court of this State, and taking such other legal steps in accordance with 'An act to provide for the drainage of lands,' as may be necessary to effect the object desired with least delay.

"M. P. CRANE, Caldwell,
"ZENAS C. CRANE, Caldwell,
"JOSIAH SPEER, Pine Brook,
"WM. BUSH, Horse Neck,
"ISAAC CANFIELD,
"HENRY S. COLE,
"JOHN J. JACOBUS,
"STEPHEN M. COURTER,
"WM. VANDERHORF,
"J. H. & M. M. COOK,
"S. M. PECK,
"A. & E. SQUIER,
"D. B. MOREHOUSE, Livingston,
"SAMUEL M. HOPPING, Hanover,
E. R. SQUIER,
P. H. HARRISON,
EZRA TOMKINS,
JOSEPH COOK, Caldwell,
HENRY W. HARRISON, Caldwell,
JOHN A. COBB, Troy,
A. J. SMITH,
S. H. CONDIT,
RICHARD SMITH,
JOHN N. MITCHELL,
JOHN F. CONDIT,
IRA H. CONDIT,
MUNROE HOWELL.

"PINE BROOK, March 18th, 1871."

"*To the Supreme Court of the State of New Jersey:*

"The Board of Managers of the Geological Survey, by virtue of 'An act entitled "An act to provide for the drainage of lands,"' approved March 8th, 1871, do hereby certify and report upon the application to us of [names of petitioners as given above], more than 5 owners of separate lots of land included within the tract of land in this State, situated in the counties of Passaic, Essex and Morris, lying on each side of the Passaic river and its branches, the Whippany and Rockaway rivers, and extending along the Passaic river from Little Falls, in Passaic county, to Chatham, in Morris county, and along the Rockaway and Whippany to Madison, in the same county, and embracing an area of drowned and wet lands of 13,196 acres. The district of country in which these lands lie extends from north to south 13 miles, and from east to west 3½ miles.

"The valley of the Passaic comprised in the above-mentioned district is almost level, and the streams meander through it in crooked and greatly lengthened channels, and with scarcely any current, and whenever there is a heavy rainfall upon the surrounding hilly country, the water pours down into this valley in torrents, and not finding free vent, it spreads out over the flat country along the streams, where it remains almost stagnant, or subsides only with extreme slowness. Especially is this the case where the flats are covered with grass in summer. So wet are these lands that habitations cannot be located upon them; they cannot be cultivated, and most of them are too soft and muddy for pasturage. The wood, bushes and hassocks have been cut off from most of these lands, and they are only used for growing coarse, wild grasses, which, when mown, make an inferior quality of hay. And even this is a precarious crop. If a heavy freshet occurs in midsummer, the dirty water from the upland covers the grass with grit, and the flood subsides so slowly that all the crop is either spoiled or greatly damaged. This result is of frequent occurrence; two or three such failures have happened within the last 10 years. The losses attending these floods are very large. To these must also be added the injury to health from a condition so favorable to malaria. Chills and fever are common, and there are occasional seasons in which nearly all the inhabitants suffer from this disease.

"The large quantities of stagnant water are unsightly, the smell of decaying vegetation is disagreeable, and the whole country is brought

into disrepute by these untoward and unnecessary influences. The upland is light and mellow, of good quality and easy cultivation, and the surrounding country, but for these drawbacks, would be charming for its scenery and location.

"Most of the land is within 20 miles of New York City; the Morris canal passes along one side of it, the Morris and Essex railroad runs along its south end and the Boonton Branch railroad across its north end. The Midland railroad also passes just north of it and a new railroad line from New York to Morristown is surveyed through the middle of it. The land is needed for a growing population. If well drained, most of it could be cultivated, and all could be made to grow the best of cultivated grasses and pasture. Its salubrity would be assured and it would become desirable as a place of residence for those who seek the country for homes while doing business in the cities.

"We have examined this tract of land which is subject to overflow from freshets, and which is usually in a low, marshy, boggy or wet condition, and deeming it for the interest of the public and of the land-owners to be affected thereby, have made a survey of said tract of land and decided upon and adopted a system of drainage for draining the same; and have caused maps of the same, together with the plans of drainage by us adopted, to be made; which said surveys, maps and plans by our written report now here made, are respectfully submitted to the Supreme Court, and we do request the aid of said court to carry the same into effect.

"The map which we here present shows the country that we describe as subject to overflow. The scale of the map is 20 chains to one inch, or four inches to one mile. The portion of the tract liable to overflow is marked around by a dotted black line and is colored with a pale-green tint. The courses and bearings are so numerous that it is not deemed necessary to record them on it, but they can all be ascertained by a reference to the scale and meridian which are placed on the map. And the bridges, streams, roads and villages placed thereon become the monuments for ascertaining and identifying points in the survey. The streams are colored blue, the upland adjoining the flowed grounds is colored of a neutral tint. The roads are marked by double black lines, and the explanatory words on the map are intended to make the whole a fair record and description.

"The profile accompanying is drawn to the same scale as the map,

horizontally; but the vertical scale is 10 feet to 1 inch. The line of the profile is intended to follow along the middle of the streams through all their present natural though very crooked courses. This, it will be seen, makes the length of the Passaic river profile represent a distance of 23 miles, while the map is only 13 miles long. The blue color on the profile represents water, the upper border of it representing the river surface as it was in a freshet in January, 1870. The lower and irregular border of the blue represents the river bottom, and the brownish neutral tint beneath the water shows earth and mud. The blackish color on the profile at Little Falls is intended to indicate trap rock. The structure over which the water is represented as tumbling at Little Falls is a stone dam which is built across the stream near the top of the falls. The heavy black line drawn horizontally from the top of the dam is intended to be a dead-level, and to show the height of the river bottom and surface in relation to the dam throughout the whole length of the streams in the district to be drained. Of the two dotted lines on the profile the upper shows the water surface during a freshet in 1868, before the dam was completed; the lower dotted line shows the surface of the extreme low water in the summer of the same year and before the dam was done. The whole rate of descent from Lower Chatham to Little Falls is only $3\frac{1}{2}$ inches per mile. The irregularities in the bottom, and obstructions to the flow of water in the stream, are plainly shown both by the bottom line and the descriptive lettering. From these it will be seen that if we begin at the lower end of the profile, the first obstruction met is the dam across the river near the head of Little Falls. The second is the reef of rocks a short distance above the dam. The third is found in a bar of earth and boulders across the river just above the mouth of Pompton river, at Two Bridges. Other obstructions of a minor character have been created by the erection of bridges with the water-way so much contracted as to materially retard the flow of water in the stream. This is plainly shown at Pine Brook, and to a less extent at the other bridges on the Passaic. The numerous bars and mud-banks shown in the stream are of less consequence, and do not present serious obstructions to the water as it now flows.

"An examination of the profile shows that excepting the three principal obstructions mentioned, the streams are deep and tolerably uniform in their descent; and we find that if these obstructions were

taken out, the surface of the stream at Little Falls would be lowered several feet, and that a uniform descent of 7½ inches per mile, on the bottom, could be secured, from Lower Chatham to Little Falls, and a considerably greater descent in the Rockaway and Whippany rivers. The inclined line in red on the profile shows this *grade*, and we have adopted it as the basis of our plan. The dam must be lowered 7 feet; the reef must be cut away $5\frac{3}{10}$ feet below its present level, and so much as to make the water-way 200 feet wide; the bar just above Two Bridges must have a passageway cut through it 100 feet wide and down to the grade line; the water-way at all the bridges over these streams must also be enlarged so as to allow a free passage for the water.

"When these essential improvements have been made, the more rapid flow of water in the stream will perhaps smooth down some of the irregularities in its bed, or should it be found necessary to remove them the expense would be small.

"By computation we find that this greater descent will increase the velocity of the stream by something more than one-half its present rate. This is thought by some engineers to be too little to accomplish effectually the needed drainage, and it undoubtedly is less than it would be desirable to have, but it is all that is adapted to the present bed of the stream, and it is not desirable to deepen the present crooked channel, or to divert it by cut-offs, so as to leave bodies of stagnant water to disfigure the surface or to render the country unhealthy. When the whole district shall have had its drainage level reduced to the lower plane proposed by us, the district on the Lower Passaic will be well provided for, and then if the current for the streams above the mouth of the Rockaway is insufficient, it may be increased by a new channel through the long meadow from Pine Brook to Deep-a-Vaal, by which the course of the stream could be shortened 5½ miles, and the whole amount of the fall would still remain the same, and of course the velocity of the current would be greatly increased. Other crooks in the present streams could also be straightened if needed, and as the drainage plane would be lowered at the same time, the old bed of the stream would be left dry and capable of improvement.

"We present here longitudinal and cross-sections of the rock-work to be done at Little Falls, and of the earth-work near Two Bridges. The colors, signs, &c., are the same as in the other profiles, the only difference being in the horizontal scale, which is 50 feet to 1 inch. The rock to be removed in lowering the reef, as proposed, is 7,394

cubic yards. The amount of earth to be taken out at the bar near Two Bridges, is 15,644 yards.

"All which is respectfully submitted,

"THEO. F. RANDOLPH,	ABRAM S. HEWITT,
"H. AITKIN,	A. K. HAY,
"C. E. ELMER,	WILLIAM PARRY,
"THOS. T. KINNEY,	WM. M. FORCE,
"ANDREW B. COBB,	S. T. SCRANTON.

"TRENTON, June 6th, 1871."

The Commissioners were appointed by the court, but the financial revulsion of 1873 rendered it impossible at the time to carry out a plan involving so large an expense, and such important and perhaps adverse interests. During the past years the monetary affairs of the country were in such condition as to warrant an effort to carry out the plan of drainage which was adopted in 1872. Of the former Commissioners Geo. W. Howell, of Morristown, Morris county, alone remained, and the Commission was filled by the appointment of Caleb M. Harrison, of Verona, Essex county, and John H. Blauvelt, of Paterson, Passaic county.

These Commissioners have held a number of meetings, during the summer and autumn, to ascertain the expenses of making the improvement, and the damages to be paid the Beattie Manufacturing Company for the water-power to be taken.

After careful consideration of all the facts which have been brought to their attention, the Commissioners have awarded $55,000 as full compensation for the property and rights to be destroyed in making this improvement. The Beattie Manufacturing Company have appealed from this award of the Commissioners, to the Supreme Court of the State of New Jersey.

The questions regarding the relations of the water-power and its mill privileges to the flowed lands above, are not new, and it may be well, when the importance of the interests involved to the sanitary condition and the agricultural improvement of the country is considered, to publish something of their history.

The tract of land on the north side of the Passaic river, at Little Falls, is covered by a grant made by the Proprietors of East New Jersey to George Willocks in 1703. That on the south side of the river, along the whole length of the falls and rapids, is covered by a

grant made to Cornelius Board in 1733. And the bed of the river itself, from the upper reef to the foot of the perpendicular falls, was the subject of a second grant made in 1736 by the Proprietors of East New Jersey to Cornelius Board and Timothy Ward. The presumption is that this grant was for the establishment of a forge at that point, but nothing has as yet been ascertained of its history. In the year 1772, as appears from a mortgage on record in Newark, the tract constituting the bed of the river was in possession of James Grey, of Newark, and the land included in the grant of 1733 to Cornelius Board was also in his possession, as appears from the following law passed by the Legislature in 1772:

[Vol. IV., Pamphlet Laws No. 73, page 34, State Library, Trenton.]

"An act for the clearing and removing the several obstructions of the free course of the waters in Passaic river, and the several branches thereof, between the Little Falls in said river and the mill-dam across said river near Day's bridge over said river, and for other purposes therein mentioned.

Passed September 26th, 1772.

"SEC. 1. Whereas, The owners and possessors of meadows, low land and swamps, lying on both sides of the river Passaic, and the several branches thereof between the Little Falls in said river and the mill-dam across said river, near the road leading from Elizabethtown to Morristown at Day's bridge, have set forth by their petition that by reason of several obstructions to the free passage and course of the waters in said river and the branches thereof, between the places aforesaid, many thousands of acres of valuable meadows and land are overflowed and rendered in a great measure useless to the owners thereof; and some of the public roads leading from the county of Essex to the county of Morris, are rendered impassable for great part of the year, to the injury of the public in general, and have prayed that they may be enabled, by a law of this colony, to clear out and remove the said obstructions in said river, and the several branches thereof, within the boundaries aforesaid;

"Be it therefore enacted by the Governor, Council and General Assembly of the colony of New Jersey, and it is hereby enacted by the authority of the same, That it shall and may be lawful for the owners and possessors of said meadows, low land and swamps, lying on both sides the river Passaic and the several branches thereof, between the Little Falls on said river and the mill-dam crossing said river, near the public road leading from Elizabethtown to Morristown, at Day's bridge over said river, to remove and take away the several obstructions of the free course and passage of the waters in said Passaic river and the several branches thereof, and keep the same clear and

open for the free course of said waters between the places aforesaid, in such parts of said river and said branches, as the managers hereinafter mentioned, or their successors, or the major part of them for the time being, shall from time to time agree to direct and order.

"SEC. 2. And be it further enacted by the authority aforesaid, That if any person or persons, after the publication of this act, shall make any obstruction of the free course of the waters in said river, and the said branches thereof, between the places aforesaid, by falling of trees or otherwise, he, she or they so offending shall forfeit the sum of five pounds, to be recovered before any justice of the peace within this colony, by action of debt, by either of the said managers for the time being, with costs of suit; and when said forfeiture is recovered, to be applied for and towards the clearing of the said river and the branches thereof.

"SEC. 3. And be it further enacted by the authority aforesaid, That all the costs and expence of said managers, or the majority of them for the time being, shall judge necessary, or be at in clearing and removing the several obstructions that now are, or hereafter shall be, in said Passaic river and the several branches thereof (the fines and forfeitures that may be recovered in virtue of this act being first applied towards the same), shall be equally assessed by the said managers, or the major part of them for the time being, upon the owners or possessors of said meadows, swamps and low land benefited by the clearing out said river, or the branches thereof, as aforesaid, in proportion of the quantity of meadows, swamps or low land any or each of said owners or possessors now do or doth, or hereafter may, hold within the boundaries aforesaid, and benefited by the clearing said river or any of the branches thereof.

"SEC. 4. And be it further enacted by the authority aforesaid, That the owners or possessors of said meadows, swamp and low land shall, and may, at all times hereafter, on the fourth Tuesday in August, yearly and every year, meet and assemble at the dwelling house of Johannes Deremus, in the township of Pequannock, in the county of Morris, or such other place as the majority of the said owners or possessors for the time being shall appoint, and then and there, by plurality of voices of them so met, elect and choose five persons for the ensuing year (until which time George Ryerson, Esq., of Bergen county; William Camp and Francis Post, of Essex county; Ellis Cook and David Tuttle, of Morris county, are hereby appointed managers), which said managers shall be elected out of the owners or possessors aforesaid; and those managers appointed by this act, or the major part of them, or those elected in their stead, or the major part of them, shall have full power to assess the said owners or possessors, pursuant to the directions of this act, in such sum or sums of money as shall be by them, or the major part of them, judged necessary for clearing and removing the several obstructions that now are, or hereafter shall be, in said river and the several branches thereof, within

the boundaries aforesaid, and also all other necessary expences relating thereto; and, in order to ascertain the just quantity of meadows, swamp or low land any and each of the owners or possessors do, or doth, or shall hold within the boundaries aforesaid, it shall and may be lawful for the said managers for the time being, or the major part of them, at any time or times hereafter when they shall find it necessary, to cause all the said meadows, swamp and low land, within the boundaries aforesaid, and benefited by the clearing of said river or the branches thereof, to be surveyed and measured, the expence whereof to be assessed and payed in the proportion aforesaid.

"SEC. 5. And be it enacted by the authority aforesaid, That the said owners or possessors shall also, at their annual meeting, on the fourth Tuesday in August, yearly and every year, elect and choose, by a plurality of voices of those met, a collector, until which time Dirick Maurison is hereby apointed collector, to receive and collect all such sum and sums of money as shall be, from time to time, assessed as aforesaid, agreeable to the list of said assessment, to be to him delivered by said managers or some of them; and that said collector shall give personal notice to said respective owners or possessors of the sum assessed on each of them, or otherwise give publick notice thereof by advertisement set up at five publick places most likely for the said owners or possessors to have notice thereof; and if any of the said owners or possessors shall neglect or refuse to pay the sum or sums of money that shall or may, from time to time, be assessed on him, her or them, for the space of thirty days after such notice, that then it shall and may be lawful for the said managers, or the major part of them for the time being, to let so much of the said meadows, swamp and low land, belonging to such delinquent or delinquents, for such a term as that the rent of the said meadows, swamp and low land will amount to a sum sufficient to pay his, her or their assessment or assessments, and no longer.

"SEC. 6. And be it further enacted by the authority aforesaid, That the said collector for the time being shall, within twenty days after demand made by the said managers, or the major part of them, pay all such sum or sums of money as he shall receive as aforesaid to said managers, or a major part of them, or their order; and upon neglect or refusal of the said collector, it shall and may be lawful to and for the said managers, or the major part of them, to sue the said collector, either while in said office or afterwards, in their own names for the respective sum or sums of money which said collector shall have received as aforesaid, and recover the same in any court where the same is made cognizable, with costs of suit; and the managers for the time being shall lay out and expend faithfully so much of the monies that may come into their hands, by virtue of this act, as they, or the major part of them, from time to time, shall or may find necessary; and the said managers and collector shall give an account on oath, yearly, at their said meeting, of all the money collected and

expended as aforesaid, to the owners or possessors of the said meadows, swamps and low land; which managers, appointed by this act, shall procure a proper sizable book in which they shall make fair entries of all their proceedings, and state a fair account of all monies by them received or expended in virtue of this act; which book, together with the balance of the monies in their hands, they shall deliver to their successors in office on the day of their being elected; and in like manner all future managers shall, in the said book, make entries of their proceedings, and state fair accounts of the monies by them received or expended, and shall deliver over the said book and balance of monies in their hands, to their successors in office; and which managers shall be allowed, out of the monies by them assessed in virtue of this act, five shillings for every day each of them shall necessarily attend in and about the several matters enjoined them by this act, and the said collector sixpence on the pound for the sums by him collected as aforesaid.

"SEC. 7. And be it further enacted by the authority aforesaid, That any person or persons neglecting or refusing to do or perform any duty or thing required by this act shall forfeit the sum of five pounds proclamation-money; to be recovered by any of the said owners or possessors before any one justice of the peace of this colony, to be applied towards clearing out said river, and the branches thereof, within the boundaries aforesaid, with costs of suit.

"SEC. 8. And be it further enacted by the authority aforesaid, That if the said owners and possessors should neglect to meet on the time or times aforesaid for electing managers and collector, in such case the managers and collector for the preceding year shall continue in their respective offices, and have the same powers as before until new ones are chosen, and be liable to the same penalties and duties as aforesaid.

"SEC. 9. And whereas, The pulling down of a mill-dam erected by Captain James Grey and others, over said *Pasaick* river, above and near the said Little Falls, for the removing the obstructions of the waters in said river without the consent of the owners thereof, may have been unlawful and unjustifiable; and the further taking up and removing a rift of rocks in said river about forty rods above said mill-dam, as well as the rift on which said mill-dam was erected, may be thought necessary by said managers for the free passage of the waters of said river, and the doing of which may be an injury to the owners of said mill-dam and rifts, for which they, on a full hearing of the parties concerned, may be awarded and adjudged to be entitled to some recompence to be made them by the said owners or possessors of the said meadows, swamps and low land, between the boundaries aforesaid, benefited thereby; wherefore, to the end that the said parties concerned may have a fair and impartial hearing and determination thereof by indifferent persons for that purpose—

"Be it enacted by the Governor, Council, and General Assembly, and it is hereby enacted by the authority of the same, That John Chetwood, of Elizabethtown, Isaac Pearson, of Nottingham, and John Schurman, of New Brunswick, Esquires, shall be and are hereby appointed and constituted judges to hear and determine between the owners or possessors of said meadows, swamps and low land; and the owners of said mill-dam and rifts (fifteen days' notice being given to said parties, or to some of them, or to their attorney or agent, of the time and place of their meeting), what sum or sums the owners of said mill-dam and rifts ought to have received for the pulling down, removing, and the taking the same out of said river; and the adjudication or determination of the said John Chetwood, Isaac Pearson and John Schurman, or any two of them, in writing, and filed in the clerk's office of the supreme court of judicature for this colony, shall be good, effectual and binding to all the said parties.

"SEC. 10. And be it further enacted by the authority aforesaid, That on a copy or copies of said adjudication or determination, signed and certified by the clerk of said court to be a true copy, being served on the managers, or any three of them, appointed, or that shall be elected and chosen in virtue of this act, the said managers, or major part of them, for the time being, shall, within thirty days after the service of said copies, if the quantity of meadows, swamps and low lands belonging to the said several owners be then ascertained; and if the same be not then ascertained and known as aforesaid, then, and in such case, within twenty days after the said quantities are so ascertained and known, shall assess the sum by the said John Chetwood, Isaac Pearson and John Schurman, or any two of them, adjudged and mentioned in said copies, to said managers delivered as aforesaid, togeather with twenty shillings by the day, to the said judges or such of them as shall attend and perform the service hereby enjoined them, and all reasonable expences, on the several owners or possessors of the meadows, swamps or low lands adjoining or adjacent to said river, and the several branches thereof, within the bounderies aforesaid, benefited by lowering the waters, and clearing said river and branches, in proportion to the quantities they respectively hold or possess within the same; and collect and recover the said assessment in such manner and form as hereinbefore is mentioned and directed for the assessing, collecting and recovering other sums of money to be raised in virtue of this act; and that on the said managers receiving said sum or sums of money by them so assessed as last aforesaid, they do pay the same within ten days thereafter to such person or persons to whose use and for whom the same was or were assessed, agreeable to the said adjudication and determination of the judges aforesaid."

The work and the obligations incurred under the law were continued through several successive years, during which the Revolution

took place, but the constitution of the State which was adopted July 2d, 1776, in its 22d section continued the laws in force which had been passed by that body previous to this date.

In 1782 the following law relating to the same subject was passed:

[From Pamphlet Laws, Vol. V., 1776 to 1782, No. 94, page 123.]

"An act to recover the arrears of certain taxes, levied by virtue of an act intitled, 'An act for clearing and removing the several obstructions of the free course of the water in *Passaick* river and the several branches thereof, between the Little Falls in said river and the mill-dam across said river, near Day's bridge over said river, and for other purposes therein mentioned.'

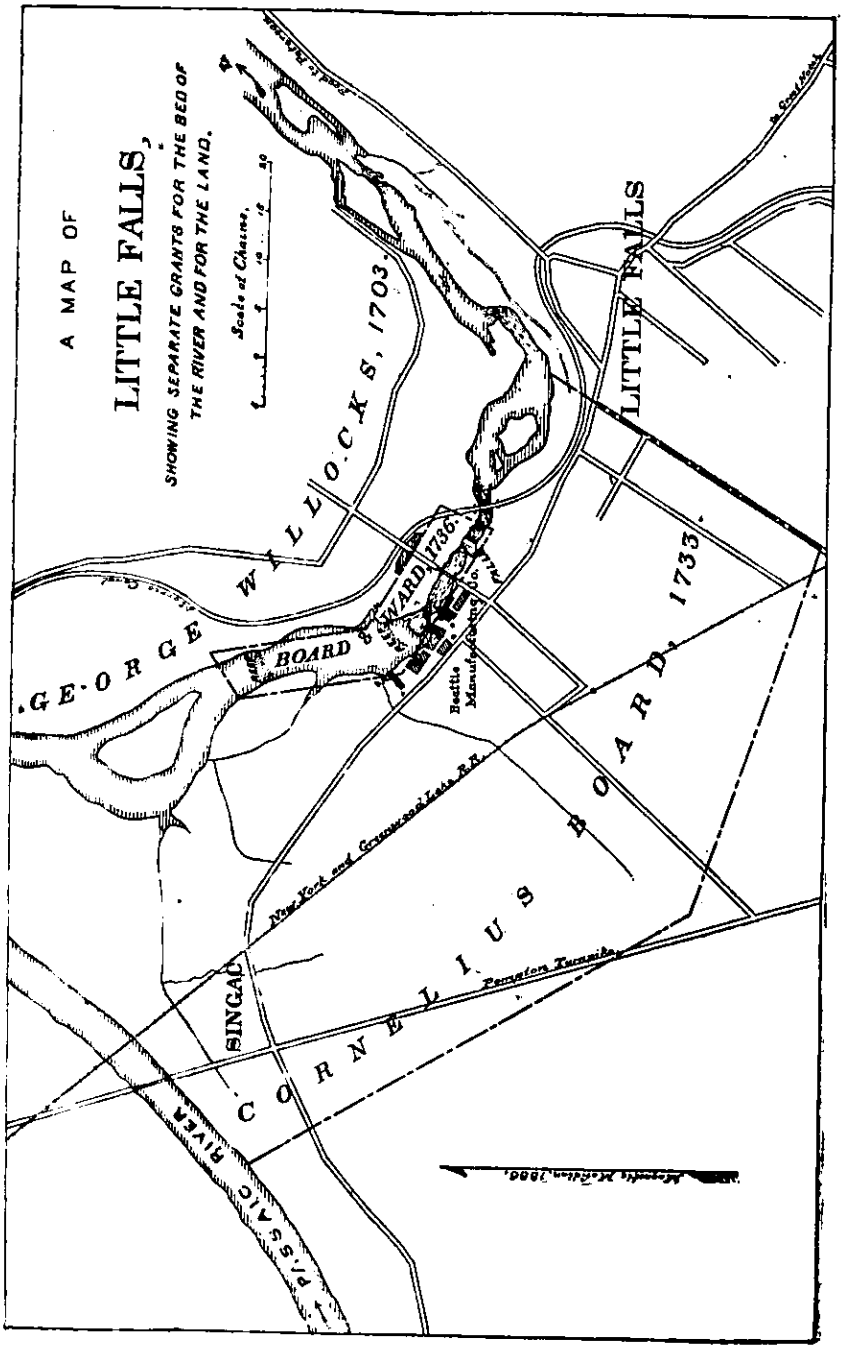
"Whereas, A number of the owners and possessors of meadow and flowed land on both sides of the river *Passaick* have, by their petition, set forth that many difficulties attend the present mode pointed out in the said law for the recovery of the taxes due in virtue thereof; for remedy whereof—

"SEC. 1. Be it enacted by the Council and General Assembly of this State, and it is hereby enacted by the authority of the same, That where any owner or possessor of any of the lands as aforesaid has not paid the whole of his tax, levied as aforesaid, it shall and may be lawful for the collector for the time being to make return thereof to any justice of the peace for the county where such delinquent shall reside, and make oath that the tax hath been demanded, or notice given, agreeably to the directions of said act, upon which said justice shall make out his warrent, directed to any constable of said county, commanding him to make distress and sale of so much of such delinquent's goods and chattels as shall be sufficient to pay such tax and the cost arising thereon, and to pay forward the same to the said collector; and the said justice and constable shall be entitled to the same fees for such services as is allowed on executions in actions of debt; and any justice or constable refusing to do any matter or thing required of him by this act shall forfeit and pay the sum of five pounds, to be recovered by action of debt by the collector aforesaid, and applied to and for the use of clearing the said river.

"SEC. 2. And whereas it may appear upon settling the debts now due for cleaning said river, that sufficient sums of money have not been assessed for the payment of them; therefore—

"Be it further enacted, That in such case it shall and may be lawful for the managers to cause to be collected, in the mode prescribed by this act, such further sums of money as will be sufficient to satisfy and pay the debts now due, and the cost of collecting the same, any law, usage or custom to the contrary in any wise notwithstanding.

"Passed at Trenton, Oct. 4th, 1782."



No records of the Board of Managers appointed to clear out the obstructions to the free flow of the stream have been found, neither has the award of the judges for recompensing Captain James Grey been found on the files of the Clerk of the Supreme Court. But the law of 1782 is itself evidence that the expenses were incurred, and that provision was made for their payment.

From the files of the New Jersey *Gazette* it is learned that James Grey was a royalist, and joined the British army in 1777. On the 26th of April, 1784, Samuel Hayes, agent for Essex county for the sale of forfeited estates, advertised that "on Tuesday, the 8th of June next, will be sold on or near the premises, all that valuable farm at the little falls, in the county of Essex, being part of the forfeited estate of James Grey; the farm contains about 230 acres of land, a great part of which is meadow-land, some plough-land, with wood-land sufficient for fewel and fencing the farm. There is on said farm a large dwelling-house, two stories high, with four rooms on a floor, and a kitchen at one end, with stables and other out-houses, a garden with a variety of grafted fruit, &c. The said farm joins near a mill on the Passaic river, where is a commodious place for building almost any kind of water-works, particularly a grist and saw-mill, on a never-failing stream of water, which privilege will be also sold with the farm. The said vendue to begin at 11 o'clock in the forenoon."

The advertisement of sale in its description agrees with the original grant to Cornelius Board, in 1733. And it makes no reference to the river bottom which was granted to Cornelius Board and Timothy Ward, in 1736, and which was held under a separate survey by James Grey, in 1772. The *water-privileges* mentioned in the advertisement include the rapids which are opposite the farm, but below the falls. These have been utilized since that time, though not now turned to any account. And the term *water-privileges* is still used in the title to the small lot which borders on them on the south side of the river, near the canal.

The rapids between the upper reef and the perpendicular falls was the only part of the stream which was easily available for water-power. It was so used in 1772—was within the scope of that law—and as the title to it does not appear in any deeds since that time, the conclusion must be that it was paid for by the owners of the flowed lands, as the law required. And in such case it would be held by the owners of flowed lands as common property—without a deed—and

open for them to clear out in the future as the means provided would warrant.

How much other work was done in clearing the stream at that time is not known.

The following is a list of the laws in relation to draining the low lands since passed:

September 8th, 1788.

An act to enable the owners and possessors of the meadows and swamps lying on the rivers Passaick, Rockaway and Whippany, between the Little Falls and Chatham, to remove the obstructions therein.

June 9th, 1790.

An act to enable the owners and possessors of the meadows, swamps and low lands on the river Passaick, and its several branches, between the Little Falls and the mill-dam at Chatham, to break up the reef at said falls, and to dig canals for the more effectual draining said lands, and to raise money for that purpose.

Under this law of 1790 some work was done in trying to lower the reef at Little Falls, and much in trying to open a passage for the water from the Passaic at Pine Brook through the Long Meadow and Deep-a-Vaal brook to the river between Two Bridges and Little Falls. The passage is still to be seen, but it was not cut deep enough. In very high freshets the water is said to run through. The distance by which the stream would be shortened in this way is five miles or more.

January 31st, 1812.

An act to enable owners and possessors of the flowed lands and swamps on the Passaick river and its branches, between the Little Falls on said river and the mill-dam at Chatham, to break the reefs in said river, near said falls, and to remove all obstructions to the free course of the waters out of said river.

No reference is made in this act to any damage to mill-owners. Neither is there any in the act of 1790. It is not known that anything was accomplished by this act.

February 8th, 1815.

An act to repeal an act and part of an act to enable owners and possessors of flowed lands on the Passaic and its branches to clear the same.

This act repealed the right to tax the land-owners for clearing the stream.

February 2d, 1820, p. 106.

An act more effectually to provide for the removal of all the obstructions to the free course of the waters in the river Passaic and its branches, between Cook's bridge and the reef at the Little Falls, next below the turnpike bridge, commonly called Singack bridge.

It is not known that this accomplished anything.

February 27th, 1834.

An act to provide for the removal of obstructions in the river Passaic and its branches, between the turnpike bridge at Chatham and Cook's bridge at Hanover.

Nothing was done under this act. It did not meet the real difficulties.

March 9th, 1836, p. 345.

An act to enable the owners and possessors of the flowed lands and swamps on the river Passaic and its branches, between the turnpike road at Pine Brook, on said river, and the mill-dam at Chatham, to break up the reefs in said river, and remove the obstructions to the free course of the waters of the same.

Nothing could come of this act. It was only like clearing a mill-pond.

February 1st, 1844, p. 38.

An act to enable owners and possessors of the meadows and flowed lands on the Passaic river and its branches, between the mill-dam at the Little Falls and the mill-dam at Chatham, in the counties of Essex, Morris and Passaic, to break up the reefs in said river, to widen the channel of the same and to remove all obstructions to the

free course of the water out of the said river, between the said mill-dam at the Little Falls and one hundred yards above the two bridges.

Under this act money was raised and expended in blasting out the upper rock-reef at Little Falls, and Mr. Caleb Harrison, of Caldwell, under whose supervision it was done, reported that the reef was lowered at least a foot entirely across, and a portion of the way somewhat deeper. He also reported that the lands along the river above were better drained and dryer than they had ever been before. In this law there is some reference to compensation if any damage were done to mill-owners.

March 11th, 1858, p. 301.

An act to authorize commissioners to dig a ditch from some point on the Passaic river, at or near Pine Brook, in a direct course, or as near as may be, to some point on the said river, at or near the mouth of Deepavaal brook, in the county of Essex, for the purpose of draining the flowed lands on the said river and its tributaries, and to relieve the people in the vicinity thereof of sickness and diseases caused thereby.

There were surveys made and contracts given out for digging the projected ditch, but the work was summarily suspended by injunction, on account of a difference of views regarding the location of the beginning of the ditch at Pine Brook.

March 8th, 1871.

An act to provide for the drainage of lands.

It is under this act and its supplements, that the proceedings are had for the drainage of the lands on the Passaic above Little Falls.

March 19th, 1874.

A supplement to the act to provide for the drainage of lands.

March 31st, 1875.

A supplement to the act to provide for the drainage of lands.

March 8th, 1877.

A further supplement to the act to provide for the drainage of lands.

As will be seen from the legislation on the subject, and the attempts at more perfect drainage, there was no further difficulty with mills or water-power for between 30 and 40 years after 1772. In 1805 or 1806, the Miller family began the erection of mills at the head of the falls on the south side of the river, and in 1812 there was a saw-mill on the north side which belonged either to Anthony Dey or to Samuel Burdge. And from that time on up to the present, the water-power from the rapids at the head of the falls has been used. Only wing-dams for turning the water from the stream upon the wheels were constructed at first, and there was no pondage. Within the memory of persons now living, the mills were liable to be deficient in power, and even to be stopped, in dry seasons by the lack of water. Gradually, however, and insidiously, the dams, even when built of timber, were made so as to completely intercept the whole stream, though they were still so leaky that they did not back the water up so as to cover the whole of the upper reef, even after it was lowered in 1844. But a strong and tight stone dam was begun by the late Robert Beattie in 1867 and finished in 1869, which was raised to a level above the highest part of the reef. This has created a pond which extends up to Horse Neck bridge, 9 miles. In this pond the waters can be stored at night so as to almost double the water-power which can be used at the mills. On the other hand, the damaging effects of the freshets, both upon the occupancy and use of the land, and upon the health of the inhabitants, are greater than ever. While the value of well-drained uplands has increased largely, the price of the lands subject to overflow has constantly diminished for many years past. The crops of hay are sometimes entirely lost, at other times greatly damaged, and while sometimes very good, the dependence upon them is precarious, while the investment and expense of preparation is constant. The swamps are in some places so overflowed with water that they are only accessible in winter, when the water and mud are frozen, so that while the timber in them is valuable, it cannot always be got on demand, and years with mild winters may intervene in which it cannot be got out at all.

The effect of these obstructed and stagnated waters and the decaying vegetation produced by them upon the health of the inhabitants living in the vicinity is still worse. Malarial diseases are almost universal in some years. Children and strangers are specially liable to be attacked by them. But the effect upon all is seen in the diminished

energy and vigor which this poisoned atmosphere produces. The smell which attends the decaying vegetation is both sickening and alarming, especially after sunset, and the fogs which rise over so large a body of wet ground are uncomfortable and injurious. An experience of more than 60 years confirms these statements, but a few facts from others may not be out of place here.

An old resident upon them, now nearly 80 years old, writes:

"During my childhood and youth, until I was 30 or 40 years old, I remember that the fever and ague was very prevalent in all the Big and Little Piece district, and after I became acquainted in the neighborhood where I now live I found it affected all the people on both sides of the river more or less all the way to Swinefield, and extended across the meadows to Troy. In the neighborhood of Big Piece and Little Piece almost every family would have it some years. Other years it was not so universal.

"I know that if anyone not acclimated went to live in what is called the Fever and Ague district, they would be sure to get chills *any* year. I remember meeting a resident of the flowed lands once after they had had a freshet, and asked him if the water had gone down, he said 'Yes, and we are a live carrion.' I have been there when the stench was awful, and then everybody expected to be sick.

"I remember years when at least half, and I think I might almost say three-quarters of the people were sick. The ague used to affect the children more than old persons.

"Our house was on the edge of Caldwell Hills, and from there on up to Caldwell the chills do not prevail."

A clergyman, whose residence was within the bounds of the flowed lands, writes as follows:

"In my opinion, the Passaic valley for 15 miles above Little Falls is a very undesirable section of New Jersey to reside in. The experience of myself and family in that locality is by no means a pleasant thing to look back upon, as we were more or less troubled with malaria during our residence there of a little more than 4 years, and in fact the germs were planted so deep that living for nearly 10 years in the bracing and life-giving air of the Catskills, has failed fully to eradicate them. I think nothing could induce us to repeat the experiment. The 'chills,' as they say in Passaic valley, is so common a thing that they seem to take it for granted that it is a part of their life and *all right*.

"I think I am safe in saying, that during my stay there not a family in my congregation (75 families) escaped an attack of malaria in some form, in some one or more of its members, and the same I

think could be said of that whole section of country. I once heard a physician say that he had practiced there for 40 years, and that during that time he had never lived a year without an attack of malaria himself."

Another clergyman, in the same district, has just informed the writer that he has been obliged to give up his charge on account of the violent and long-continued attacks of chills and fever, which took away his strength, and which attacks he found would return from very slight causes. He considers the disease to be incident to the flooding of the lands, and that very few of the inhabitants escape its attacks.

The testimony of physicians to the unhealthiness of these flowed lands is also decided and clear.

Quinine is the medicine used to prevent or cure the chills, and its use is so common and well understood, that it is kept in the country stores with other family supplies, and a stock of it is provided in families, to be ready whenever any one is taken with chills. In mild cases, the quinine is administered without calling in a physician for advice, and it, undoubtedly, is the best thing that can be done, short of draining the land and removing the causes of the disease.

It would hardly be worth while to publish this condition of things in the Passaic valley if it were necessary that it should exist. But it is not necessary. The lands can be made among the most desirable in the State; the salubrity of the district can be assured, and the thorough reclamation of these now discredited grounds, will make the whole valley, with the hills and mountains bounding it on every side, one of the most beautiful and attractive regions in the State. And all this can be done at a moderate expense, and without damage to the valuable manufacturing industry which is carried on at the village of Little Falls.

The agricultural value of the alluvial soils along the river is not at all understood. When drained they will take their place among the richest and most productive lands of the State. They are as good as the banked meadows on the Delaware, or the Maurice river, or the drained lands on the Pequest, or the rich bottom lands along the Raritan. They have the same qualities which have made the Bedford level, in England, and the polders, in Holland, the most profitable agricultural lands in Europe.

Drainage for health has been so often and so satisfactorily tried

that it is a proved and accepted mode of preventing disease, or, if the disease has come, of curing it. The Great Meadows drainage, cited at the beginning of this report on drainage, is a case in point. Another remarkable case is given in the Annual Report of the State Board of Health for 1881, in which the village of Bound Brook, in Somerset county, with a population of about 1,200, where 95 per cent. of the whole number were sick with malarial disease in a single season. The sickness was caused by the decaying vegetation in a shallow mill-pond of fluctuating level. The owners of the mill were compelled to take out their dam and clear the stream of sediment down to its original depth. There has been no malarial disease in the place since that season, and it has become a thoroughly healthy village.

The foregoing statements are sufficient to show that the stream and flowed lands of the Passaic above Little Falls constitute a public nuisance. The abatement of this was begun in 1772, and has been continued in various ways and at different times since that year. There is good reason for the conclusion that the owners of the flowed lands were taxed for the purchase of the river bottom at the falls, and that the title to it was given up to them as a public body and owner. It was a public benefit to all to have the water-power at the falls used, so long as it did not interfere with the free flow of the stream above them. But the property and health of the people in the valley above now require that the nuisance which has so long existed shall be still further abated, and they claim the right to use their ownership of the river bed at the falls, and to clear it out to the full depth of the stream above.

The water-power there is usefully employed by the Beattie Manufacturing Company, and it has been occupied by them for a number of years. They claim the ownership of it by long possession as well as by the purchase of all the land on both sides of and bordering on the river.

If long possession of property which is partly a public nuisance, and partly the means of maintaining such a nuisance, gives good title to it, then the question may be properly investigated for the company on that ground. But if no length of possession can give title to that which is a public nuisance, then the public, through the proper authorities, may well claim and endeavor to maintain their rights.

The Board of Commissioners in making their award have evidently undertaken to fully carry out the plan of drainage, and at the same

time to leave the amount of water-power which is used undiminished. The mills are now run with 14 feet head of water. When the dam is lowered 7 feet, one-half the power at present used will be taken away. The narrow gorge in which the falls are has been too formidable for mill-owners to improve, or else there has been no demand for the power which is there running to waste. To protect and continue the important industry which the Beattie Manufacturing Company are conducting, and which is the principal source of occupation for the people in the village of Little Falls, the commissioners consider that the unused falls which may belong to the public can be brought into use, and power greater than that now used can be connected with the mills just as they stand. To do this, it is proposed that a strong dam be built on the rocks at the lower falls and raised to a height 7 feet lower than the present dam, that a wheel-pit be blasted out in the rocks at the foot of the falls in which the proper wheels can be set and connected by shafting with the mills. The available head of water which this would give is nearly double that with the present arrangements, and it can be so prepared for as to stop the running of the mills only one or two weeks.

The Commissioners have probably taken this expense into the account, with other items, in making up their award. Looked at from the land-owners' side of the case it may be thought a large sum, but it is not an unmanageable or burdensome one even for the poorest. From the side of the manufacturing company it may be thought too small, but it takes from them no productive property, and instead of what are only prospective values, it gives them relief from claims and complaints which will never be quieted till the flow of the water at and above the falls is clear and unobstructed.

IV.
MISCELLANEOUS PAPERS.

MUSEUM OF THE GEOLOGICAL SURVEY.

The burning of the State House in 1885 destroyed many of the specimens which were collected and on exhibition there. Fortunately a good representation of them was away on exhibition at the New Orleans Exposition, and was saved. These are now stored in the State Arsenal at Trenton. In the new State House now being erected, a convenient, spacious and well-lighted room has been set apart for the museum. The building is under contract to be finished by November 1st, 1887. And it is the plan of this Survey to make and arrange as complete a collection as possible of its rocks, minerals, ores, limestones, building stones, slates, soils, marls, clays, sands, etc.; also collections of its plants and animals. And it is intended also to put on exhibition as large a collection as possible of the fossils found in the State, and of the implements and other relics of the men who formerly had our State for their home.

Jerseymen and other friends who desire to have these objects of interest brought together and preserved for public inspection, have already tendered their aid in making collections for the museum, and the contributions of others who may have objects in these lines, are solicited. Notice of contributions may be sent to the State Geologist at New Brunswick. A record of the gifts and deposits will be made and published yearly.

PUBLICATIONS OF THE SURVEY.

THE ANNUAL REPORTS OF THE STATE GEOLOGIST are printed by order of the Legislature, and as part of the legislative documents. They are distributed largely by the members of the two houses. Extra copies are supplied to the Managers of the Geological

Survey and the State Geologist, who distribute them to libraries, public institutions, and, as far as possible, to any who may be interested in the subjects of which the report treats. Most of the reports of former years have been distributed, and the editions are exhausted.

THE REPORT ON FIRE AND POTTERS' CLAYS OF NEW JERSEY has been widely distributed. Of the copies which were left, most of them were lost in the burning of the State House, and but few copies are remaining.

THE PRELIMINARY CATALOGUE OF THE PLANTS of the State has been generally distributed among botanists, so as to get in return reports of the localities of plants, and to thus have the assistance of botanists in making a *complete* list of all our plants. The revision is going on; several new plants have been discovered during the last year, and many new localities of well-known plants have also been found. A few copies of this preliminary catalogue are still on hand, and the co-operation of botanists in getting new species is earnestly solicited. It will be one or possibly two years before the revised edition will be completed so as to be published.

A TOPOGRAPHICAL MAP OF A PART OF NORTHERN NEW JERSEY, on a scale of one mile to an inch, is printed, and has been distributed to some extent. In addition to the delineation of boundaries, streams, roads and geographical matter, it has on it contour lines of level, so that the elevations of the surface above mean tide are accurately marked on all parts of it. This map has been very generally approved, and is in demand for laying out drains, ditches, water-works, roads and railroads, and for selection of building-sites, and as a study for drives, bicycle excursions, etc.

THE ATLAS OF NEW JERSEY is now in course of preparation, and several sheets are done. These sheets are each 27 by 37 inches, including margin, and are intended to fold once across, making the leaves of the atlas 18½ by 27 inches. The completed work will be made up of seventeen of these maps, on a scale of 1 mile to the inch, and one map of the whole State, on a scale of 5 miles to the inch. The location and number of each map are given on the reference map, on page 37 of this report, and are printed on the paper cover of the atlas. Num-

bers 1, 2, 3, 4, 6, 7, 8, 9, 11, 12, 13, 16 and 17 are now ready. The other numbers will be issued, probably, in 1887 and 1888.

The following is a list of the titles of the sheets, with their numbers:

New Jersey State Map. Scale, 5 miles to an inch.

No. 1. Kittatinny Valley and Mountain, from Hope to the State line.

No. 2. Southwestern Highlands, with the southwest part of Kittatinny valley.

No. 3. Central Highlands, including all of Morris county west of Boonton, and Sussex south and east of Newton.

No. 4. Northeastern Highlands, including the country lying between Deckertown, Dover, Paterson and Suffern.

No. 5. Vicinity of Flemington, from Somerville and Princeton, westward to the Delaware.

No. 6. The Valley of the Passaic, with the country eastward to Newark and southward to the Raritan river.

No. 7. The Counties of Bergen, Hudson and Essex, with parts of Passaic and Union.

No. 8. Vicinity of Trenton, from New Brunswick to Bordentown.

No. 9. Monmouth Shore, with the interior from Metuchen to Lakewood.

No. 10. Vicinity of Salem, from Swedesboro and Bridgeton, westward to the Delaware.

No. 11. Vicinity of Camden, to Burlington, Winslow, Elmer and Swedesboro.

No. 12. Vicinity of Mount Holly, from Bordentown southward to Winslow and Woodmansie.

No. 13. Vicinity of Barnegat Bay, with the greater part of Ocean county.

No. 14. Vicinity of Bridgeton, from Allowaystown and Vineland, southward to the Delaware Bay Shore.

No. 15. Southern Interior, the country lying between Atco, Millville and Egg Harbor City.

No. 16. Egg Harbor and Vicinity, including the Atlantic Shore from Barnegat to Great Egg Harbor.

No. 17. Cape May, with the country westward to Maurice River.

GEOLOGICAL MAP OF NEW JERSEY.—Scale, 6 miles to an inch. The improvements going forward in the State call for a revision of our map very often. The one which was printed with the Annual Report of 1882, and was corrected up to that date, had some corrections in railroads, some minor improvements in the geological coloring, and much was added in new places along the sea-shore, and the life-saving stations were all located. A few copies are still on hand.

DISTRIBUTION.—The Board of Managers of the Geological Survey is made by the terms of the law "a committee of publication, with authority to print and publish the annual and final reports of the State Geologist" ——— "as will best conduce to the interests of the citizens of the State." The Geology of New Jersey, printed in 1868, was published by the Board. And the engraving and printing of the Topographic and Geologic maps have also been published by their authority. But the printing of the annual reports and their distribution, and to some extent the distribution of the maps and special reports, have been by the action of the Legislature and its members. This has tended to a very general distribution of the publications of the Survey among the people of the State, who have approved them, and in many cases have turned their practical suggestions to useful purposes.

The distribution of so many and such expensive reports and maps among the people, seems almost unwarranted, but the continued and rapid growth of the State in all its material interests, may be considered as proving that this general publication of its natural resources and advantages, is an advertisement for it, and that the information disseminated in this way brings a quick return. If a price were put upon the publications they would not be so widely circulated, and their benefits would be attained much more slowly. A complete register is kept of all maps and reports which are sent out from the office of the survey, and in the case of the maps it is intended to keep a record of all that are sent out, and of the persons to whom sent. Applications for them are generally made in good faith, and by those who would wish to make use of them, but some cases occur in which the person applying is seeking them for trade, and others where there is no knowledge of their real use.

Copies are sent to all known public libraries in the State, and to those of New York, Brooklyn and Philadelphia, and to all the State

libraries; also to State officers, to judges of the Supreme Court, to many surveyors and engineers, to persons engaged in public works, to many geologists and naturalists, and to many others who have been accredited by members of the Board or by public officers.

A list of the members of the Board of Managers of the Geological Survey is given at the beginning of this report, and persons desiring to secure copies of any of the publications will please make application through a member representing the congressional district in which they reside.

The results of the survey are intended for the benefit of the citizens of the State, and the Board of Managers have charge of and direct the distributions of its collections, reports, &c. The addresses of the members of the Board are given on page 3 of this report, and application made for publications to them, or through them to the State Geologist, will be received and given due attention.

EXPENSES.

The annual appropriation of $8,000 a year has been sufficient to meet the expenses, and all bills are paid in full to date.

The expense of topographical surveys paid by the United States Geological Survey was:

From July 16th, 1884, to June 30th, 1885	$9,213 03
From July 1st, 1885, to June 30th, 1886	11,999 95
From July 1st, 1886, to December 31st, 1886	7,914 46
Balance appropriated to June 30th, 1887, unexpended	4,085 54
Total	$33,212 98

The expense of the Geodetic Survey is paid by the United States Coast and Geodetic Survey, and the total amount expended for this work since 1875 is $22,629.76.

ASSISTANTS EMPLOYED.

My own time and attention have been given to keeping the survey, in all its departments, in operation. The triangulation, the topography, the works of drainage, the questions of water-supply, the agricultural improvement of our lands, the progress of our mining,

quarrying and other industries of like character, demand attention, and the systematic resurvey of the geology of the State, with the aid of our completed topographic maps, has been begun.

DR. NAT. L. BRITTON, of Columbia College School of Mines, has been engaged in surveying the Archæan rocks of the Highlands, and in collecting the characteristic rocks. This service was begun the first of June, and with some interruptions is continued to the present time. He still has the revision of the New Jersey Flora in hand.

MR. FRED J. H. MERRILL, PH.B., has been engaged in surveying and describing the geology of the Tertiary formations in Southern New Jersey a part of the season, and later in studying the Green Pond Mountain rocks.

PROF. R. P. WHITFIELD is still engaged in figuring and describing the Cretaceous invertebrate fossils of New Jersey. He has completed his figures and descriptions of the Gasteropods.

DR. J. S. NEWBERRY is just completing his paleontological work of describing and figuring the fossil flora of the Triassic and Cretaceous periods, and the fishes of the Triassic.

MR. C. CLARKSON VERMEULE, Topographer in Charge, has prosecuted the Topographic Surveys steadily throughout the year. He has been aided by the following assistants:

MR. F. W. BENNETT, Assistant Topographer, has been principally engaged in leveling and sketching for topography. He also had charge of a transit party on Delaware bay in May and June.

MR. P. H. BEVIER, Assistant Topographer, has been engaged in leveling and sketching for topography, and in running primary levels. He had charge of a transit party on Delaware river in June.

MR. WM. H. LUSTER, JR., Assistant Topographer, has been principally engaged in leveling and sketching for topography.

MESSRS. P. D. STAATS and ASHER ATKINSON, Assistant Topographers, have been engaged in topographic work throughout the year.

MESSRS. CYRUS F. SPROUL and FRANK VAN BRAKLE, Draughtsmen, have been steadily employed in mapping and in furnishing data to the field parties during the year.

MESSRS. N. B. K. HOFFMAN and WM. F. MARVIN, Odometer Recorders, have been surveying roads throughout the season.

The above assistants have been employed in the field from April 5th to December 10th, and during the winter months in the office. The following gentlemen have been at work during portions of the year:

PROF. A. A. TITSWORTH was employed in July and August, in the triangulation of Southern New Jersey.

MR. JOHN E. HILL was employed at the office during June and July, and in the field, assisting Prof. Titsworth, in August.

MESSRS. J. B. REYNOLDS, L. M. RICE, JR., C. M. DU BOIS, H. S. SPROUL, H. M. VEGHTE, C. B. MARSHALL, H. L. LEHR and H. A. IRICK have been employed as field aids during the season.

MR. J. G. TAIT was employed in the office in February and March.

STATISTICS OF IRON AND ZINC ORES.

IRON ORE.

The output of the iron mines of the State for the year 1886, as shown by the shipments of iron-ore from stations in the State and the amounts used at furnaces which do not come in the tonnage of the railroad lines, aggregated 500,501 tons—an increase of 170,501 tons as compared with the production of 1885. For the convenience of reference the statistics of iron-ore mined in the State for the years 1870–1886, inclusive, are here inserted in a tabular form. Estimates and U. S. census figures at intervals back to 1790 are also given at the head of the column:

1790..... 10,000 tons ..... Morse's estimate.
1830..... 20,000 tons.....Gordon's Gazetteer.
1855.....100,000 tons.....Dr. Kitchell's Estimate.
1860.....164,900 tons .....U. S. census.

1864	226,000 tons	Annual Report State Geologist.		
1867	275,067 tons	"	"	"
1870	362,636 tons	U. S. census.		
1871	450,000 tons	Annual Report State Geologist.		
1872	600,000 tons	"	"	"
1873	665,000 tons	"	"	"
1874	525,000 tons	"	"	"
1875	390,000 tons	"	"	"
1876	285,000 tons*			
1877	315,000 tons*			
1878	409,674 tons	"	"	"
1879	488,028 tons	"	"	"
1880	745,000 tons	"	"	"
1881	737,052 tons	"	"	"
1882	932,762 tons	"	"	"
1883	521,416 tons	"	"	"
1884	393,710 tons	"	"	"
1885	330,000 tons	"	"	"
1886	500,501 tons	"	"	"

This tabular statement shows that from 1870 to 1874 there was a gradual and steady increase in the annual production. The financial depression in the latter part of 1873 marked a turn in the rate of production, and the lowest output for the decade was reached in 1876. The product for 1877 was slightly in excess of that of 1876, and from that year onward there was a gradual rise to the boom of 1879, which showed itself in the large increase in 1880. The maximum was attained in 1882. The decline since has been marked.

ZINC ORE.

The product of the zinc mines for the year 1886, as shown by the shipments over the transporting lines, was 43,877 tons.

The following tabular statement shows the production of the zinc mines of New Jersey for a number of years:

	Estimated tons.			
1868	25,000	Annual Report State Geologist.		
1869				
1870				
1871	22,000	"	"	"
1872				
1873	17,500	"	"	"

*From statistics collected later.

1874	13,500	Annual Report State Geologist.		
1875				
1876				
1877				
1878	14,467	"	"	"
1879	21,937	"	"	"
1880	28,311	"	"	"
1881	49,178	"	"	"
1882	40,138	"	"	"
1883	56,085	"	"	"
1884	40,094	"	"	"
1885	38,526	"	"	"
1886	43,877	"	"	"

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K.

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Y.

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