GEOLOGICAL SURVEY OF NEW JERSEY.

ANNUAL REPORT

OF THE

STATE GEOLOGIST,

FOR THE YEAR

1879.

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1879.

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

SIR—I have the honor to submit herewith my annual report on the progress of the State Geological Survey for the year 1879, as required by the "Act to complete the Geological Survey of the State," approved March 30th, 1864.

With high respect,

Your obedient servant,

GEORGE H. COOK,

State Geologist.

REPORT.

INTRODUCTION.

The Geological Survey of New Jersey has been continued during the year 1879 as in preceding years. Charged with work of an economic and practical character, the results of which are of immediate use, the annual reports are necessarily much occupied with these results. There is, however, joined to this, some work of a scientific character, and every year something is added to the knowledge of our geology. For the proper delineation and location of the various natural products found in the State, good maps are needed, and it has been found necessary to give much attention to the construction of such maps. The nature of the work of the survey will be best understood by an examination of the list of topics which are discussed in this report.

1. U. S. Geodetic Survey of New Jersey.
2. Topographical map of Northeastern New Jersey.
3. Economic Geology of New Jersey, with a map.
4. Triassic or Red sandstone formation of New Jersey.
5. List of iron mines in the State, with notes.
6. Soils.
7. Drainage.
8. Water supply.
9. Artesian or driven wells.
10. Miscellaneous laboratory examinations and analyses.
11. Statistics.
12. Publications.
13. Expenses.
14. Persons employed.

1. UNITED STATES GEODETIC SURVEY OF NEW JERSEY.

The first element in the geographical description of any place is its location on the surface of the earth; in other words, its latitude and longitude. This has been ascertained for many places, with more or less accuracy, by means of astronomical observations made by astronomers and navigators, after which, by measurement with bearings and distances, the locations of other places have been determined. The results of this kind of work, however, were not accurate enough to meet the requirements of the present day, either on land or along our shores. The United States Coast Survey was set in operation for the benefit of navigators. Its work was to determine with accuracy the location of the prominent landmarks on our whole coast. It has done its work well; it has originated new and more accurate methods for ascertaining the location of points, and has computed and published, in lists and on its maps, the exact latitude and longitude of hundreds of places along the coast of our country. New Jersey is favorably situated to be benefited by this work, and along the whole eastern side of the State, and up Delaware bay and river, above Trenton, the latitudes and longitudes of a sufficient number of places have been determined as part of the work of surveying the coast. In addition, the field of operations of the coast survey has been enlarged so that it now has the work of determining latitudes and longitudes across the continent from the Atlantic ocean to the Pacific, and it also has authority to aid States which are conducting geological or topographical surveys —ascertaining for them, at the expense of the general government, the geographical positions of places in such States away from the coast.

Under this authority its work has been going on, to a moderate extent, in our State for the last five years. The system of primary triangles which was originally marked out across middle of the State, from New York to Philadelphia, and thence down the coast, has now been extended so as to take in the whole of the northern end of the State; the *reconnaisance* has been made, the principal and many of the secondary and tertiary points have been located, and a sufficient number

of observations have been made from several of these points to compute their position accurately.

The labor and expense attending this work are very great. These will be better appreciated when it is remembered that the sides of the triangles are some of them nearly 30 miles long, and in our hazy atmosphere the signals which mark the angles cannot, on the average, be seen accurately one day in the week, and the times when they can be seen are entirely uncertain, so that constant watch has to be kept; that each angle has to be measured at least seventy-two times, and these measurements must not vary from each other more than 6″, and the sum of the angles thus carefully averaged must not vary 2″ from 180° plus the computed spherical excess. As angles of several triangles (8 to 12) are measured from the same station, it may require three or four months of patient observations to complete the work at one such station.

When this work is done, however, and the computations completed, the positions of the points on which observations have been made are known to within a very few inches—in some cases, which have been verified, not more than 1 or 2 inches, on lines which were several miles long.

For the work in northern New Jersey eleven primary stations have been established, in addition to the two old stations which were occupied in connecting these stations with the work formerly done. Of these eleven primary stations, work has been completed on three besides the two old ones, and that on a fourth is two-thirds done.

The *reconnaisance* of northern New Jersey is chiefly done, and the work of observations is not quite half done. The field in southern New Jersey is not so large as in the northern part of the State, and has not yet been begun. It is to be hoped that the United States Coast and Geodetic Survey, with its completely organized methods of work and its admirable equipments for field operations, will carry their survey of New Jersey through to its completion, so as to give us an accurate basis for our maps.

2. TOPOGRAPHICAL MAPS.

The topographical map of the country between the Hudson river and the mountains west of Newark, and extending from the Raritan to Paterson, was well advanced last year. This year it has been extended so as to take in the country west to the main range of the Highlands. It now covers an area of 746 square miles. It has been drawn on a scale of 3 inches to a mile, and the elevation of the surface is shown on the map by contour lines at every twenty feet of elevation in the hilly parts, and at every ten feet in parts nearer level or where the rise is more gentle. To insure the accuracy of this map in those parts over which the United States Geodetic Survey had not yet extended, it was found necessary to extend their triangulation over a small part of the country covered by the northwestern part of this map; and 13 tertiary points have been observed upon by our survey, so as to make sure of the accuracy of the basis of this map. The result shows the necessity for this preliminary work, for the old county and State maps are found to be fully one-third of a mile out in their locations on those parts of the map farthest from the stations of the geodetic survey. This work has involved labor and expense, but they are well repaid, and it is believed that the map is now right in its location to within a small fraction of 1″; and the elevations are marked so nearly that there is no spot on the whole 746 miles of the map where the height of the surface above sea level cannot be seen within 3 or 4 feet.

This map covers the ground which is occupied by more than half the population of the State. The country is developing very fast, and the increase in population and wealth is rapid and steady. The map furnishes needed information in regard to locations, drainage, laying out roads, and for local and general improvement and embellishment.

For engraving, it can be reduced to a scale of 1 inch to the mile without much crowding of the material, and will make a map about 3 feet square. A scale of 1½ inches to the mile would make a better map, and being then only about 4½ feet square would not be unwieldy in size.

A similar topographical survey should extend over the whole Highland range of mountains. Our great deposits of iron and zinc ores are all in this range. The immense value of the ores, the increasing demand for them, and the occasional discovery of new and rich mines, show that it is of public importance to help on the development of this region. Information in regard to the exact location of these deposits, and their relations to or connections with each other, cannot be furnished by private enterprise. It is the proper work of the geological survey, and it is proposed to begin it as soon as the necessary arrangements can be made.

3. MAP OF NEW JERSEY—ECONOMIC GEOLOGY.

The map which accompanies this report is drawn on a scale of six miles to an inch, and is intended to show the leading features of our economic geology.

1. By means of colors, and by the columnar section it gives the geological structure and formations of the State.

2. By means of conventional marks it shows the location of the principal mines of iron and zinc ore.

3. By reference to the characteristic colors on the columnar section, and on the map the beds of limestone, marl and fine clay are easily found.

4. The colors on the map furnish a clue to the location and origin of the characteristic soils of the State.

All the larger geological formations of the United States, except the coal formation, are found in New Jersey. They occur in parallel belts or zones, usually some miles in breadth, which traverse the State in a northeast and southwest direction; and they are so regular in this respect, that a person may travel on a northeast and southwest road from one side of it to the other, and see but a single geological formation. But, on the contrary, if he should journey from Barnegat, on the Atlantic coast, northwest to Port Jervis, on the Delaware, he would cross every one of its formations.

Its oldest rocks make up the mountain range which crosses the northern part of the State from northeast to southwest in parts of Sussex, Passaic, Bergen, Warren, Morris, Hunterdon and Somerset, and which is known in New York as the Highlands, in Pennsylvania as South Mountain, and is here without any general name, but its individual ridges are known as Ramapo Mountain, Hamburg Mountain, Schooley's Mountain, Trowbridge Mountain, Watnong Mountain, Musconetcong Mountain, Scott's Mountain, Marble Mountain, and others. The newer geological formations lie upon each side of this central ridge, and run parallel with it; the Silurian and Devonian limestones and other formations being mostly in a broad belt upon its northwest side, and a little in its valleys; the Triassic red sandstone

adjoins it in a broad belt on its southeast side; the Cretaceous clays and marls stretch across the State in a belt just southeast of the red sandstones, and the Tertiary and the recent formations lie southeast of the marls. The columnar section of New Jersey formations on the map shows their order and relative position, as they have been proved by measurement and comparison at the various places where they occur in different parts of the State. It does not, however, give the relative thickness of the different formations, those in the lower part being much thicker in proportion to the higher, and the layers or strata are not level as represented here, but are almost all of them slanting or *dipping* downwards towards the northwest or southeast. The Azoic, Cretaceous, Tertiary, and most of the Recent, have a prevailing dip towards the southeast, while the Silurian, Devonian and Triassic mostly dip towards the northwest.

The Azoic rocks are the Archaic of Dana, and the Laurentian of Canada; they are the oldest of the geological series, and are made up of granitic, gneissic and other crystalline rocks, and contain no fossils. The mountain ranges which cross the northwestern part of the State, and which are known by the names of Ramapo, Warwick, Hamburgh, Pochuck, Schooley's, Mine, Musconetcong, Scott's, and other mountains, are made up of these rocks. They cover an area of about 772 square miles in New Jersey, and they contain all the mines of magnetic iron ore.

The country which this formation occupies is hilly or mountainous in all its parts. The northeastern end of the belt in this State is rough, and has many boulders scattered over its surface, so that much of it is still in forest. The southwestern end of the belt is much smoother, and has few loose boulders on its surface, and a considerable portion of it is cleared and in good farms.

The Silurian are the lowest and oldest rocks of the geological series which contain fossils. The rocks are sandstones, limestones and slates. These formations occupy many of the valleys between the mountains of Azoic rock and the whole of a belt of country of 15 or 20 miles wide, northwest of and adjoining these mountains. A marked feature of this district is the high, narrow and long ridge which is near its northwestern border, and which is known in New Jersey as the Blue Mountain, in New York as the Shawangunk Mountain, and in Pennsylvania as the Kittatinny Mountain. The divisions of the Silurian are the Potsdam.

Sandstone, including the Green Pond Mountain Conglomerate, which is the oldest, and then, in order, the Magnesian Limestone, the Trenton Limestone, the Hudson River Slates, the Oneida Conglomerate, the Medina Sandstone, and the Lower Helderberg and associated limestones. The rich farming lands of Sussex and Warren counties are on the Magnesian Limestone, and the grazing and dairying lands are on the Hudson River Slates. The area covered by these formations is about 650 square miles.

The Devonian rocks have a very limited exposure in New Jersey, along the Delaware from the New York State line to the Walpack bend. The area included is about 40 square miles. There are some valuable limestones and some good soils, but much of it is encumbered with glacial and terrace drifts. The Oriskany Sandstone, the Caudagalli Grit, the Corniferous and the Onondaga Limestones are well exposed, but the Marcellus shale appears only in a very limited space on the bank of the Delaware.

The Triassic Formation includes the red sandstone of the State. Its soil and rocks are characterized by their red color, and its surface is marked by many abrupt mountain ridges of trap rock. It occupies the belt of country next southeast of the Azoic region. It is about 20 miles wide, and extends entirely across from the Hudson to the Delaware. Its area is 1543 square miles. The rock contains many beds of excellent freestone, which is extensively quarried. The soil, though not rich, is generously responsive to good cultivation, and has been specially noted for the excellent quality of the fruit grown upon it.

The Cretaceous Formation is characterized by containing extensive and valuable beds of fine white clay, and of green sand. The belt of country in which it occurs adjoins the Triassic on its northwest border, and extends from the Raritan bay and the seaside to the Delaware river near Salem. It is 90 miles long and from 12 to 15 miles wide, and has an area of 1491 square miles. The white clays occupy the northwestern side of the belt, and the green sand marls the southeastern side. The clays are extensively used for making common and fine pottery, and fire-bricks made from them are among the most infusible known, and they are more used where refractory materials are needed than any other in the country. The green sand marls have been largely used by farmers, and have produced most remarkable effects on the soil, restoring fertility to worn-out and abandoned fields, and bringing productiveness and thrift to the whole country where they are used.

Tertiary Formations. The southern portion of the State is mainly occupied by these formations. They consist of sand and clay, and the surface is covered with a thin soil, which is not naturally very productive. Some of the clays contain shells enough to be designated as marls; and extensive beds of the purest of white sand, for glass-makers' use, are common. A large part of it is still in forest. Some good farms are found on this formation, and in and along its borders are some of the best farms in the State.

Post-tertiary Formations. The formations which belong to this division are the glacial drift which covers much of the northern third of the State; the banks of sand and gravel which, in the form of terraces or level-topped hills, occupy much space in valleys; the alluvial deposits along the borders of streams, and the tide-marshes and sand beaches which border the State along the seaside and on Delaware bay.

2. MINES OF IRON AND ZINC ORE.

The Magnetic Iron Ores are all in the Azoic formations, and occur in beds, interposed conformably between the layers of the Gneiss rock. They sometimes extend for a considerable distance, but are not continuous like the rocks themselves; thinning out to nothing at their edges, and in many cases descending beneath the surface in long folds or rolls to an unknown depth. The mines have long been worked, and much of the ore is carried to furnaces near the coal mines in Pennsylvania. There are sixteen blast furnaces in the State, all of which are largely run upon this ore.

The mines now opened number nearly two hundred, and are capable of supplying one million tons of ore annually. The ores are rich, and being near the great markets of the country, find a ready sale. They vary in purity, some containing a little phosphorus, others sulphur, while others are almost entirely free from these impurities. Many of the ores in the northwest, or Pequest belt, contain oxide of manganese, and are in demand for making Bessemer steel.

The manufacture of iron in New Jersey was begun by Lewis Morris, at Tinton Falls, in Monmouth county, as early as 1682. Forges for working the magnetic ore into bar iron were built at Whippany, Morris county, about 1710. The blast furnace at Oxford was built in 1742; and iron has been a staple product of New Jersey from those early

days. The annual product, however, has been subject to great variations, with the business of the country, the improvements in methods of manufacture, and the convenience of locations for cheap transportation, abundant supplies and ready markets.

Red Hematite Iron Ores have been found in a few places, but not in large quantities.

Limonite, or Yellow Hematite, is found in beds, mostly in the magnesian limestone.

Zinc Ores are mined at Stirling Hill and Mine Hill, in Sussex county. Oxide and silicate of zinc and franklinite are the principal ores. Much of the ore is worked directly into the white oxide of zinc, for painters' use, but there is a large quantity used in making spelter of a superior grade. The residuum left after making zinc oxide, contains oxides of iron and manganese, and is used in making spiegel-eisen.

These mines are noted among metallurgists for the remarkable minerals which constitute the ore, and for their unequaled size and richness. The demands for our whole country are largely met from these mines. The ores are accompanied by a white, crystalline limestone, which contains a small quantity of carbonate of manganese. This peculiar limestone, which is easily recognized by the brown or black color of its weathered surfaces, has been traced 40 miles towards the southwest, but as yet no other remarkable beds of zinc ore have been found.

3. The rich deposits of limestone, marl and clay, unlike those of iron and zinc ore, are found in continuous beds, extending entirely across the State, and of almost uniform quality, so that the working of them depends upon the convenience of their location, and their nearness to good transportation or to market. The study of this map, on which the great markets of our country are laid down, and the lines of transportation marked out, in connection with the deposits of these useful substances, will show where the supplies needed can be most easily procured.

4. The map gives the best possible exhibit of the variety of soils found in the State, as they partake to a greater or less degree of the same composition with the rocks or earths on which they lie. *The soils have all originated from the underlying rocks.* Some of them have since been mixed by the glacial drift, and others have been sorted into finer and coarser portions, or into clayey and sandy earths by the agency of rains and running water, and soils which are obviously of the same origin may differ widely in physical condition on account of

differences in drainage; but both chemical and skillful management and tillage prove that the general principle stated above is correct. The composition and character of the different classes of soils in the State are given in a subsequent part of this report.

RED SANDSTONE OR TRIASSIC FORMATION.

This is the geological formation which occupies the middle and most thickly settled part of New Jersey. It is bounded on the east by the Hudson river from below Jersey City, north to the State boundary line; its breadth on the north, where it extends on into New York, is from the Hudson river to the Erie railway, at Sufferns station. Its northwestern boundary is a somewhat irregular, southwesterly line from Sufferns to the Delaware river, a little above Milford. The formation extends on beyond the Delaware into Pennsylvania, but that river is its western boundary in New Jersey from the last-named point, as far down as a mile above Trenton. Its southeastern boundary is in a line from the last-named point, onwards in a northeast direction to the south of Princeton and New Brunswick, till it reaches the shore of Staten Island sound, near the mouth of Woodbridge creek, and thence along the sound to the Hudson river. Its characteristic red rocks and earth are well known to all travelers, and its remarkable capabilities for agricultural and other industrial improvements have been well known and highly appreciated from the first settlement of our country. But its geology has been more difficult to study out than that of any other part of our country, and at the present time it offers several problems for solution, which are of a most perplexing character.

Its rocks consist of red sandstone, shale and trap—the former two being sedimentary rocks and the latter one of igneous origin. It contains no limestones of any account; a layer about two feet thick, and extending on its outcrop for a mile or two on the east side of the valley near Feltville, and crowning the county line between Somerset and Union. Conglomerate rock of magnesian limestone is found in numerous places along the northwest border of the formation, and some limestone pebbles are found in the pudding-stone at Paterson, near the Passaic Falls.

The rock is of various degrees of hardness, but generally it is much

softer and less tenacious than limestone. The softer portions disintegrate rapidly when exposed to the weather, a single season's exposure to the sun and rain being sufficient to crumble large masses of it into small grains, and two or three years' exposure brings it down into fine, clayey earth. In most cases the shales disintegrate more rapidly than the sandstones, and as these two rocks alternate with each other in thick beds and strata, as well as in other cases, in thin layers, they wear away with very different degrees of rapidity. The unevenness of the surface of the country is due to the fact that the soft rocks have disintegrated most rapidly, been carried away by rains and streams, and left the valleys, while the harder rocks have worn away more slowly, and now constitute the hills and ridges. Examples of this are to be found everywhere in the district where this formation extends.

At several places along the northwestern border of the formation ridges start out from the Highlands and extend southerly for from 1 to 3 miles. Holland Hill, near the Delaware, Gravel Hill, just east of the last named, hill west of Pattenburg, hill between New Germantown and Pottersville, hill west of Peapack, and Mt. Paul, north of Peapack, are such ridges. Their rock is largely made up of quartzose, gravel and cobbles, cemented but slightly. The material of which these hills are made, and their north and south direction, form points of interesting inquiry regarding them. On the eastern side of the State, and from the Hudson to the Highlands, along the New York boundary, there are not less than ten ridges, which are equally high and marked in their direction, but the material is not so distinctly quartzose.

The quarries are all in the ridges or on the side-hills, and none in the bottom of the valleys. Those which have produced good building stone are not found, however, in all places where the rock is hard enough to resist the action of the weather. The rock in the high hills in north part of Bergen county is too coarse-grained and crumbles too easily to make good building stone, though it resists the action of the weather. And in Hunterdon county the high barrens and swamps there are partly sandstone and partly an indurated shale, but they have no quarries from which valuable building stone can be got. The stone at various places along the west foot of the Palisades is very handsome, and would make good building stone, but it is not quarried. The stone from the quarries at Newark, Bloomfield, Belleville, Pater-

son and Little Falls is very largely used. The quarries in Washington Valley and at Martinville have produced some very handsome drab building stone. But in all the country from New Brunswick and Princeton towards the northwest, shaly and soft rocks prevail, and no good quarries of brownstone are opened. Along the Delaware the sandstones and shales alternate along nearly the whole breadth of this formation, and good quarries of brownstone are opened.

At Milford extensive quarries of flagstone are opened. And at Woodville, in Mercer county, there are quarries of a flagstone which is of remarkably smooth and fine grain.

The trap-rocks have characters by which they are easily distinguished from the sandstones and shales. They are all of a dark gray or greenish gray color in fresh fractures, and where they are weathered they are of a dull, rusty color, varying from brown to almost white. They are much more likely to be mistaken for granite or gneiss, but can be distinguished by containing no mica, and, in the solid portions, no quartz. The rock is, in some parts, of a uniform quality, and in other parts is made up of grains more or less coarse, consisting of hornblende and a feldspathic mineral. It varies much in solidity and hardness—some of it being soft, cellular and dull in fracture, other varieties being hard, tough, homogeneous and bright in fracture, and still others very hard, coarse and crystalline. The ridges farthest east are composed of the hardest and most crystalline rocks, and the rock diminishes in hardness in ridges farther west. Whether this difference is due to a difference in composition, or is simply due to a difference in age, or in depth to which it has been worn down below the original surface, is not determined.

The rock from Bergen Hill, from the first of the Watchung Mountains and from Goat Hill has been used extensively for making paving blocks, for Telford pavements, for ballasting railroads, and for rough, strong masonry. It is extremely tough, and stands the weather well, and for the purposes for which it is used is better than any other rock.

Thin seams of coal have been found in the rock in many localities, and some expensive work has been done in the hope of finding it in quantity profitable for mining, but without success. There is no reason to dig or bore for coal, for the structure and dip of the rock are such that all its strata crop out on the surface, and the thickness

and quality of the strata can be seen there as well as at any depth beneath.

Copper ore and metallic copper have been found in the sandstone, and also at the meeting of the sandstone and trap in many localities. And mining operations have been begun at many of them at various times for the past 150 years; but all have been unsuccessful. The ore is disseminated in the rock, and is not in regular veins, so that its continuance in any particular working is uncertain, and in all past workings it has failed.

The following is a list of brownstone, flagstone and trap-rock quarries opened in different places. It might be considerably enlarged:

BROWNSTONE.

Alpine, Bergen County.—A grayish-white feldspathic sandstone has been opened and quarried to a very slight extent on the western slope of the Palisades Mountain, about a quarter of a mile northwest of the village, and on the road to Closter.

Englewood, Bergen County.—A considerable amount of gray and light-colored sandstone has been quarried in the drift on the western slope of the Palisades Mountain, north of Englewood, and on towards Tenafly. The abundance of the stone in the drift-earth indicates a solid mass under the drift, and resting upon the trap-rock. The beauty of the stone and the ease with which it is worked make it a desirable building material. And such stone is to be looked for near the foot of the mountain, between Tenafly and New Durham.

Homestead Station, Hudson County.—A red sandstone of inferior quality has been opened at the foot of Bergen Hill, a few rods east of the station.

Saltersville, Bayonne City, Hudson County.—Red sandstone for local uses has been obtained at Forty-fourth and Forty-seventh streets. It appears to lie in a belt between trap-rocks on the east and west.

Hohokus, Bergen County.—There is an old quarry near the place.

Paterson, Passaic County.—There are three quarries in the eastern face of the First Mountain, and south of the city, whence a large quantity of brownstone has been taken. The larger part of it has been used in the city. These quarries are conveniently located for trans-

portation, being near the Morris canal and the Delaware, Lackawanna and Western R. R.

Stone House Plains, Essex County.—There is a quarry northwest of this place, in the eastern face of the First Mountain.

Llewellyn Park, Essex County.—Sandstone has been quarried in the mountain side in the Park.

Orange, Essex County.—Bell's quarry is in the mountain, west of Orange.

Avondale, Essex County.—A new quarry has been opened near the N. Y. & L. E. R. R.

North Belleville, Essex County.—These quarries are on the bank of the Passaic. They have furnished a large amount of superior stone.

Newark, Essex County.—Three quarries are here worked. They are on the ridge west of the Passaic, and in the northern outskirts of the city. The ridge is 150 to 170 feet high, and has a northerly trend. The southernmost quarry is that of Copeland Bros. Next to it, northward, is the Newark Brownstone Co.'s quarry. It has reached a depth of 40 or 50 feet, and has been opened several hundred feet in length. North of the Bloomfield avenue is Philip Hoehnle's Newark stone quarry. All of these quarries are in steady operation, and their stone has a wide market.

Snake Hill, Essex County.—Red sandstone is quarried to a limited extent in the western face of Snake Hill.

Franklin Lake, Bergen County.—Red sandstone is quarried for a local market on the western side of the lake, and near the Second Mountain.

Haledon, Passaic County.—There is a small quarry here, in the valley between the two ranges of trap-rock.

Pompton, Passaic County.—James Ludlam's quarry, northeast of Pompton Furnace, meets the demands of the country around it. There is much variation in the rock at the quarry—from shale to coarse conglomerate.

Schuyler's Basin, Passaic County.—There is an old quarry at this place, on the east bank of Pompton Feeder.

Hook Mountain, Morris County.—John H. Vreeland's quarry. This quarry supplies a local demand for stone.

Little Falls, Passaic County.—Robert Beatty's quarries at this place were extensively worked many years ago, and much handsome stone

was sent away from here. Of late they have not been so actively worked.

West Orange, Essex County.—A new quarry, in the face of the Second Mountain, and near the Centreville road, is reported as a very promising locality.

Washington Valley, Somerset County.—This quarry is between the First and Second Mountains, and two miles north of Plainfield. It is not in operation. A light drab stone was obtained here, which was used in Plainfield with great favor.

Martinville, Somerset County.—Bartle's quarry, at this place, continues in steady operation, and meets the demand of a large circle of surrounding country. Some of the stone is of a light color. The upper beds are red, and are used for rough work. It is five miles from Bound Brook, in a north-northwest direction.

Pluckamin, Somerset County.—Dow's quarry, in the red sandstone, a half a mile east of Pluckamin, is not now worked.

Millington, Somerset County.—The Millington quarry is in the southern foot of Long Hill. It is near the N. J. West Line R. R.

New Providence, Morris County.—A quarry at the foot of Long Hill.

Basking Ridge, Somerset County.—The quarry near the village is not worked.

Five-Mile Lock, Delaware and Raritan Canal, Somerset County.—An old quarry, which has not been worked in many years.

New Brunswick, Middlesex County.—James Neilson's quarry in the city is occasionally worked for local market. The stone is red in color and somewhat shaly.

Lawrence Brook, Middlesex County.—Sandstone has been quarried at Weston's Mill, near New Brunswick, and at Provost's quarry, near Milltown, but they have not done more than supply a very limited demand in the immediate neighborhood.

Heathcote Brook, near Kingston, Middlesex County.—A dark-colored, slaty stone was here found. The place has been idle for many years.

Kingston, Somerset County.—The red sandstone quarry at this place is in operation, and supplies the Delaware and Raritan canal with stone for slope walls. It is on the bank of the canal, and near the Rocky Hill R. R.

Ten-Mile Run, Somerset County.—There is a small quarry at Ten-Mile Run.

Rocky Hill, Somerset County.—The more or less altered sandstone at Rocky Hill, for half a mile north from the depot, and on the east side of the canal, has been quarried at intervals, but not much of late years.

Princeton, Mercer County.—The quarry near the canal, southeast of the town, furnished stone for several of the college and seminary buildings. There is a much smaller quarry in the place. They do not send stone to any distance.

Greensburg, Mercer County.—The Greensburg quarries are four miles north of Trenton, and on the east side of the canal and Belvidere Delaware railroad. Beginning at the south, they are as follows: Keeler's, Walton & Brother's, Moore's, James Green's, Peter Clark's. The strata opened in these quarries consist of red, shaly and gray sandstone. The strata worked in these several quarries consist of red and gray sandstones, and in thick beds. In some of the beds there are scattering white quartz pebbles. The thick beds, the ease of working, and convenient location give them advantages, and they are steadily worked. The stone finds a market in Trenton, Camden and Philadelphia, and at other points along lines of canal and railroad transportation. Their capacity is large, and can be indefinitely increased.

Lambertville, Hunterdon County.—The blue indurated shale is here quarried for building purposes in the town. The red sandstone, further from the trap rock, is also quarried to a small extent for local needs.

Brookville, Hunterdon County.—Here are two quarries, one of which was opened lately.

Stockton, Hunterdon County.—There are several quarries along the upland bluff in Stockton, and thence to Prallsville and on northwest, up the river. Peter Best works one in the village.

Prallsville, Hunterdon County.—In and near the village there are four quarries, but only one is in operation, which is worked for the Pennsylvania Railroad Company. The stone in these Stockton-Prallsville quarries is of a light-grayish shade, and occurs in thick beds. Some of these contain scattered pebbles of quartz. It can be quarried in large blocks, and it is liked for heavy work. It has had wide use in the construction of bridge piers and abutments.

Raven Rock, Hunterdon County.—Here are two quarries, but they are not worked to any great extent.

FLAGSTONE.

Milford, Hunterdon County.—Flagging stone is obtained near Milford, at the quarries of Smith Clark, M. McGuire, and Rawlings. Large-sized stone are quarried and are sold in Trenton, Easton, Philadelphia and points along the Delaware river valley.

Woodville, Mercer County.—Burroughs' flagging stone quarry is actively worked for the surrounding county. Stone slabs of as large size as can be transported, true on the surface and as smooth as slate, can be furnished.

TRAP-ROCK.

Palisades and Bergen Hill.—Along the eastern face of the Palisades Mountain, and in Bergen Hill, Jersey City, the trap-rock is quarried at several points, for paving-blocks and dock-filling. The supply of stone for these uses is practically inexhaustible.

New Durham, Hudson County.—On the western foot of the hill, stone is here quarried on lands of Abram W. Duryee, for Telford road material.

Bergen Cut, Hudson County.—The cutting of the new line through the hill, for the Pennsylvania railroad, affords a large amount of trap-rock, which is used for road-ballasting and for Telford roads.

Snake Hill, Hudson County.—There is an extensive quarry on the western point of the hill, which is worked by D. Brennan, Jr., of Orange, for materials for Telford roads and streets.

Orange, Essex County.—The rock from the steep face of the south-east side of the First Mountain is extensively worked for materials to make Telford roads; and various avenues about Orange and Newark have been made models of driving-roads by its use.

Paterson, Morris Hill, Passaic County.—The trap-rock of this hill is being rapidly removed for road material.

Plainfield, First Mountain, Somerset County.—Considerable stone has been quarried north of the town, in the gap of the First Mountain, for road-making in the vicinity.

Rocky Hill, Somerset County.—M. A. Howell, of New Brunswick, quarries paving-blocks and road-making materials, as well as finer

broken stone, for walks, &c., in the side hill east of the railroad and canal, and south of the Rocky Hill station. It has remarkable advantages for cheap transportation.

Smith's Hill, Titusville, Mercer County.—A large amount of stone has been obtained on the southwestern point of this hill, at the side of the Belvidere Delaware railroad, and one mile north of Titusville, and from its convenient location is finding use over a very large district of country.

Lambertville, Hunterdon County.—A very large amount of stone has been worked here out of the large blocks which lay on the steep westerly end of Goat Hill. The fast rock has also been quarried. The paving-blocks are sold in Trenton, Camden and Philadelphia. The smaller stone, unfit for blocks, and the chippings, are used for road-making materials. Two firms have been at work at this locality. As at Smith's Hill, this place also is convenient to both canal and railroad, which run along its foot.

Rocktown, Hunterdon County.—Trap-rock from the surface of Sourland mountain at this place has been worked at Flemington for monumental bases, and with great success.

FOSSILS.

Fossils are not common in this formation in New Jersey. No marine shells have been found, but there have been remains of land plants, footprints of birds or reptiles, and fossil fish found in different places.

At the Belleville quarries thin seams of coal and impressions of the stems and branches of plants are not uncommon. A fragment of the stem of a plant with surface markings like the lepidodendron was found, and is now the property of Mr. David Hitchcock, of Orange. It is a very plainly-marked, flattened stem, 8 inches long, 4½ wide, and 1½ thick. Photographs of this were taken and sent to Prof. L. Lesquereux, of Columbus, Ohio. He returns the following answer:

"The photographs are sufficient, if not for specific determination at least for positive reference of the specimens to Lepidodendron. Even I should say that the specimens represent *L. Weltheimianum Prest.* as distinctly as a specific representation can be made upon a decorticated trunk of Lepidodendron. *L. Weltheimianum* is a leading species of the old red sandstone found here, as in Europe, from the sub-

carboniferous measures down to the Devonian, while until now we do not have any remains of Lepidodendron of any kind from the upper coal measures (Permo-Carboniferous), or from higher up than the Pittsburg coal.

"*L. Weltheimianum* is recorded only once from the true coal measures; this by Eichwald, from the carboniferous sandstone of Russia. But European authors, among others Goeppert, doubts the identity of the Russian species with *L. Weltheimianum*, which is moreover extremely variable, and has been described already under about thirty different names."

Another fragment has since been obtained from the same quarries by Dr. Skinner, of Belleville, and is now in our possession. It is 7 inches long, 5½ inches wide, and 1½ inches thick, and is as plainly marked as the first. Other and smaller specimens somewhat like the above have also been found in the quarries in Newark. If these fossils are sufficient to determine the geological age of these beds, they put it in the Upper Carboniferous, at least, which is lower than has been heretofore claimed for it. A larger and more complete collection of such fossils must be made if possible.

Vegetable impressions are found in large numbers at the quarries of Mr. Smith Clark, of Milford, but most of them are fragmentary and indistinct. Those which can be seen plainly enough for identification resemble the Equisetum and some coniferous plants. They are evidently much newer than the fossils at Newark and Belleville.

Fossil fishes have been found at several places: in the shales on the bank of Rockaway river, below Boonton; in the old stone quarry at Pompton; in the copper mines in Washington valley; and in other places in the shales at the west foot of the mountain between Bound Brook and Pluckamin. A collection of fishes was made by the late W. C. Redfield, of New York, and his descriptions and conclusions were published in *Am. Jour. of Science* (Vols. 36, 44 and 45) in 1843 and earlier. He described several species of the genera Paleoniscus and Catopteris. His specimens were from Boonton and Pompton. Since that time numerous specimens have been collected by others; we have a number among the specimens belonging to the survey. Mr. I. C. Russell has also made very extensive collections of them, and placed them in the hands of Prof. J. S. Newberry, of Columbia College, New York, from whom we may expect soon to have full

and complete descriptions of all the different species found in our State.*

Footprints of various three-toed animals have been found in different places in the sandstone; one was found by Prof. Gale, of New York, at Pompton, and noticed in *Silliman's Journal* as early as 1840. The specimen was in relief, and about 6 inches long. Other rather indistinct impressions were found near Boonton by different persons, and others in the quarry near Milford. In 1867 a slab of stone was found in the brook near Tumble Station, on the Belvidere Delaware R. R., on which there were tracks in order, as if made by one animal. They are three-toed, each toe about 3 inches long, and the tracks somewhat in pairs. The specimen is in the cabinet of Rutgers College.

Mr. I. C. Russell obtained a good specimen in relief from the sandstone near Boonton, in 1878. It is 6.2 inches long and 5.5 inches wide. During the past autumn the survey has obtained several large slabs of sandstone, with footprints, from the quarry of Mr. John H. Vreeland, near Whitehall, in Morris county.† The slabs are now in the Museum of the Geological Survey at Trenton. Two of the slabs have the tracks in depression, and two others have them in relief—that is, they are casts of the first. One of the slabs is $4\frac{1}{2}$ by 6 feet, and has on it 26 tracks, most of which have the toes from 3 to 4 inches long, but one of them has the whole track, 12 inches long. The other slab is 5 by 7 feet in size, and 25 tracks can be counted on it; most of these also are small, but there are two large tracks which appear as if made by the same animal, and are 3 feet apart. Great numbers of such tracks have been found in the sandstone of the Connecticut valley, and a special study was made of them by Prof. Ed. Hitchcock, of Amherst College, Mass. The results of his work, "The Ichnology of New England," were published by the State of Massachusetts in a quarto volume of XII. and 220 pages and 60 plates, and the Ichnological Museum at Amherst College is filled with his specimens. Our fossil footmarks are of the same general character, and probably of the same species.

* By the generous assistance of H. W. Crane, of Boonton, a fine suite of these fossil fishes was secured for the museum of the Geological Survey at Trenton.

† These specimens were obtained through the generous assistance of H. W. Crane, of Boonton, and were quarried by F. Wilson Van Duyne.

There is much still to be done in the study of these interesting fossils; but one conclusion may safely be drawn, which is that the formation is altogether of fresh-water origin.

The sandstone and shale rocks are all in uniform layers, and with a prevailing dip towards the northwest; and none of it dips regularly towards the southeast. The variations from the regular dip are limited in extent; and the change in direction is not more than a quadrant on either side. A section taken along the Delaware river, from Trenton to Milford, which is a distance of 30 miles, shows a uniform dip towards the northwest of from 5° up to 20°, and with an average of 15°. A section following up the Raritan river, and onward towards the northwest, shows a northwest dip, averaging 8°, for a distance of 9 miles, when the dip changes to the northeast, and so continues through the remaining 14 miles of the formation in that direction. A section following in a northwest direction across the formation in the basin of the Passaic, shows nearly the same change with that in the Raritan section. The principal changes of dip appear to be, in some unexplained way, connected with the direction of the trap ridges, and are near them.

TABLE OF DIPS OF THE RED SANDSTONE.

I.—Section along the East Bank of the Delaware, from Trenton to Milford.

DIRECTION.	AMOUNT.	ROCK.	LOCALITY.
N. 60° W.	25°–27°	Sandstone.	Trenton, near Cadwallader place.
N. 8° W.	10°–12°	Sandstone.	Walton & Bro.'s quarry, Greensburg.
N. N. W.	10°–15°	Sandstone.	Green's, Greensburg.
N. W.	15°–20°	Red Shale.	Titusville.
N. 35° W.	22°–25°	Altered Shale.	Lambertville.
N. 45° W.	20°	Sandstone.	Brookville.
N. 25° W.	20°	Sandstone.	Prallsville. (Old quarry.)
N. 30° W.	15°	Altered Shale.	Raven Rock.
N. 40° W.	10°	Altered Shale.	Point Pleasant.
N. 15° W.	15°	Red Shale.	Near Tumble Station.
N. 45° W.	5°–8°	Red Shale.	Frenchtown to Milford.
N. 40° W.	20°	Flagstone.	Clark's quarry, Milford.
N. 60-70° W	15°–20°	Conglomerate.	Pebble Bluff, N. W. of Milford.
N. 60° W.	40°	Conglomerate.	Johnson's Ferry.

II.—Section along the Lower Raritan and the Central R. R. of N. J., from below New Brunswick to Lebanon.

DIRECTION.	AMOUNT.	ROCK.	LOCALITY.
N. 40° W.	10°	Shale.	Martin's Dock, Raritan river.
N. 15° W.	5°	Shale.	New Brunswick.
N. 40° W.	12°	Shale.	New Brunswick.
N. 40° W.	10°	Shale.	Five-mile lock. (Old quarry.)
N. 20° W.	5°	Shale.	Between Bound Brook and Middle Brook.
N. 50° E.	5°	Shale.	R. R. cut, one mile east of Somerville.
N. 40° E.	8°	Shale.	R. R. cut, near North Branch.
N. 35° E.	21°	Shale.	One-half mile S. E. of White House.
North.	30°	Shale.	One and a half miles W. of White House.

III.—Section from near Plainfield across the Trap Ridges and the Valleys to Basking Ridge.

N. 30° W.	15°	Shale.	Near Ambrose's brook, Samptown.
N. 15° W.	10°-15°	Shale.	Old copper mine at Plainfield.
N. 30° W.	8°	Shale.	Near Coontown.
N. 75° E.	30°	Shale.	Basking Ridge, N. W. of village.
N. 20° E.	15°	Sandstone.	Quarry at Millington.

IV.—Section from Weehawken west to Green Village and the Highlands.

N. 60° W.	20°	Sandstone.	Weehawken.
N. 20° W.	15°	Sandstone.	Almshouse, Snake Hill.
N. 20° W.	10°	Sandstone.	Newark, brownstone quarries.
N. 50° W.	7°-10°	Sandstone.	Llewellyn Park. (Quarry.)
N. 70° W.	10°	Sandstone.	Yost's quarries, bet. First and Second Mts.
S. 85° E.	7°	Shale.	Olmstead's Mills, west of Green Village.

V.—Section from Fort Lee on the Hudson west to the Highlands.

N. 60° W.	88°	Sandstone.	Fort Lee.
N. 75° W.	Gentle.	Sandstone.	Near Closter Landing.
Westerly.	Gentle.	Sandstone.	Hohokus.
N. 80° W.	10°	Sandstone.	Paterson, Pope's quarry.
N. 50° W.	10°	Sandstone.	Little Falls, Beatty's quarry.
S. 80° W.	20°	Sandstone.	Pompton, Ludlam's quarry.
S. 60° W.	25°	Shale.	Pompton, near Ransley's hotel.
Northwest.	7°	Sandstone.	Hook Mountain, John H. Vreeland's quarry.
S. 70° W.	8°-9°	Sandstone.	Rockaway river, S. E. of Boonton.
N. 40° W.	20°	Conglomerate.	Union Hill, Sufferns, N. Y.

The thickness of the formation appears to be very great. A well in New Brunswick was bored into it 450 feet deep. Several wells in Newark are bored to depths of from 400 to over 600 feet, and one in Paterson is nearly 1300 feet deep—all in red sandstone and shale. It is assumed that the materials of the rock were deposited in horizontal

layers, as sediments now are, and that these layers have since been raised on their southeastern edge or lowered on their northwestern edge, so as to take the inclination they now have, and that, then, their elevated edges have been worn off so as to leave the surface of the formation as it now is. The thickness of the body of the rock becomes a matter of trigonometrical calculation. The measure across the formation from one side to the other may be treated as the hypothenuse of a right-angled triangle; the dip of the strata constitutes one of the angles of the same triangle, and the leg opposite to the angle of dip is the thickness sought. Calculated in this way the formation along the Delaware should be 43,760 feet, or over 8 miles thick; and on the Raritan and Passaic sections the thickness, estimated in the same way, is 5179 feet, or a little less than one mile.

But this enormous thickness is not accepted by most persons, and the question is considered to be an unsettled one.

The materials of which the rock is composed appear to have been derived in the first place from the older rocks which lie on both sides of the belt. The rock composing the southeastern margin of this formation contains mostly grains of feldspar instead of quartz, as if it had been made from a very feldspathic gneiss or granite, such as is found in great quantities on that side of the formation. The rock composing the northwestern side of this formation is remarkable for containing fragments of magnesian limestone, such as is found in place in the older rock formations on that side of the red sandstone belt. In many specimens of the sandstone (brownstone) from this formation, small fragments of red sandstone or shale are to be seen, as if the rock were made of older sandstone which had been worn away in fragments, grains and mud, and deposited anew to make this rock. It is to be remarked, too, that the stone containing magnesian limestone does not extend more than a mile or two in from the northwestern boundary in any case. There is also in one case at the Great Falls of the Passaic in Paterson a conglomerate which contains some pebbles and even cobbles of true limestone. In addition to the rock containing gneissic pebbles and feldspathic grains along the southeastern margin of the formation, there are several long outcrops of strata near the middle of the formation which are quite light-colored with grains of feldspar.

Just above New Hope, Penna., on the west side of the Delaware

river, and nearly opposite Lambertville, magnesian limestone of the Silurian Age is exposed in a belt of a mile or more wide, and 6 or 8 miles long. The red sandstone is on both sides of this belt of limestone, and lying as the limestone does near the middle of the formation, it gives reason to suppose that in other places also the older rock is not far beneath the surface of the red sandstone, and that the latter rock is not so thick as the calculations given would lead us to expect.

The trap-rocks, which form the abrupt mountain ridges which are so characteristic of this formation, are of igneous origin, and appear to have come up from the interior of the earth since the deposition of the sandstone and shales. They are true eruptive rocks, as can be seen in many places where they have broken across the strata of other rocks, but in general they appear to have found their way to the surface by opening a passage between the layers of sedimentary rocks, rising until they have reached their present position. And their prominence above the surface is due to the rock being so much harder than the sandstones and shales, that the latter have been worn down and washed away by the action of the elements, while the trap itself has been but little affected by it, and now stands prominently above the red sandstone in these mountain ridges. As the layers of red sandstone all dip towards the northwest, the trap, in rising between them, has presented its outcropping edge towards the southeast, and now, when the sandstone is worn away, these great bodies of trap present a series of almost perpendicular ledges on their southeastern faces, whilst their northwestern slopes are comparatively smooth and gentle. This is well seen in the Palisades along the Hudson river, and in the Watchung Mountains west of Newark. The trap ridges are not continuous in long lines, but are in crescent-form sections, of lengths varying from two to ninety miles, and these, with scarcely any exception, have their convex sides towards the southeast. The beds of sandstone and of the intruded trap have the same dip, and it is remarkable that at the curved ends of these crescent-shaped ridges the dip of the sandstone conforms to their curvature, so that at the northeast end the dip is southwest, and at the southwest end it is northeast. To this latter statement some exceptions have been noted in the inside of the great curve of the Hook Mountain, in Rockland county, New York, where the trap has broken directly across the beds of stratified sandstone.

To account for the apparently great thickness of this formation, it

has been thought that faults, running in the line of the strike of the rock, have occurred, in which the rock on the northwest side of the fault has risen, and that on the southeast side has sunk, and that in this way we get a repetition of the same layers of rock. There is so much uniformity in the color and composition of these rocks, they being all either sandstone or shale, and the rock on exposed surfaces decomposes so rapidly, that it is difficult to either prove or disprove this theory. Along the Delaware, a few miles above Trenton, there is a succession of stone quarries which have the general appearance of being repetitions of each other—as if they had been made by a series of faults which had brought the same layers up in the different quarries, and careful search has been made for such faults, but they have not been found. In the rocky cliffs along the Delaware, above Milford, several faults are to be seen, and they are all in the way to increase the apparent thickness of the formation, but it is not possible to determine the amount of the off-set. Similar faults have been observed in the rock cuttings on the Easton and Amboy railroad, near Sidney Church, in Hunterdon county. On the Central Railroad of New Jersey, in the rock cuttings about a mile east of White House station, faults are exposed. In the deep rock cutting on the New York and Greenwood Lake railroad, just east of the Passaic river, there is a very plainly marked fault. Slickensides are also to be seen in many places, but there is nothing in the surface or on the adjoining sides to indicate the extent of this movement.

Folds or curves in the strata are very uncommon, and the beds themselves are of almost uniform thickness throughout. None are to be seen along the Delaware. On the Easton and Amboy railroad, near Sidney Church, there are some curved strata.

The occurrence of magnesian limestone in the belt, at different places, is not favorable to the idea of the great thickness of the formation; it seems as if they might be like islands in a shallow sea, which project above the surface, and show that in other places they are not far below the surface. At various places along the northwestern edge of the New Jersey belt, Silurian limestones are found in place, and the sandstone overlies them. The same limestones are also to be seen above the surface and extending six or seven miles southeast into the red sandstone belt, and cross-wise of its strata, near Clinton, in Hunterdon county. The same stone is also to be seen on the west side of

the Delaware, near the middle of the belt, in a long strip which runs many miles towards the southwest. The boring of the deep well at Paterson is watched with much interest, to see if it will not prove something in regard to this question of thickness.

From the change in the dip of the strata near the trap-rocks, as well as from the great depth of the earth* down to the solid rock, inside the curves of some of the crescent-formed trap ridges, it has been questioned whether there have not been local changes of level in the surface of the sandstone during and since the eruption of the trap-rocks.

The facts thus far collected and stated would lead to the conclusion that this formation has been deposited first from materials on its borders, and chiefly from those on the southeastern side; that it has formed slowly, and through a very long period of time, and that in the course of its deposition there has been a slow and long-continued subsidence of the land on its northwestern border, and an equally long-continued elevation of the land on its southeastern border. In this way the strata, which were originally horizontal, would be tilted up so as to dip towards the northwest, and their out-cropping edges would be exposed to the weather and would be liable to be worn off, and their abraded material would be carried forward towards the northwest to be deposited again, and thus to form new beds of the same kind of rock. The new beds would extend farther towards the northwest, thus widening the formation in that direction, and covering ground where the lower beds which have their out-crop on the southeast border are entirely wanting.

The trap rock has evidently been intruded into the red sandstone after the deposition of the latter was complete, for the over-lying sandstones are altered by the trap-rock near them as much as the under-lying ones are, and besides, no fragments or pebbles of trap are found in any beds of the sandstone, shale or conglomerates of this formation.

After the close of this period of time, the high ground southeast of the red sandstone must have undergone a gradual subsidence, during which the plastic clays of the Cretaceous age must have been deposited

* At the farm of Judge Lathrop, in the Great Swamp, in Morris county, an iron pipe was driven 165 feet without reaching the rock, though the basin in which it lies has solid rock on all sides, nearly as high as the surface of the earth where the well is bored, and this basin has either been worn out to this depth, or the solid rock has sunk down when the trap was thrown out.

as we now find them, in the same fresh-water basin with the red sandstone and over-lapping the latter. This is apparent from the absence of marine shells and all calcareous matter from them, and the great abundance of trees and fresh-water vegetation still to be found in them. It was not till the time of the clay marls and green sands of the Cretaceous age that this southeastern ridge had sunk low enough to admit the salt water and the marine animals and plants which characterize that age, and which we now find over-lying the plastic clays; and the clays which must originally have been deposited in beds which were level, or dipping towards the northwest, are now found dipping towards the southeast at an angle of less than one degree.

LIST OF IRON MINES IN NEW JERSEY—WITH NOTES.

For six years, from the panic in 1873 to the autumn of 1879, the iron mining industry of the State participated in the general business depression of the country. It suffered more than some other branches of industry, in consequence of the extreme dullness of the iron market. Throughout 1873 and 1874 there was a general expectation that business would revive, and the mining companies were in hopes that the depression would soon give way to steady and profitable work. In consequence of this the contraction did not begin at once, and the minimum of production was not reached the first year of the panic. The older and larger mines were kept in operation, although in all of them there was at the outset a reduction in the working force. The effect upon the work of prospecting and the opening of new mines was more marked, and scarcely anything was done in these directions. In many cases the working of the larger and more important mines was made necessary by the terms of leases, or of contracts for the ore. One of the first results of the contraction was the surplus in the labor market in all the mining centres. The loss of work sent many elsewhere, and there was a temporary check to the growth of the population, and in some localities a diminution. A large part of the labor supply found work in the anthracite coal fields of Pennsylvania, and in the mining camps of the far West. The price of labor fell over 100 per cent. The dullness in the iron market led to greater economy in mining, and the expenses per ton were much reduced. Notwithstanding these economies in production, the extremely low prices for ore and the slack demand compelled the suspension of many old mines, which had struggled along in hope of better times, and stopped nearly all further developments in new localities. To show how general the suspension was, of the 200 mines and ore localities given in the list in the report of the Geological Survey for 1874, only 30 kept in operation throughout the whole period of depression. Ores low in phosphorus and suitable for the manufacture of Bessemer steel, found sale at low prices. Rich ores also met with a steady demand. Others failed to sell at

any remunerative price. The gradual decline in the production of our mines appears in the following statistics the several years from that of 1873 onward:

In 1873 the product was			665,000	tons.
" 1874	"	"	525,000	"
" 1875	"	"	390,000	"
" 1878	"	"	410,000	"

No attempts were made, either in 1876 or in 1877, to collect the statistics, but from a careful survey of the field, and from estimates by well-informed observers, the aggregate for 1876 was found to be considerably below that of 1875. And the lowest point in the scale of production was reached in the years 1876 and 1877. The next year witnessed a slight increase. While there was no buoyancy in the market the demand was steady and the mines had attained to a minimum in the cost of working. Such was the condition of our iron mining industry at the beginning of the past season, and when the business revival began to manifest itself in the rise in the price of iron. The rapid growth of prices and the increasing demands of the market during the late summer and autumn, were soon felt in the mines. The companies at work sought additional help, and soon began to increase their output of ore. Wages advanced slowly, and labor found a ready market. The greater demand for ore started up many of the old mines and gave a new impetus to the work of prospecting and exploration. The general result is already well known to the public, but it can hardly be fully appreciated outside of the iron ore district. There is an active inquiry about mining localities, such that it cannot be at once answered.

Wages are 35 per cent. above that of 1876 and 1877, and there is a demand for additional labor, notwithstanding the very general introduction of labor-saving appliances and machinery. And men are returning from the West and from the coal mines to their old homes. The working forces have in many places been doubled and even trebled. And the monthly production of the mines during the past few months is probably three times that of the early part of the year. The increased production appears in the sum total of all the mines of the State. This aggregate amounts to 488,028 tons, or 78,000 tons more than in 1878. The increased activity is apparent in the accompanying details of localities. Nearly all of our larger mines are either

working or are being re-opened and put in working condition. And many of the places, which can hardly be called *mines*, are being examined and tested as to their capabilities.

It is highly probable that all of them, which can be profitably worked, will be in operation in 1880, and that the production of the iron mines of the State for that year will be equal to, if not greater than that of 1873.

At the commencement of this new era in the history of our mines, it has been deemed opportune and desirable to report on the condition of the iron-mining industry of the State. The subject is one of importance to our own citizens generally, and of special interest to those in any way engaged in the manufacture of iron, and in the mining of iron ore. The labor of collecting material for this report has been difficult on account of the activity causing constant changes, so that scarcely any two consecutive days would exhibit like conditions. Again, many of the mines were not in a condition favorable for examination. Some were in process of being unwatered, others were in different stages of preparation for working. The greater part of the district has been traversed, and by personal examination supplemented by information from reliable correspondents, those details have been gathered and here given, which show the present condition of the mines. An attempt has been made to get the names of owners and lessees, and the dates of working, but there are many cases in which it was not easy to ascertain these facts. The prominent geological features of the newer localities have been briefly noted, as also the peculiarities of the ores. Where mines have been described in previous reports of the survey, the references have been given and such notes have been added here as to supplement the former descriptions. Of the older and well-known mines very little is said, excepting the facts as to working. In short, this report may be regarded as supplementary to those of previous years. The following list of mines and localities where ore has been found in workable quantity precedes their descriptions. This list includes nearly 300 numbers, or what may be termed mines and ore openings. The list in the report of 1873 had about 200. The increase in the number is due in part to a new mode of counting, whereby such groups as Oxford Furnace, Irondale and Ringwood are resolved into individual mines, and in part to new localities. The number of the latter, which were not mentioned

in the report for 1873, is not large, as an inspection of the detailed descriptions will show. The arrangement in the list conforms to the division of the Highland Range of Azoic Rocks into four parallel belts, known as the Ramapo, Passaic, Musconetcong and Pequest. This division was made in 1873, and the boundaries as then described are here reprinted. The arrangement in these four belts is convenient for reference, although a provisional one, and one which may be superseded by the results of a more detailed survey of the district.

1. RAMAPO BELT.

This belt begins near Peapack, in Somerset county, and extends on in a northeast direction by Pompton to the State line, and in New York, to and beyond the Hudson river. It is about 2 miles wide at the southwest, and at the New York line its width is 5 miles. Mine Mountain, Trowbridge Mountain, the low mountains between Denville and Boonton, the mountain extending from Boonton to Pompton, and the Ramapo Mountain, are all in this belt. Its southeast border is defined by its meeting the red sandstones and conglomerates of the Triassic Formation. Its northwest border is marked by a characteristic white, crystalline limestone, containing serpentine, in grains, in large masses and in fibrous forms known as chrysotile. There are outcrops of this limestone near Mendham, at Turkey Mountain, north of Montville, near Wynokie, near Monks, and at the old Blue Mine, Ringwood.

2. PASSAIC BELT.

The Passaic Belt is the next belt to the northwest, and the line just described is its southeast boundary. It begins at Clinton, in Hunterdon county, at the southwest. Its breadth is nearly uniform, and is about 5 miles. It is bounded by the red sandstone and conglomerate of the Triassic Age from Lebanon to Peapack. Nearer Clinton the magnesian limestone adjoins it on the southeast and south. The northwest border is marked by a continuous valley. This valley begins at the Spruce run, north of Clinton, where its first eastern branch comes in, and follows up the valley of that branch, and over into German Valley. Thence the Berkshire, Longwood and West Milford Valleys are the parts of this long depression. No crystalline

limestone has been found in this belt, but it is distinguished by its rich mines of iron ore.

3. MUSCONETCONG BELT.

The valley above described, as far as it goes southwest, is the southeast boundary of this belt. From the Spruce run to the Delaware river it is bordered by the newer limestones and sandstones. The northwestern boundary is marked, as it runs from the Delaware, by Lower Harmony, up Harker's Hollow, and over the mountainous divide near Mount No More to Oxford Furnace; thence up the valley of the Pequest to Vienna, and then up Bacon creek to Warrenville and Alamuche; along the east foot of Allamuchy Mountain and east of the Cranberry reservoir and the Roseville iron mine to the high dividing ridge between the streams running into the Musconetcong and those running into the Wallkill; from this divide it descends into the valley of the Wallkill and follows along the east border of that valley by Franklin, Hamburg and Vernon to the New York line. Musconetcong, Pohatcong, Schooley's, Hamburg, Wawayanda and other mountain ridges are in this belt. It ends near Newburgh, in New York. It is 6 to 8 miles wide, including several long valleys of magnesian limestone. No crystalline limestone has been found in it, in which respect it differs from the belt next adjoining it on the west.

4. PEQUEST BELT.

In the Pequest belt are included all the Azoic rocks northwest of the boundary line just described. It extends across the State from the Delaware to the New York line. Its northwestern edge is overlaid by Paleozoic rocks. Marble, Scott's, Jenny Jump and Pochuck Mountains are in it. Its greatest breadth is about 3 miles. Crystalline limestone is very abundant in this belt. And it is also characterized by its rich zinc mines, and by its iron ores containing manganese.

The order of description in the belts is from southwest to northeast, and according to the political subdivisions of townships and counties. The townships have been given as far as it was possible to do so. In a number of cases the veins of a mine cross these political boundaries. The locations of the working shafts have determined the township in these instances.

The list of mines is believed to be complete. There may be *localities* where openings have been made years ago, which are not included in it. And the recent impetus to prospecting throughout the whole district is so great that some new openings may have been omitted.

The description of the hematites and limonites follows that of the magnetic ores. And the order of arrangement is from southwest to northeast, beginning at the southeast and proceeding towards the northwest.

RAMAPO BELT.

Mines.—Bernardsville, Janes, Connet, Beers, Taylor, Cole farm, Kahart, Lanagan, De Bow, Jackson, Ryerson's De Bow, Beam, Brown, Kanouse, Butler.

Bernardsville, Bernards Township, Somerset County.—There have not been any further developments at these localities since the report of 1874.

Janes Mine, Bernards Township, Somerset County.—This mine has not been worked in many years.

Connet Mine, Mendham Township, Morris County.—The Connet Mine has been idle for three or four years.

Beers' Mine, Hanover Township, Morris County.—The Report for 1878 contained an analysis of ore from the farm of John H. Beers, near Morris Plains. According to recent information from the owner, the place is leased to Judge Wood, of Dover, and two additional openings have been made. And altogether there have been thirty tons of ore mined and shipped to Rockaway, where it has been used in the Wilson Furnace. No regular vein has been struck. The deepest shaft is down 25 feet.

Taylor Mine, Montville Township, Morris County.—This mine has not been worked for several years.

Cole Farm, Montville Township, Morris County.—The openings on the Cole farm and the indications were described in the Report for 1874. Little work has been done since that time.

Kahart Mine, Pequannock Township, Morris County.—The Kahart mine stopped in 1874. It was re-opened last fall and worked until very recently. The extent of the late mining operations in it were not learned.

Lanagan Mine, Pequannock Township, Morris County.—This mine has not been worked since 1874.

De Bow Mine, Pequannock Township, Morris County.—This mine has not been worked since 1874.

Jackson, or Pompton Mine, Pequannock Township, Morris County.—This mine has not been worked since 1874.

Ryerson's De Bow Mine, Pequannock Township, Morris County.—Mining operations were stopped at this mine in 1874. There is a strong probability that it will be soon re-opened.

Beam Lot, Pompton Township, Passaic County.—An old iron-ore locality on the Beam lot, about 2 miles north-northeast of Bloomingdale, was re-opened in 1875 by a New York company. Some rich ore was mined from a shaft about 20 feet deep. The vein was said to be 4 or 5 feet wide. The place was abandoned shortly after the re-opening, in 1875.

Brown Mine, Pompton Township, Passaic County.—No work has been done here since the winter of 1874–75. A notice of it appeared in the Report for 1874.

Kanouse Mine, Pompton Township, Passaic County.—The old Kanouse Mine, northeast of the Brown openings, has been idle since 1875.

Butler Mine, Hohokus Township, Bergen County.—This mine is on Ramapo Mountain, 2 miles south of Ramapo Station. There has been nothing done in the way of mining here since 1874. During the summer of 1879 some surface work was done, and three veins were opened by R. F. Galloway, of Sufferns, N. Y. They are from 3 to 10 feet wide. About 50 tons of ore were taken out.

PASSAIC BELT.

Mines in Hunterdon County.—Large, High Bridge, Silverthorn, Sharp, Emery, Old Furnace, Cokesburgh, Fisher, or Fox Hill, Sutton, Pottersville, Bartles.

Morris County, Chester Township.—Pottersville (northeast), Rarick, Langdon, Pitney, Budd & Woodhull, Topping, Samson, Hotel, Collis, Creamer, Swayze, Cooper, Hacklebarney, Gulick, Creager, Hedges, Dickerson, Creamer, De Camp, Leake, Daniel Horton, Barnes.

Randolph Township.—Henderson, George, David Horton, De Hart, Lawrence, Dalrymple, Trowbridge, Solomon Dalrymple, Cooper,

Munson, Lewis, Combs, Van Doren, Bryant, Connor Fowland, Charles King, King, McFarland, Evers, Brotherton, Byram, Baker, Millon, Randall Hill, Jackson Hill, Canfield's Phosphatic Iron, Black Hills, Dickerson, Canfield, Baker, Spring, Sullivan, Corwin, Stirling, Hubbard, North River, Harvey, Hurd, Orchard, Erb, Scrub Oak.

Rockaway Township.—Johnson Hill, Hoff, Dolan, Washington Forge, Mount Pleasant, Baker, Richards, Allen, Teabo, Mount Hope, Hickory Hill, Swedes, Sigler, White Meadow, Beach, Hibernia, Beach Glen, Tichenor, Righter, Meriden, Cobb, Splitrock Pond, Greenville, Chester Iron Company's Mine, Green Pond, Howell, Kitchell, Charlotteburgh.

Pequannock Township.—Botts, De Camp, Decker, Gould, Stony Brook, or Pike's Peak.

Passaic County.—Vreeland, Wynokie, Tellington, Rheinsmith, Monks, Board, Hard, Little Blue, Little Red, Blue, Bush, Cannon, St. George, Cook, Miller, Cooper, Peters, Hope, Winslow, Ward.

Large's Mine, Clinton Township, Hunterdon County.—The mine opened by the late John K. Large, on the Hoffman place, west of Round Valley, has not been worked since 1875. The veins were narrow. Several hundred tons of ore were mined.

High Bridge Mines, High Bridge Township, Hunterdon County.—These old and well-known mines have been described in previous reports of the survey. The line of shoots is held by two owners, John Kane on the west and the Thomas Iron Company on the east. The property line runs a northeasterly course, and cuts the vein in such a manner as to give the upper shoots towards the southwest to the one, and the deeper portion of the ore as well as the northeastern end of the vein to the other. The former, or Kane property, was worked until June of this year by the late John K. Large, of White House. The Thomas Iron Company stopped work last April, and the mine is partly filled with water. Llewellyn James, the superintendent of the company, is raising a little ore from above the water line.

The several openings, extending from the public road—northeastward to the end of the hill—and to the Chester railroad, are at least a half a mile in length. And the deepest of them are down 200 feet below the surface of the hill. They show very plainly the shoot structure and a series of shoots, which run more towards the east than

the general trend of the ore, *i. e.*, they are oblique to the course of the *vein*. The pitch is towards the east—northeast—and is steeper at the northeast end of the hill than at the southwest. The workings of Mr. Large discovered three and four parallel shoots, side by side, separated by thin rock masses. As to details: the deepest shaft on the Large lease is near the road, and is 105 feet vertical, then inclined, on the slope of the foot-wall. A few rods north—northwest of that one, and at the south end of a large shoot—there was a shaft 70 feet deep. Parallel to this shoot were three others, one of which measured 55 feet across. It was worked by both lessees. The width of these shoots nowhere exceeded 100 feet, and the deeper workings stop at their lower edges. It is said that no one of them pinched out, but became thin—1 to 2 feet. The *pinches* were due to the *rolling* of the foot-wall, becoming flat, and so cutting out the vein. A great deal of ore was found near the surface and worked in open pits. Whenever the property line was reached, the working was transferred to the Thomas Iron Company. In their mining operations the shoot structure with its accompanying pinches has been found to continue northeast, and as deep as they have worked. On account of it the mine has presented widely differing prospects, but a judicious system of working, recognizing the peculiarities of structure, has succeeded in finding new shoots, and in making the mine a productive and valuable one. In some of the older open pits on the north end of the hill the wall rocks show the pitch very distinctly. It is on an average at an angle of 60° towards the northeast. The dip is, in places, almost vertical, or at a very high angle towards the southeast. There is a tunnel at this end of the hill running into an old open working, but the mining went 100 feet below its level, so that it has been of no use. Had it started in lower down on the hill, it would have been deep enough to drain the deepest workings, and it need not to have been 100 feet longer. Trial pits on the north foot of the hill have failed to strike ore. It is possible that the shoots pitch down so much as to get beyond the depth of any ordinary trial shafts. The annual product of these mines has been large, and the greater part of it has been used at the works of the Thomas Iron Company, at Hokendaqua, Penn.

Silverthorn, or Kane Openings.—The above name is given to openings on the southern slope of a hill, near the school-house, one mile

northwest of High Bridge. The property is owned by John Kane, of Elizabeth. The hill has been tested by several holes, of which the deepest is not over 15 feet. In this one there appears to be a vein several feet wide, and dipping to the southeast. The ore contains pyrite and hornblende. The openings are not deep enough to show the extent or probable size of the vein. The attraction about the pits is positive, and amounts to 10–40 degrees. Northward it is negative.

The searches here were made several years ago, and no work has been done since that time. The indications and the location so near to railroad transportation are such as to suggest further exploration. It was not mentioned in the Report for 1868 nor in that of 1873.

Sharp's Mine.—A little mining was done on the farm of Morris Sharp, 1½ miles east of High Bridge, previous to the panic of 1873, and at intervals up to last spring. One shaft is 50 feet deep. There are several holes. The ore was said to be of good quality, but the excessive amount of water made the mining expensive. The engine-house is standing, but the engine has been removed.

Emery Farm.—On the farm of Geo. L. and A. Emery, 1 mile east-northeast of High Bridge, there are two openings on ore. They are about one-quarter mile northeast of the farm-house, and about 200 feet apart in a northeast and southwest line. The northeast one is 25 feet deep. Here a vein of ore 2 feet thick was struck. It dips to the southeast. The ore contains some pyrite and some hornblende. Over 200 tons of it were shipped. The southwest opening is shallow, and 12 to 15 feet wide. The material here is a reddish, garnetiferous rock, containing some magnetite. Some of it was sent to Uhlerstown, Pa., where it was used in blast furnace. It may have answered as a flux. As an ore it is very lean. The indications are that there is a large body of it. Some work was done here in the autumn of 1878.

Old Furnace Mine, Tewksbury Township.—This mine has been idle since the last notice of it—in the Report for 1873.

Cokesburgh Mine, Tewksbury Township.—The Cokesburgh mine has been idle for several years.

Fisher, or Fox Hills Mine, Tewksbury Township.—This locality was opened in November of 1873. A notice of it was in the report for that year. A sample of the ore received from the lessee, John D.

Mills, M. D., of Rockaway, was analyzed, and the analysis published in last year's report. When visited in October, the main shaft was down 25 feet. It is west of the first openings, which were made in 1873. There is much water in the shaft, but the pumping is conveniently done by water power working a 3 inch pump. The ore on the bank contained a little pyrite and some hornblende. It is very hard. According to the analysis of last year it contains 57.5 per cent. of iron, .59 of sulphur, and only .04 of phosphorous. No ore has been sent away. The nearest railroad station is at Califon, 4 miles distant.

Sutton Farm, Tewksbury Township.—On the farm of George B. Sutton, adjoining the Fisher place on the southwest, two shafts have been sunk in searching for ore. The deepest is 22 feet deep. About 50 tons of ore were sent away from here to Allentown, Pa. These openings are in a southwest line from Mills' shaft, and about 100 yards from it.

Pottersville Openings.—Nothing further is known of these openings than the description as given in the Report in 1873.

Bartles' Openings.—Of these openings, also, there is no further information.

Openings Northeast of Pottersville, in Chester Township, Morris County.—The locality remains one of exploration rather than one of supplying ore.

Rarick Farm.—This locality is not worked.

Langdon's Openings.—A line of attraction 1000 feet long, and several trial pits and ore, are reported on a farm owned by Langdon & Nichols, in Washington township, Morris county.

Pitney Farm.—This property is 1¼ miles from Hacklebarney, down the valley of Black river. It is being explored by Cooper, Hewitt & Co. It was not visited. Some of the red surface ore has been shipped from Hacklebarney by the High Bridge railroad.

Budd and Woodhull Mines.—These mines have been idle for several years.

Topping Farm.—A considerable amount of ore was mined here by the Union Iron Company, previous to the panic, but the openings have been filled up.

Samson Mine.—This mine is now idle.

Hotel Property.—This property has not been developed into a mine.

Collis Farm.—Like the last-named place, this one is yet to be further tested.

Creamer Farm.—The line of ore on the Creamer farm has not been opened to any further extent.

Swayze Mine.—The Swayze Mine is held by the Chester Iron Company. It is idle, but is to be started as soon as miners can be found.

Cooper Farm.—A line of attraction is traceable on the property of the late Gen. Nathan A. Cooper, from the Swayze Mine. According to report the place is about to be tested and the vein opened.

Hacklebarney Mines.—The uninterrupted and extensive mining at Hacklebarney, since the Report of 1873, has developed such an extent of ore on both sides of the Black river, that it seems proper to designate the several openings as mines rather than parts of one mine. Northeast of the river there are five veins worked, although it is not altogether certain that there are not more, as in most of the workings no walls are found behind which there is no more ore. Near the river there are three veins quite close together, so that the removal of the intervening rock may be necessary as the drifting progresses in them. The working in these open cuts and drifts has not yet gone much below the level of the river. The amount of ore in the hill above the water level makes the mining easy and economical. To the northeast and on the hill the vein of the main open cut is cut by a tunnel which runs into the hill a distance of 300 feet from the railroad track, along the western foot of the hill. Beyond this point, and further northeast, there are several openings. Some of them are in the old open pits. To the east of these pits there are two whim shafts on two shoots of ore, which appear to be southeast of the lines of strike of the open cuts at the river. They are 35 to 40 feet deep. The most easterly opening on the property is nearly a half mile from the river, measured on the course of the veins.

On the southwest of the Black river the opening known as the Coal House Cut is about 150 feet long and 45 feet deep, and the breadth of ore in it is 40 feet. But the surface indications and diggings show the existence of veins, both to the east and to the west of the walls of the cut. The hoisting and pumping from this cut are done by water power furnished by the river. The same stream is used to compress air for a drill which is employed in this cut.

On the hill southwest of the Coal House Cut four openings are being worked. Two of these appear to be on the same vein. The stratification in them is very distinct, and the dip is 70° to the southeast.

The strike is slightly undulating. In general, the strike of the ore on the southwest of the river is more north and south than that of the veins on the east of the stream. The ore in these western openings has a schistose structure, occasioned by the greenish mica occurring in parallel and thin laminæ and layers with the magnetite. The same mineral occurs in the ore of the openings east of the river, but not to the same extent. The laminated structure is, however, common to the ore from all parts of the property. The layers of mica are sometimes one-quarter to one-half inch thick, but more commonly they are thinner. The magnetite ranges from one-half inch upwards. Pyrite is common to all the blue ore. In the surface specimens it is not seen, having disappeared through changes induced by atmospheric agencies.

The following analyses for iron, sulphur and phosphorus, were made last winter. The samples were carefully selected, and are good averages of the several parts of the mines.

NUMBER OF SAMPLE.	1	2	3	4
Metallic Iron	55.72	57.46	53.75	57.68
Sulphur	3.29	3.42	3.33	2.66
Phosphorus	0.032	0.033	0.036	0.025

1. Southwest Hill, Open Cut.
2. Andrews' Cut.
3. Birch Tree Opening.
4. Wiggins' Open Cut.

The agreement between Nos. 1, 2 and 3 are noticeable. No. 4 is richer and carries less sulphur, and very little phosphorus.

The low percentage of phosphorus in the greater part of the Hacklebarney ores admits of its use in the manufacture of Bessemer pig metal. Owing to this character it has found sale, and the mines have been worked steadily since our last Report in 1873. The completion of the branch of the High Bridge railroad to the mines has facilitated greatly the work of transportation. The extent of the openings is such as to give employment to a large force of men, and at a number of points, and these mines are capable of producing annually a much greater amount than at present mined. The product for the year 1879 was 21,548 tons. They are now yielding 3000 tons of ore a month, and the company hopes soon to make the monthly

output 4000 tons. The Chester Iron Company owns and works the mines.

Gulick Mine.—The Gulick Mine was worked by W. J. Taylor & Co. until quite recently, when it reverted to the original owner.

Creager Mine.—This place has not been worked lately.

Hedges Mine.—This mine yielded a large amount of ore, which was worked up in the Chester furnace. It is now idle.

Dickerson Farm.—The developments on this farm were discontinued several years ago.

Creamer Farm.—The Creamer farm lines have not been opened into an ore-producing mine.

De Camp Mine.—No work has been done here since 1874.

Leake Mine.—This mine has been idle since 1869.

Daniel Horton Mine.—This mine has been idle since the panic began.

Barnes Mine.—No work has been done here in several years.

Henderson Mine, Randolph Township.—This mine is idle.

George Mine, or Logan Mine.—The Logan Mine is owned by A. Pardee. It was worked for the Musconetcong Iron Works until it stopped, in October, 1873.

David Horton Mine.—This mine has been idle since the beginning of the hard times.

De Hart Mine.—The De Hart and Lawrence, or Gordon Mine, have been leased recently by the Reading Iron Company. They are now being re-opened.

Lawrence Mine.—The Lawrence Mine was worked up to 1878. There are three shafts, one of which is 110 feet deep. Between the middle and the southwest shaft there is an offset in the vein; and the shoots are said to pitch towards the southwest. The line of vein on the Lawrence lot is short, and the northeast shaft is close to the Dalrymple property. John Moyse is superintendent of the mining operations here.

Dalrymple Mine, or Carbon Mine.—This mine was worked by the Carbon Iron Company to 1876. The property is owned by Lawrence Dalrymple. The lease has been sold recently to the Crane Iron Company. And this company has been at work three months re-opening the mine. It was described in the Report for 1873. Since that publication a new shaft (known as No. 9) has been sunk near the

line of the Lawrence property. It is about 70 feet deep on the dip of the vein, which is at an angle of 70° towards the southeast. From this slope there are working drifts both to the east and west. The ore from it is fine-grained and rich, and has a tendency to a prismatic structure. Of the old shafts, Nos. 5 and 6 are said to be down nearly 300 feet. West of the latter the vein is faulted towards the foot wall corresponding to the offset in the Lawrence Mine. The ore is carted to Vanatta station and shipped to the company's furnaces at Catasauqua.

Trowbridge Mine.—This mine has been idle for several years.

Solomon Dalrymple Mine.—This mine has been idle for severral years.

Cooper Mine.—This mine has been idle for several years.

Munson's Mine.—This mine has been idle for several years.

Lewis Mine, or Herrick Mine.—This mine has been idle for several years.

Combs Mine.—From E. Canfield, of Ironia, who is now working this mine, the following notes were received: There are 2 shafts, 1 of which is over 100 feet deep, and the other between 50 and 60 feet deep. The latter is the working shaft. The vein has been opened 500 to 600 feet in length. It is about 10 feet wide. The ore contains feldspar and is lean, yielding on an average 40 per cent. of metal. The walls are hornblendic rock. The ore is carted 2½ miles, to Ironia, and is sent to the Lackawanna Coal and Iron Company's furnace at Franklin, where it is used with Spanish and other ores for making Bessemer pig.

Van Doren Opening.—The place has not been worked since 1873.

Bryant Mine.—This mine is idle.

Connor Fowland Mine.—This mine is idle.

Charles King Mine.—This mine has been idle for about fifteen years.

King Mine.—The King Mine, on the property of the Dickerson and Succasunny Mining Company, is worked by A. Pardee.

McFarland Mine.—This mine is idle.

Evers Mine.—This mine is idle.

Brotherton Mine.—The Brotherton Mine has been lately re-opened by the Andover Iron Company. It is yielding now about 650 tons a month. There are 2 small veins which are a few feet apart. The mine is 200 feet deep.

Byram Mine.—The Byram and Byram-Russell Mines continue to be steadily worked by the Andover Iron Company. At present ore is being mined from the most southerly shaft, near the road. The old mine slope is 900 feet long. The vein averages 6 to 7 feet in width. In consequence of the greater volume of water at the bottom of the mine, it has been necessary to put in larger pumps. Formerly the most of this water was held at 450 feet and raised from that depth. A narrow gauge railway runs from the mine to Ferromont, carrying the ore to the High Bridge railroad, whence it is sent to the company's furnaces at Phillipsburg.

Mellen Mine.—The work of re-opening this mine has been very lately begun by the Boonton Iron Works, under the superintendence of Robert F. Oram, agent of the company. The ore is for the supply of the company's furnaces.

Randall Hill Mine.—The Randall Hill Mine is steadily worked by the Crane Iron Company. The ore is used at Catasauqua, Pa.

Jackson Hill Mine.—The mining operations at this mine stopped several years ago. The buildings and machinery have been removed. It is reported that the vein had gone beyond the property line, towards the east, and that the workings had reached that boundary.

Canfield Phosphatic Iron Ore.—The openings on this vein of mixed magnetite and apatite have not been continued since the Report of 1872; and there have not been any attempts to utilize the ore or phosphate.

Black Hills Mine.—This name is given to the veins which are worked on the hill south of Dickerson Mine, and on the property of the Dickerson Mining Company. The workings are in charge of John M. Barnes, and the ore is sent to the furnace of A. Pardee & Co., at Secaucus. There are four small veins, two of which are worked by one slope. At no point are the workings down 100 feet. The ore is remarkable for its low percentage of phosphorus and the presence of white quartz. It is valuable for mixing with the rich Spanish and other foreign ores for the manufacture of Bessemer metal.

Dickerson Mine.—This old and well-known mine continues to be steadily worked and is now producing at the rate of 2800 tons a month. Since the Report of 1873, at which time it was held by the Allentown Iron Company, it has been leased to A. Pardee, and is worked under the superintendence of E. S. Moffatt, M. E., of Stan-

hope. A new slope was completed in November, 1878. It facilitates greatly the raising of the ore, and increases the capacity of the mine. It is about 900 feet in length, and the northeast heading is now northeast of the old Dickerson mansion. The big vein and the side vein on the hanging-wall are worked. The larger part of the ore goes to the Musconetcong Iron Works, at Stanhope. It commands a ready sale on account of its richness, and brings a large royalty to the owners, the Dickerson Succasunny Mining Company. The product of the mine in 1879 was 27,251 tons.

Canfield Mine.—The Canfield Mine also belongs to the Dickerson Mining Company. It was worked several years by E. Canfield. It is idle.

Baker Mine.—The mine of this name, northeast of the Byram Mine, has not been worked for several years.

The Baker Mine, until recently owned by Waterman & Scranton, is on the same property, but further to the west. This mine is now worked under the superintendence of A. Beemer, of Dover. It is 110 feet deep, and is opened on the vein a length of 225 feet. The ore varies from 2 and 3 feet to 12 and 20 feet in breadth, and is, on the average, 8 or 9 feet. The ore is rather lean, containing considerable quartz and feldspar. The percentages of sulphur and phosphorus are low, so that it is said to be suitable for Bessemer metal.

Irondale Mines.—The group of mines owned by the New Jersey Iron Mining Company, and commonly known as the Irondale Mines, includes the following:

Spring Mine, Sullivan, Corwin, Stirling, Hubbard, North River, Harvey, Hurd. Of these mines all are idle excepting the Stirling and the Hurd, both of which are leased to the Thomas Iron Company.

The Stirling Mine shoot has been followed about 1500 feet on a gentle pitch to the northeast. The average thickness of the ore is 6 feet. And the height of the shoot is now 90 feet. The mine is producing about 1200 tons per month.

The Hurd Mine was opened in 1872 by the Thomas Iron Company. In 1874 a subterranean stream of water prevented working it to its full capacity, and finally led to a stoppage. Similar difficulty was met with in the Harvey and Orchard Mines. To relieve these mines of the excessive amount of water, the Orchard and Irondale Adit was projected. The following description of this work is by L. C. Bier-

wirth, Mining Engineer and Agent of the New Jersey Iron Mining Company.

The Orchard and Irondale Adit was commenced in April, 1877, by the New Jersey Iron Mining Company, the Thomas Iron Company and the trustees of the estate of J. C. Lord, with a view to draining the Orchard and Hurd Mines at Port Oram, both of which at the time were idle and full of water. In the Orchard Mine it had required 2 18-inch, 1 14-inch, and 1 6-inch pump, with a 4 feet 10-inch stroke, and running 8 strokes per minute to keep the water; and at the Hurd Mine it had broken in in the spring of 1874 with such force as to drown the pumps.

The mouth of the discharging ditch connecting with the adit was located at a point on the west bank of Rockaway river, 200 feet below the "Three-Span" Bridge of the D., L. & W. R. R., and the ditch and main adit have been carried up on the south side of the railroad a total distance of 3667 feet, the ditch being 983 feet and the adit 2684 feet long and 5 feet wide, with a grade of about three-quarters of an inch to 100 feet. The ground encountered has generally been coarse gravel, with numerous boulders and occasional beds of quicksand, but no rock in place was met in the entire distance. The drainage to the east and northwest, after the adit had been driven some 1000 feet from the mouth of the ditch, became very marked, and reached to a great distance. The work was carried on with 3 8-hour shifts, and the greatest distance driven in any month was 184 feet in January, 1878. After the adit had been driven the above-named distance of 3667 feet, which had been accomplished in April, 1879, the breast was still 420 feet distant from the Orchard pump shaft; but owing to the porosity of the gravel, the water had been lowered in that shaft from 40 feet below the surface, at which level it stood before the adit was commenced, to a depth of 64 feet 4 inches from the surface, being within 10 feet of the point at which the adit was calculated to reach the shaft. The agent of Mr. Lord's estate, Mr. Robert F. Oram, determined to try the quantity of water which the mine still made, and on starting to pump it out, found that a 14-inch pump running 6 strokes per minute was more than sufficient to keep the water.

The effect of the adit upon the Hurd Mine, which was still 1530 feet distant, had not been so great, but still was sufficiently marked as

to induce the Thomas Iron Company to put up powerful pumps and take the water out in the summer of 1878, when the water in the Hurd shaft had been upward about 20 feet. This season a branch of the main adit was driven towards the Hurd Mine, a distance of 653 feet, from the diverging shaft at the end of the main adit. When within 110 feet of completing this distance, a bed of quicksand was encountered, causing much trouble and delay; but as soon as it had been cut through, the water in the Hurd Mine was very greatly decreased, so much so that whilst it had previously amounted to 300 gallons per minute, it is now only 80 gallons, making a saving of 50 tons of coal per month. The work on the adit has been suspended for the present. When completed to the Hurd Mine, it will unwater that mine at a depth of 94 feet from the surface of the old shaft.

The velocity of the stream in the main adit is 42.8 feet per minute and its average depth 14 inches, with a width of 4 feet 8 inches inside of the timbering.

Orchard Mine.—Work was resumed in the Orchard Mine February, 1879. The adit carried away the surface water, so that it was found that 1 10-inch pump running at 7 strokes a minute, would raise the water, whereas, before there were 2 18-inch pumps, 1 14-inch, and 1 10-inch pump, with a stroke of 4 feet 10 inches, and working 9 strokes per minute. The mine is now about 500 feet deep. It is worked by the trustees of the estate of J. Couper Lord.

Erb Mine.—The Erb Mine belongs to the Andover Iron Company. It has been idle for 10 years.

Scrub Oak Mine.—This mine also is owned by the Andover Iron Company. The vein is wide, and has been opened for over 1000 feet in length. The ore is lean.

Johnson Hill Mine.—The Johnson Hill Mine is the southwest extension of the Huff veins. The hill is 100 feet approximately above the level of the road, and the northeast shaft of the Huff Mine. It is not now worked.

Huff Mine.—The Huff Mine was idle from 1874 until November of the present year, when work was resumed by the lessees—the Chester Iron Company. The openings indicate a succession of shoots, which pitch to the northeast. The deepest shaft is at the side of the public road, and is 114 feet deep. The pumping here takes the water from the other openings above it, on the hillside. The ore of these

shoots contains some mica, which gives it a laminated structure. But the bottom ore is more solid. The open cuts higher up the hill show alternations of ore and rock, and do not reach a hanging-wall. To the northwest of the main line of openings there is what is known as the Hard Vein. The ore in it is lean and hard, containing quartz. The mine is now yielding at the rate of 1000 tons per month.

Dolan Mine.—The Dolan Mine is on the mountain northeast of Mount Pleasant. It has not been worked to any extent; and it is now idle.

Washington Forge Mine, Rockaway Township, Morris County.—The adit to the Orchard Mine appears to have taken off much of the surface water, which was formerly so troublesome at this mine; and the work of pumping out the water and re-opening the mine has been begun by John Brown, of Easton, Pa.

Mount Pleasant Mine.—The Mount Pleasant Mine has been going steadily through the dull times. As heretofore, the greater amount of ore is got in the eastern part of the mine, and very little is done in the west mine. The depth of the east mine is 600 feet. The thickness of the ore is found to be greater at the bottom than it was at a less depth. Since the stoppage of the furnaces at Boonton the ore has been sold. The owners are the trustees of J. Couper Lord's estate, and the mine is in charge of Robert F. Oram, of Dover. Joseph Richards is superintendent at the mine.

Baker Mine.—The Baker Mine was worked by the Allentown Iron Company until in 1877. At the bottom the vein *pinched* almost out. Borings 100 feet downwards and in the plane of the dip failed to discover any workable body of ore, and it was abandoned.

Richards Mine.—The Thomas Iron Company is working the Richards Mine. The southeastern vein is the larger of the two veins, and from this one comes the most of the ore which is raised from the mine. The ore is sent to Hokendauqua, Pa.

Allen Mine.—The Allen Mine is owned by the New Jersey Iron Mining Company, and is leased by the Andover Iron Company. The shoots are found to be the largest to the northeast. Towards the southwest there is more rock mixed with the ore between well-defined walls. One vein is worked. A tunnel 60 feet long runs into it. The deepest parts of the mine are 250 feet below its level. From this vein a tunnel was driven 300 feet across the strata, in search for

the big vein of Mount Hope Mines. No ore was found. Mr. George, the agent of the Andover Iron Company, is having a drift cut in the eastern vein of the Richards Mine towards the Allen line. It will be 275 feet long to the property line. At the starting point the shoot in the Richards Mine is large, and he hopes to follow the Richards shoot on to the Allen property, and so find an eastern vein. The results of these explorations will be of much interest, and important to all engaged in mining iron ore as well as to geological science. The ore from this mine is worked at Phillipsburg.

Teabo Mine.—The Teabo Mine continues to be worked by the Glendon Iron Company. The explorations in search for the Big or Taylor Vein, which has been supposed to extend from Mount Hope across on to this property, have failed thus far to discover it. The mine is yielding steadily a large amount of rich ore. The general features of the mine are about the same as when last visited.

Mount Hope Mines.—The Mount Hope and Hickory Hill Mines are owned and worked by the Lackawanna Iron and Coal Company. During the financial depression the Hickory Hill Mines were idle, as also the Taylor or Tunnel Mine. The Elizabeth Vein was the only one which was worked steadily. The mines on Hickory Hill are still full of water. The Taylor mine is being put in order for work. The aggregate production of the mines has been about 2400 tons a month, but it will be doubled and trebled as soon as the arrangements for increased mining operations can be made. The ore is sold.

Swedes Mine.—This old and noted mine, belonging to the heirs of J. Couper Lord, has not been in operation since 1875.

Sigler Mine.—This mine is not in operation.

White Meadow Mines.—These mines are not in operation.

Beach Mine.—This mine is not in operation.

Hibernia Mines.—The mine lots, or mines at Hibernia, are beginning at the south end of the hill; Lower Wood, worked by the Andover Iron Company; Glendon, worked by the Glendon Iron Company; Crane, worked by the Glendon Iron Company; De Camp, worked by the Glendon Iron Company; Upper Wood, worked by the Glendon Iron Company; Willis, worked by the Bethlehem Iron Company.

The New Jersey Iron Mining Company owns the Lower Wood, Upper Wood and Willis Lots.

The Lower Wood Mine is worked out to a depth of 250 feet below the Hibernia brook; the sink is about 400 feet deep. There are two shafts and one incline. The latter is 600 feet long. The ore is raised in cars running up the incline. A separate engine works compressor for driving three drills. The company is erecting another to run an additional number of drills. The Rand pattern is used. The working force has been largely increased lately, and Mr. George, agent of the company, reports a monthly product of 4000 tons.

The Glendon Iron Company has been mining a great deal of ore, and preparing for a larger output by the construction of a tunnel, which serves for draining as well as for transportation.

The Bethlehem Iron Company is preparing to resume work in their mine at the northeast end of the hill. The continued productiveness of the Hibernia Mines is exhibited in the tonnage of iron ore, of the Hibernia Mine railroad. This amounted to 99,123 tons in 1879.

Beach Glen Mine.—This mine was not in operation from 1875 to 1879. During the greater part of the year it has been worked under the management of the estate of James Couper Lord, the owners. The ore goes to Boonton. Two veins have here been worked to a depth of 100 to 130 feet throughout a distance of several hundred feet, northeastward from the border of the old Horse pond. A peculiar feature of these veins is their dip towards the northwest. It is very steep, almost vertical. The veins are large. In the eastern there is remarkable alternation of mica and magnetite, constituting a highly laminated structure. A short branch road connects the mine with the Hibernia railroad.

Cobb Mine.—The Cobb Mine on the east side of the Splitrock Pond is now worked for the supply of the Wilson furnace, at Splitrock. It is producing 350 to 400 tons per month.

Splitrock Pond Mine.—In the Report for 1874 there was a short description of the mine at the head of Splitrock Pond. It was worked a little while in 1875. During the past year operations were resumed by Wm. S. De Camp. The surface indications were carefully noted in a magnetic survey of the locality made in 1875. There is a belt of strong attraction on the east side of the Charlotteburgh road, and crossing the same northward towards the pond. It is about 300 feet long, and 100 feet wide at the southwest end, and about 50 feet wide at the northeast end, (near the barn.) At the southwest and

on the western side it is negative. Elsewhere it is positive. Going southwest to the holes near the pond, the attraction is very light. And it does not appear to be continuous with that of the main belt. Northeastward a light attraction is said to be traceable for a half mile, along the line of the Charlotteburgh road.

Two veins have been opened. They are not more than 50 feet apart. The pump shaft in the hanging-wall vein is 60 feet deep. This vein is reported to be 14 feet across from foot-wall to hanging-wall, (as workings have opened it,) with ore in the hanging-wall side. In the foot-wall side of the vein, and for a breadth of 7 feet, there are alternating strings of ore and mica. The foot-wall, or west vein, has been opened so as to show a shoot of rich ore, which is 25 feet high and 8 wide. A drift from the bottom of the shaft to the east vein allows the water to flow into the sink in the latter. The ore raised the past autumn has been shipped to the furnace of A. Pardee & Co., at Secaucus, where it has been worked into Bessemer metal. Analysis of average ore from east vein, made at the Survey Laboratory in 1875, gave:

Metallic Iron	63.399 per cent.
Phosphorus	0.0109 "
Sulphur	0.068 "
Titanium	none.

Greenville Mine.—There have been no further developments at this place since 1873. The locality is one of exploration, and not producing ore.

Chester Iron Company's Mine.—Nothing has been done at this place since the Report of 1873.

Green Pond Mines.—These mines were described in the Reports for 1873 and 1874. Since the latter appeared the failure of the Green Pond Iron Mining Company has necessitated a change in the management. For two years they have been worked under the superintendence of Robert F. Oram, for the creditors of that company, Charles E. Maxwell, trustee. William V. Curtis has charge of the mines. A large amount of ore has been mined, and the existence of large shoots of ore has been demonstrated. The present operations are on the south tract, or Wild lease, and in slopes Nos. 1, 3, 5 and 2, in order, going northeast.

South Tract.—Here the ore has been found close to the surface, on the east or lower side of the road, and not more than 200 feet from

the ledges of conglomerate. In the trial pit south of the road to the mines, the dip of the ore bed is 25° to 30° towards the southeast. The pyrite in the ore undergoes decomposition quickly, causing the ore to fall to pieces after a few months' exposure. In the shafts north of the mine road the vein is quite flat and the ore is pyritous, but rich. It contains less mica and is harder than that of the mines to the northeast. Some of the surface ore would need to be washed. The deepest of these openings on the south tract is 40 feet. There is no water in them. Thus far they indicate a succession of shoots, which may not be in the same vein.

Slope, or Opening, No. 1, is at the border of the swamp. It is the deepest on the property, and is 300 feet long. The ore mass here worked is 70 feet wide and 20 to 25 feet thick. An engine at the head of the slope raises the ore and pumps the water. But there is little water to be raised. Preparations are making to change the track here so as to work down the ore, which crops out at the head of the slope and under the engine-house, and which appears to be the end of a lower shoot. The work here has not advanced far enough to determine any of the dimensions of this newly-opened shoot.

Opening No. 3 is but a few feet north of and above No. 1. This slope is 170 feet long, and the shoot of ore is 60 feet wide, or high, and 20 feet thick.

Slope No. 5 is separated from No. 3 by 2 feet of rock. The Green Pond Iron Mining Company took a large amount of ore from this opening. It is not worked at present.

Slope No. 2 is northeast of the office, and 250 yards from No. 1. The track is 250 feet long, descending at an angle of 30° towards the northeast, on the bottom rock of the shoot. The dip of the foot-wall here is 40° to the southeast. The breast of ore is 20 feet wide, but there appears to be a separate vein, 3 feet thick, on the foot-wall, going back, under the slope. Further opening may prove the rock under the track to be a horse which ends near the present heading. The foot-wall is clean; the hanging-wall is not, but ore and rock mined. Pillars of ore are left to support the latter, so that there is no timbering. And there is no water, except that from rains. The ore is raised in cars by an engine at the head of the slope.

The ore of these several slopes is very uniform in character. All of it contains pyrite, and nearly all of it has to be roasted before

smelting. A greenish mica in it in thin layers, alternating with thicker layers of magnetite, gives it a schistose structure.

The ore is loaded on cars at Slope No. 1, the terminus of the Green Pond railroad, which connects with the New Jersey Midland railway near Charlotteburgh, and is sold to Pennsylvania furnaces. On account of the low percentage of phosphorus, it has been used in making Bessemer steel.

The development of this property has been very interesting to the Geological Survey, as it is one of the more recently opened iron mines, and repeated visits have confirmed the first observed indications of a great extent of ore. It is hoped that under its present skillful and energetic management additional veins will be found, and several large and enduring mines opened.

Howell Tract.—The lot adjoining the property of the Green Pond Company on the north belongs to Monroe Howell. Attraction was observed across it; and 50 to 100 tons of ore have been taken from one trial shaft.

Kitchell Tract.—The Kitchell tract is on the eastern side of the Copperas Mountain, and adjoins the Howell lot on the northeast. Two veins of ore were opened several years ago by five test pits, and a small amount of ore was obtained. It is rather lean, and contains some pyrite, resembling that of the Green Pond mines. The Green Pond railroad runs near the eastern boundary line of the tract.

Charlotteburgh Mines.—The Charlotteburgh Mines belong in part to Martin J. Ryerson.

The Bethlehem Iron Company worked here up to the commencement of the panic. Harry J. Blackwell, of Newfoundland, did some work after the Bethlehem company gave up the lease, and opened two veins on the hanging-wall side of the old mine holes. The mines are now idle. Analyses of these ores were reported in 1878.

Botts Farm.—There is nothing to add to the notice of this place as it was given in the Report for 1873.

De Camp, or Rockaway Valley Mine.—This mine was in operation until shortly before the panic of 1873. It was worked for the Musconetcong Iron Works, at Stanhope, and the total product was large.

Decker Farm.—This locality is idle.

Gould Farm.—This locality is idle.

Stony Brook, or Pike's Peak Mine.—Notices of this mine have

appeared in the Reports for 1868, 1873 and 1876. It possesses some historic interest as having been opened by the London company more than 100 years ago. It was worked a little about 18 years ago by Mr. Ryerson, and last autumn work was resumed. The vein is narrow, 2½ to 3 feet wide, but the ore is rich, and of superior quality. Analysis of a sample from Mr. Ryerson was made in 1876. [See Annual Report for 1876, pp. 54, 55.] The locality is 1 mile from the Charlotteburgh and Splitrock road, and 2 miles southeast of the former place.

Vreeland Farm.—Magnetic ore has been discovered lately on the farm of Thomas B. Vreeland, 1 mile north of Charlotteburgh station, and close under the conglomerate cliffs of the Kanouse Mt. Several holes have been dug, of which the deepest is between 35 and 40 feet deep. The ore is similar to that which is found in the mines at the foot of Copperas Mountain. This new locality shows the existence of a range of ore bodies and mines, in the gneiss rock, close to the Green Pond Mountain conglomerate.

Wynokie Mines.—No work has been done in these mines in many years.

Tellington Mine.—A notice of the Tellington Mine appeared in the Report for 1874. The further developments have been very slight, and the place is not worked.

Rheinsmith Farm.—Like the last-named, the Rheinsmith place has not developed into a producing mine.

Monks Mine.—There is no report of this mine as being worked.

Board Mine.—The mine here stopped before the late depression began.

Ringwood Mines.—The several mines on the Ringwood Tract are the Hard, Little Blue, Little Red, Blue, Bush, Cannon, St. George, Cook, Miller, Cooper, Peters, Hope, Winslow and Ward. They are owned and worked by Cooper, Hewitt & Co.

MUSCONETCONG BELT.

Mines in Hunterdon County, Holland Township.—Hager, Duckworth, Bloom.

Alexandria Township.—Martin.

Bethlehem Township.—Turkey Hill, Swayze, Alpaugh, Wild Cat, Church or Van Syckle, Rodenbaugh, Asbury, Miller.

Lebanon Township.—Banghart, Terraberry, Fritts, White Hall, East Castner, Hunt or Pidcock.

Morris County, Washington Township.—Sharp, Hann, Hunt, Stoutenburgh, Fisher, Marsh, Dickinson, Hunt, Lake, Naughtright, Sharp, Rarick, Hopler.

Mount Olive Township.—Shouse, Cramer, Smith, Lawrance, Mount Olive or Solomon, Drake, Osborn.

Roxbury Township.—Hilts, Baptist Church, King, Gove.

Jefferson Township.—Davenport, Nolands, Hurdtown Apatite, Hurd, Lower Weldon, Weldon, Dodge, Ford, Scofield, Fraser, Duffee, Shongum.

Warren County, Franklin Township.—Cline, Smith, Dean.

Washington Township.—Chapin and Lommasson, Lanning, Oxford Furnace.

Mansfield Township.—Creager, Mitchell, Johnson, Bald Pate, Egbert Church, Rockport, Shafer.

Independence Township.—Searle, Bucks Hill.

Allamuchy Township.—Frace, Young, Pyle, Axford, Bryant, Excelsior, Eureka, Haggerty, Brookfield or Waterloo.

Sussex County, Byram Township.—French, Smith or Cascade, Allis, Hude or Stanhope, Wright, Silver, Haggerty, Lawrence, Gafney.

Sparta Township.—Sickles, Goble, Boss, Sherman, Bunker, Ogden.

Hardyston Township.—Greer Farm and Franklin Iron Company, Hopewell Forge.

Vernon Township.—Canistear, Tracey and Crane, Henderson, Williams, Rutherford Estate, Hunt, Wawayanda, Green, Welling.

Passaic County, West Milford Township.—Kimble, Budd and Hunt, Scranton and Rutherford, Jennings and Rutherford, Clinton Tract, Wallace, Squiers.

Hager Mine.—The Hager Mine has not been described or mentioned in any of the Reports of the Survey. It is on lands of John Hager, 1¼ miles west of Spring Mills, and on the southern foot of the Musconetcong Mountain. About 700 tons of ore were mined here by Hartpence, Van Syckel & Bird several years ago. Two shafts were sunk to a depth of 40 feet. The ore found near the surface was weathered and was of a rusty red color. It had lost the sulphur originally in it in the form of pyrite. The ore from the bottom of the shafts and workings shows the pyrite quite regularly disseminated through the

mass. The Holland Mining Company has recently re-opened this mine. John Jameson, superintendent, in a letter dated December 11th, says that in the lower shaft, at a depth of 60 feet, the vein is 7 feet wide and pitches (dips) to the southeast. And there is much less sulphur than there was at a depth of 50 feet. The company is now shipping 20 tons of ore a day. By the first of the year they expect to have both shafts in working order, and to raise 50 tons a day. The following analysis of a sample received from Mr. Jameson, indicates the richness and quality of the ore:

ANALYSIS.

Metallic iron	56.13	per cent.
Sulphur	7.59	"
Phosphorus	0.29	"
Titanium	0.84	"
Manganese	none.	

The percentage of sulphur is unusually large. The titanium in the form of titanic anhydride amounts to 1.40 yer cent.

Duckworth Farm.—This locality is one-half mile west of Little York, and near the foot of the Musconetcong Mountain. A hole was dug here about a hundred years ago. A few years since Mr. Duckworth sunk two shafts, one 50 feet deep, the other 25 feet. A thin bed of ore was found between the gneissic strata. A sample of the ore was analyzed, and found to contain 64.32 per cent. of metallic iron, .0039 of phosphorus, and 9.92 of insoluble matter. The work of exploring was resumed last autumn. Thus far these searches are reported as not very successful.

Bloom Farm.—In the Report for 1874 the Bloom openings were noticed under the head of "Little York Mine." In the Report for 1875 an analysis of a sample of ore from P. C. Bloom was published. The ore was lean, and contained 4.7 per cent. of titanic acid, and *traces* only of phosphorus. Nothing has been done here since that Report was published. The locality is on the southern foot of the Musconetcong Mountain, one mile west of Little York.

Martin Farm.—Magnetic iron ore is reported to have been found in mining quantity on the farm of Wm. C. Martin, east of Little York, and on the southern slope of the Musconetcong Mountain.

Turkey Hill, or West End Mines.—A short account of these mines was published in the Report for 1874. During a very short visit to

them last autumn, the following notes were obtained from the superintendent, N. H. Heft: The mines were discovered and opened by Mr. Heft in September, 1872. They have been worked without interruption to the present time, and they are now worked by G. M. Miller & Co. and Daniel Runkel. Two veins are known, 60 feet apart, but one only is worked to any extent. There are seven openings on it, and two trial pits further east are now being sunk. The course, or strike, is N. 75° East, and the dip is about 60° towards the south-southeast. The walls are clean and straight, and generally parallel. The rock of the foot-wall of the big vein is generally a dark-colored gneiss; that of the hanging-wall is a coarse crystalline gneiss. The size of the vein varies somewhat on account of *rolls* in the foot-wall. But they do not, in any case, cut out the vein. The vein runs from 6 to 20 feet wide. At one place it was 40 feet wide, but in it was a horse of rock, 8 feet across. Beginning at the west the several shafts are located as follows: A slope 75 feet deep, connected with shaft No. 1, which is 100 feet from it; from No. 1 to No. 2, 630 feet; from No. 2 to No. 3, 380 feet; from No. 3 to No. 4, 340 feet. The latter two are connected by underground workings. The others are separate. East of No. 4, 600 feet, they are now sinking on the vein, and also 3000 feet from the same shaft. Of the several shafts, No. 4 is 75 feet deep vertical, then on the foot-wall, inclined, over 100 feet deeper. It is the deepest on the property. The company has five Copeland & Bacon hoisting engines. The boiler-house is near No. 2 shaft, and has four plain cylindrical boilers. Culm is used for heating. They are now raising 1500 tons of ore a month, all of which is sold to the Bethlehem Iron Company, and is used for Bessemer steel. Between shafts 1 and 2, 174 feet in length of the vein is worked by Daniel Runkel, of Asbury.

Since the completion of the Lehigh Valley railroad the ore from these mines has been shipped from West End station. The company is now constructing a branch railroad from West End to the mines. The grade is such that cars can be run by gravity to the station. The company is preparing to work the mines to a much greater extent than heretofore, and under the energetic superintendence of Mr. Heft the outlook of their mines is promising.

The Crane Iron Company is opening on the line of the Turkey Hill Mine, northeast of the latter and near Bethlehem.

Swayze Mine.—This mine also is owned by G. M. Miller & Co. It was called the Bethlehem Mine in the Survey Report for 1873. Work here was stopped in 1875, after reaching a maximum depth of about 90 feet. The present owners are re-opening it and getting ready to work it again. According to Mr. Heft, there is a line of attraction from this mine, traceable southwest, to the Turkey Hill Mines.

Alpaugh Farm.—A shaft 25 feet deep was sunk on the Alpaugh estate, 1¼ miles from West End and southeast of the Swayze Mine, and a small vein opened, but the volume of water was so great that further exploration without an engine for pumping was impossible, and the work was stopped.

Wild Cat Mine.—The Wild Cat Mine is near Bethlehem. It is worked by Theodore Hoffman, of Clinton, who reports a layer of ore about four feet thick; then rock, two to three feet thick; then ore again—the lower stratum taking a turn gradually downward. The depth of the opening is about 30 feet. The ore is shipped to the Keystone furnace, Pennsylvania.

Church, or Van Syckle's Mine.—This old mine is on lands of John T. Leigh. It was worked last in 1875, by Cooper, Hewitt & Co., and the ore was smelted at Durham. The ore is remarkable on account of the large percentage of titanium in it and the traces only of phosphorus. The mine is two miles from the Easton and Amboy railroad.

Rodenbaugh Mine.—This locality has been opened since the last report on the iron mines of the State appeared. The lease is held by Theodore Hoffman, of Clinton. The openings are three or four trial shafts, none of which are more than 25 feet deep. They are on the crest of the Musconetcong Mountain, about 300 feet above the Asbury depot and the Central railroad. At the most westerly shaft the strata dip steeply towards the northwest; in others the dip is towards the southeast. The hornblende in the rocks and mixed in the ore is noticeable. Very little ore has been sent away.

Asbury Mine.—This mine is on lands belonging to Daniel Osmun. It has been leased lately to R. A. Laity and Edward Moyle. The mine was worked many years ago. A tunnel, 100 feet long, runs in the side-hill across the strata to the vein, and from that the workings go down 130 feet below the tunnel level. Near the mouth of the adit, or tunnel, there is a coarse crystalline granite. The vein in the

bottom of the mine is said to be 6 feet wide. The vein is opened to the south, higher on the hill, in several open cuts. The ore and the rock associated with it, both contain hornblende. The strata dip about 60° to the southeast. The ore is lean. When visited, Messrs. Moyle and Laity were preparing the mine for work, so that it was not in a favorable condition for inspection. It is so conveniently located for working and so near to the railroad that it can be worked profitably, if there be a vein of good size and carrying a fairly good ore.

Miller Farm.—Messrs. Laity and Moyle have leased this property also, and have begun exploring it further. They report two small veins. The locality is one mile southwest of Glen Gardner.

Banghart Mine.—This mine is now held by Theodore Hoffman, who reports the shaft as 35 feet deep and on a vein of good ore, which is 3 feet wide. As this place is one mile only (northeast) from Glen Gardner station on the Central railroad, it is convenient for transportation.

Terraberry Farm.—As the last report on iron ores did not mention this locality, it is here given, although it is now idle. It is less than a mile south of White Hall, Hunterdon county. The openings are little more than test pits. The ore is lean and mixed with mica and hornblende.

Fritts Farm—Alvey Gray's Farm.—The Saucon Iron Co. is lately reported to have leased this property and begun work on it. It is a half a mile southeast of White Hall. The ore on the bank at the time of a visit in 1875, was lean. Up to that time only about 400 tons of ore had been taken out of the shaft.

White Hall, East.—The locality thus named remains idle.

Castner Farm.—Some ore has been mined on the farm of Adam Castner, on the brow of the mountain and three miles northwest of White Hall.

Hunt, or Pidcock Mine.—This mine is not worked. At a recent visit some ore was seen on the bank. It is lean. There is a positive attraction of 10° to 20° about the main opening, which is 100 feet long from east to west, and east of the old mine holes. A horse whim was used for hoisting the ore. The opening was free from water 35 feet down. The mine is nearest to the canal at Port Murray, but the road is very hilly.

Sharp's Mine, Pleasant Grove.—Work stopped at this locality in

1874. About 50 tons of rich ore were taken out from a narrow vein. The shaft had reached a depth of 60 feet.

Hann Farm.—On the farm of Wm. Hann, northeast of Pleasant Grove, mining has been done at intervals by two distinct parties. Very recently the property has been leased by Wm. W. Marsh, and the ore has been uncovered in two shafts. At the southwestern openings, made by Marsh & Trufant, the vein was thin and dipped gently towards the south. Towards the northeast, A. H. Seam & Co. worked up to 1875, and W. W. Marsh, of Schooley's Mountain, after that time. The amount of ore taken from this opening was estimated to exceed 5000 tons. The strike of the vein is a few degrees south of west, and the dip is about 30° towards south-southeast. A succession of open pits were dug in working the two parallel veins. The ore of the foot-wall vein is brownish; that of the other vein is bluish. Grains of feldspar give the mass a speckled appearance.

An analysis of an average sample was made since the mine has been re-opened. It shows the following percentages: of

Metallic iron	56.970 per cent.
Sulphur	0.088 "
Phosphorus	0.367 "
Manganese	none.
Titanic acid	1.050 "

Hunt Farm.—Ore was found in digging a well and a cellar on the farm of H. Hunt, one mile southwest of Schooley's Mountain and near the Pleasant Grove road. An exploration is about to be made to test the locality.

Stoutenburgh Mine.—The Stoutenburgh Mine was idle from 1873 to 1877. The total product in the first working period was 6000 tons, and a depth of 115 feet was reached. The vein at the bottom was *cut out* to a width of 2 feet when the lease was given up. In 1877 Mr. Stoutenburgh began prospecting for other veins, and up to the present time he has sunk nine trial pits, and has found ore in each one of them. What may now be termed the *mine* is several rods southwest of the old shafts. In the main shaft the ore was struck 7 feet beneath the surface of the ground. This shaft has a vertical depth of 22 feet, and then descends on the foot-wall, towards the southwest, 70 feet—in all over 90 feet. From the shaft the ore has been worked out each way by drifts, one of which connects with a second shaft, 35 feet distant. The westerly drifts have opened a lean ore, consisting of magnetite in

a granitic rock, and it has varied from 1 to 3 feet in width. Towards the east there is more regularity in the structure, and the vein attains a maximum thickness of 7 feet. The dip is towards the southeast, but is steeper as it gets down. The foot-wall is fairly defined, but there are traces only of a hanging-wall. The rocks are much disintegrated. In the eastern shaft, which is 35 feet deep, the rocks are harder and the vein is 6 feet wide.

There is considerable water in the mine, and a small engine is in use for pumping and for hoisting the ore. On account of the disintegrated nature of the ground, the ore can be picked out. Some of the finer ore has to be washed to remove the earth. There is some feldspar mixed with the magnetite. It is carted to the High Bridge railroad at German Valley, and shipped to Allentown, Pa.

Mr. Stoutenburgh found a vein 5 feet wide of lean ore, at a depth of 22 feet, in a shaft a few rods east of the old mine. On account of a scarcity of hands, the further sinking in this shaft has been deferred for the present, until it may be needed. On the west of the old mine, and on the west side of a lane, there is a shaft 35 feet deep, in which, at the bottom, the vein is 3 to 4 feet wide and bounded by good walls. The ore is rich. Drifts each way about 30 feet long have opened a length of 70 feet on this vein.

In the fields east of the mines there are two main belts of negative attraction, which extend northeastward to the public road. The attraction varies from 5° to 35°. Much *float-ore* has been picked off these fields. It is possible that they indicate the easterly extension of the vein of the old mine. Their development is awaited with interest.

Fisher Mine.—This mine has been known as the Beattystown Mine. It was first worked by the owner, J. B. Fisher; afterwards by Wm. W. Marsh, of Schooley's Mountain, until the depression in the iron ore trade caused the suspension of operations, since which time it has been idle. Several thousands of tons of red ore were taken out of a large open cut, and shafts sunk at each end of the opening, one of which was 140 feet deep, and penetrated a rich ore, but containing some sulphur. A large body of ore is still in the mine, and *in sight.* From the mine to the railroad depot at Hackettstown the distance is four miles.

Marsh's Mine.—The mine on the farm of Wm. W. Marsh, near the Schooleys Mountain House, was opened in 1855 and worked for a short time, and yielded from 3000 to 4000 tons of ore. Again in

1872–3 it was in operation. The first mining was open cuts in the surface ore. In the shaft sunk in 1872–3 a vein 3 to 4 feet wide was found, dipping to the southeast. The ore was rather lean, and contained quartz. Some observations with the dipping needle, made at a recent visit, show both positive and negative attraction about the mine and a belt of attraction towards the northwest; and these run west-southwest. Several tons of surface ore have been picked up from the adjoining field. The indications are very good, and the mine is soon to be put in working order. An average sample of the ore was lately received from the owner, Mr. Marsh. It has been examined, and contains of

Metallic iron	57.620	per cent.
Sulphur	0.055	"
Phosphorus	0.167	"
Manganese	none.	
Titanic acid	2.050	"

Dickinson's Mine.—This mine has been idle for more than ten years.

Hunt Farm.—One mile northeast of Schooley's Mountain Post-office and of Marsh's mine, several pits were dug by Mr. Bess on one of the farms of Hon. H. Hunt, and ore, much like that of Marsh's mine, was found. About 300 tons were mined. The place is reported to have been leased very recently.

Lake Farm.—This locality is east of Schooley's Mountain Post-office and in Washington township. A shaft thirty feet deep was sunk by the lessees, Cook & McAuley, in 1875, and a little ore was taken out. Some of it was very rich and strongly magnetic, but much of it was lean—a mixture of coarse crystalline rock and ore. Lately mining here has been begun, and it is said that some good ore has been found.

Naughright Mine.—The first notice of the Naughright Mine by the Survey was in the Report for 1873. The last annual report contained analyses of two samples of the ore of the mine, sent to the laboratory by Theo. Naughright. The mine has been idle since February last. It has been leased recently by D. Runkle & Co., and it is to be worked for the Keystone Furnace, near Glendon, Pa.

Sharp Farm.

Rarick Farm.

These localities are not now worked.

Hopler Farm.—The work of re-opening the vein on this property has been resumed, and it is reported that ore of a good quality has been found.

Cramer Mine.—Some ore from the Cramer farm was sent to the laboratory in 1877, and the analyses were published in the Report of that year. The place has not otherwise been noticed in any of the Survey Reports. It is on the western brow of Schooley's Mountain, and about two miles east of Hackettstown. Many years ago ore was got here for the supply of a forge near Hackettstown. The old holes are still to be seen. About twenty-five years ago the place was worked a while by Messrs. Scranton, of Oxford Furnace. In 1873–4–5 the place was worked by a Pottsville company. They had three main shafts on a northeast and southwest line. One of these was 80 feet deep, and another 50 feet deep. Some of the ore was very rich, but in the greater part of that mined there was considerable rock. The vein near the surface dipped steeply towards the northwest, then, as the mine got deeper, it became vertical, and at the bottom had the common, southeast dip. The attraction on the line of shafts and trial pits, going northeast, is regular, although not very strong.

Warne & Shouse Tunnel.—This locality is referred to as a good illustration of costly exploration, rather than as a mine. It is 1¼ miles east of Hackettstown and about 50 yards south of the Budd's Lake road. It was driven over 300 feet into the hill-side, and was designed to strike a vein of ore which is indicated by a long line of positive attraction on the hill, north of the road. Two shallow test pits on this line did not discover a workable thickness of ore. A small fractional part of this adit would have sufficed to test the surface.

Smith's Mine.—This mine was described in the "Geology of New Jersey." It has not been in operation since that Report was issued. The mine yielded a large amount of ore, but it contained pyrite. It is now owned by Aaron B. Mitchell.

Lowrance Mine.—The openings known as the Lowrance Mine were made many years ago. No work has been done there since the first openings. The ore is sulphureous. There is a good belt of attraction. And the mine is so near to both canal and railroad that it has advantages for shipment of its ores.

Mount Olive Mines.—The Mount Olive Mines have been worked very little since 1857. There is a long line of ore opened on the lands of A. L. Solomon, John Drake, and others, between Mount Olive and Turkey Brook. Some work was done here in the winter of 1874–5, by Wiley, McCormack & Wistar and by Uhler & Solomon. The

slope on A. L. Solomon's property was 100 feet deep. The dip of the vein was 35° at the surface, but increasing to 45° towards the bottom. The shoots of ore pitched towards the northeast. The average thicknesss of the ore was ten feet. Uhler & Solomon's slope on Drake's land was 60 feet deep. Three veins were found, close together; only the middle one was worked. The surface ore was of a rusty red color. That from the bottom of the slope and the lower drifts contained considerable pyrite. The most southwesterly opening on this lease opened a shot-like ore, but pyritiferous, as is all the ore of this line.

These openings were visited in October last. The work of pumping out the water and retimbering the shaft, preparatory to mining, had just been begun by Wm. E. George & Co., the present lessees. They proposed to drain the openings on the Drake place by connecting them with an unfinished adit which runs in at the foot of the hill. The mines are about two miles from the High Bridge railroad at Flanders, and less than four miles from Stanhope. Under one management the working of the several openings can be so systematized as to be done economically. Their present outlook appears to be more promising than it has ever been.

Drake's Mine.

Osborn Mine.

Hill's Mine.

Baptist Church Mine.

Not in operation.

King Mine.—This Mine has been recently opened on the hill west of Drakeville. Some exploration was made near the present openings several years ago by James Lewis, of Dover. It is reported to have been leased by the Thomas Iron Co.

Gove Mine.—The Gove mine is a new mine which has been opened since the report of 1873. It is in Roxbury township, Morris county, and one mile northwest of Drakesville station. It is worked by Francis M. Gove, of Dover. Very recently it is reported as sold to James Sutherland, of New York city. This mine is less than a mile from canal and railroad at Shippenport.

Davenport Mine.—The Davenport Mine has not been worked since it was described in the "Geology of New Jersey."

Noland's Mine.—The mine at Noland's Point, also, has not been in operation for several years.

Hurdtown Apatite Mine.—The occurrence of magnetite with the

apatite at this place, and the geological formation, justify placing it in the list of mines. It has not been worked either for the apatite or as an ore of iron.

Hurd Mine.—The Glendon Iron Company continues to work this mine, and it is maintaining its reputation for regularity and for the richness of its ore. The shoot is 60 feet high and 40 feet wide, and the slope has reached a length of 1450 feet. The only recent change is in the clean walls. Formerly there were no well-marked planes of division between the ore body and the bounding walls. The large annual yield of this mine is working the shoot down rapidly, and lengthening the slope about 100 feet a year. It is a matter of practical as well as geological interest to know the maximum length of such workable shoots of ore. Judging from the known length of some of them, where they are worked on the *side*, and not on the *end*, as is here the case, it is safe to conclude that it may continue quite as far as it can be conveniently followed in the present mode of working. Machine drills and air compressors have been lately introduced, and the capacity of the mine has been enlarged. The ore is shipped by way of the Ogden Mine railroad and Lake Hopatcong, and thence by canal or rail to the Glendon company's furnaces at Glendon, Pa.

Lower Weldon Mine.—This mine has been idle for several years.

Weldon Mine..—The Weldon Mining Company, Wm. Allen Smith, manager, is preparing to work this mine. It stopped about six years ago. It has always been an interesting mine geologically, on account of the two approximately parallel shoots of ore which pitch towards the northeast, and approach one another as they descend. It is hoped that further working will discover ore in quantity, and also answer questions as to structure.

Dodge Mine.—This mine is also to be re-opened very soon by the Weldon Mining Company.

Ford Mine.—The Ford Mine is worked by A. Pardee & Co., for the supply of their furnaces at Stanhope. It is a little over 200 feet deep. The vein which is worked continues large, and is opened a distance of several hundred feet in length. The walls dip very steeply towards the southeast. The Ogden Mine railroad is the outlet for the ore to Lake Hopatcong.

Soofield Mine.—The Crane Iron Company worked this mine until September, 1874, when mining was suspended. The vein here is the

northeastern extension of the east vein of the Ford Mine. It joins the latter on the southwest. It is owned by the Crane Iron Company.

Fraser Mine.—This mine has been idle for several years.

Duffee Mine.—This mine has been idle for several years.

Shongum Mine.—This mine has been idle for several years.

Cline Mine.—As there has not been any reference to the Cline Mine in previous reports of the Survey, a short notice is here inserted. It is on the foot of the Pohatcong Mountain, 1½ miles southeast of Stewartsville, in Warren county. The openings consist of a shaft 20 feet deep and an adit 200 feet long driven in on the vein, and are about 100 yards east of Mr. Cline's residence. A considerable amount of ore was taken out and sold. That which was seen on the dump, when it was recently visited, was rather lean. The attraction about the openings is light and positive.

Smith's Openings.—Two shafts and a shallow pit were sunk on lands of Robert J. Smith, of Bloomsbury, a few rods east of the Cline Mine, and on the side of the mountain. The shafts are 20 feet deep. The work was done under a lease by Keler, Reese & Co., who mined 200 to 300 tons of ore, and sent it to Hellertown, Pa. The ore is lean, containing some altered feldspar and some hornblende. Pyrite occurs in some lumps. The walls are of hornblendic gneiss. There is a line of positive attraction (10° to 20°) connecting the shafts.

Dean Lot.—The Dean lot adjoins Smith's land on the east. There are here two lines of openings, the westernmost of which is 150 yards east of that of Smith. Keler, Reese & Co. worked this place also. None of the shafts exceed 25 feet in depth. The ore is lean. At the northeast shaft, on the western line, the ore is magnetite, mixed with epidote. That of the southern shaft has a schistose structure, in which the ore is in parallel planes, or *strings*, alternating with rock. It contains pyrite also. The eastern vein is not more than 100 yards from the other, and on it there are two shafts. The ore here is also lean. There is a third shaft on another vein, and 50 yards south of the last-mentioned line.

These openings on this part of the Pohatcong Mountain were made previous to the panic, and no work has been done since. All the ore obtained was more or less mixed with rock. The lines of attraction are quite regular, but its amount is slight. The location is within easy distance of railroads at Bloomsbury and Stewartville, and of the canal at the latter place.

Chapin & Lommasson Diggings.—There does not yet appear to be a workable vein of ore here.

Lanning Farm.—The explorations on this place were stopped several years ago.

Oxford Furnace Mines.—The mines at Oxford furnace are locally known as the *New, Car-Wheel, Welsh, Staley, Washington* and *Harrison Vein,* and the *Franklin Vein.* The last named is west of the furnaces, and is not much worked. The shoots in the New Mine, which were extraordinarily large, and carried a very rich ore, have become smaller and the mine has not been worked so vigorously as in former years. The developments of the Washington and Harrison veins are now very promising. These veins are close to each other, and are worked together. The line of magnetic attraction over these veins has been mapped out by Wm. H. Scranton, and a copy of the survey has been placed by him at our disposal. It is inserted under the head, "Searching for Magnetic Iron Ores." This line is one remarkable for its length and constancy, and it indicates a large supply of ore for the works here. The northeastern end of this line was opened in 1860. Work was resumed here last October. Towards the southwest the sinking of two shafts was begun in November. The results of these openings will be awaited with interest, as tending to prove the value of magnetic surveys. It is hoped that they will be suggestive to land-owners, and those persons who are developing iron ore property. They show much more than can be seen from a careless and hap-hazard examination with the dip compass.

The Welch mine is on the hill near the Car-Wheel shaft, and 150 yards northwest of it. The vein is parallel with the slope vein, and nearly at right angles to the Car-Wheel. It appears probable, according to Mr. Scranton's explanation, that it and the New and Car-Wheel Mines are on one vein, which is here bent around so as to run a short distance in a northwest and southeast direction.

The following determinations of phosphorus made on samples, carefully averaged by Wm. H. Scranton, show the character of the Oxford ores:

Staley Mine ore	0.160	per cent.
Car-Wheel "	0.050	"
New Mine "	0.108	"
Welch "	0.050	"

Creager Mine.—This place has not been worked in four or five years.

Mitchell Mine.—No work at mining has been done here for several years past. Many thousands of dollars were spent in the original explorations.

Johnson's Explorations.—The openings at this locality discovered a narrow vein, but no work at mining has been done.

Bald Pate Mine.—The Bald Pate Mine has been worked for short periods by different parties. The last was a Boston firm, who stopped in the autumn of 1876. Altogether, the mine has produced about 2000 tons of ore. The mine is interesting geologically, on account of the large body of white quartz rock which was struck in the first shaft, which was sunk by Mr. Henry, of Oxford. It was found at a depth of 40 feet, and continued to the bottom, 96 feet deep, and also in a drift northward. The middle shaft, sunk in 1873 by the late Philip Smith, was in gneiss and ore. The shaft of the Boston firm is northwest of the Henry shaft, and is 60 feet deep. In it a greenish, slaty rock was found on the hanging-wall side of the ore. All the workings at this place show the existence of irregular strings and masses of ore, rather than any well-marked ore-bed. The ore is coarse crystalline, and is rich. The mine is on the farm of Amos Beatty, and it is reported to have been lately leased and re-opened.

Rockport.—The searches near Rockport were given up, as no ore in quantity was discovered.

Shafer Mine.—This locality is reported as being near the Bald Pate Mine. It has not been visited. A sample of ore sent to the laboratory by Charles Scranton was analyzed. The following percentages were determined:

Insoluble in acid	26.40
Peroxide of iron	64.60
Titanic acid	4.95
Phosphoric acid	0.20
Sulphur	...
Manganese	traces.

Or—

Metallic iron	45.22
Phosphorus	0.09
Sulphur	0.023

Egbert Church, or Smith Mine.—This mine was worked up to autumn of 1876, and yielded several thousand tons of ore. When

visited in the autumn of 1875, it had reached a depth of 130 feet, and the lengths of the workings were 65 feet towards the southwest and 150 feet northeastward. The foot-wall was gneiss, and the ore came off clear from it, but in the hanging-wall side there was some rock mixed with ore. The strike of the vein was south 15° west, and the dip east-southeast. South of the southwestern shaft there is a positive attraction of 10° to 30°. The same degree of attraction is noticeable about the north shaft.

Pyrite is found in all the ore of the mine, and it necessitates roasting. A considerable part of the ore was worked up at Pottsville, Pa.

On the Egbert property, one-fourth mile southwest of the mine, there is a long line of attraction in the fields west of the road, and five openings from 20 to 40 feet deep on this line were made by the late Jacob Stiers, but without finding any workable vein of ore. The attraction is positive, and varies from 10° to 40°.

Searle Mine.

Buck's Hill.

Frace Farm.

Young's Farm.

Pyle Farm.

Axford Farm.

Bryant Mine.

Excelsior Mine.

Eureka Mine.

These mines have not been in operation for several years.

Haggerty Farm.—The Haggerty farm openings were described in the Report for 1876. They were made in 1874, and about 100 tons of ore were taken out of them. The attraction is traceable over a long and rather broad belt, which runs from west-southwest to east-northeast. The openings are not deep enough to afford any safe conclusions as to the probable size of the vein. The place is so near to canal and railroad that it has advantages in the way of transportation. A recent analysis shows that the ore contains of

Metallic iron	58.55 per cent.
Phosphorus	0.33 "
Sulphur	0.05 "
Titanic acid	4.20 "

Brookfield, or Waterloo Mine.—The Waterloo Mine has been idle

since December 31st, 1873. It was the most productive of the openings north of Hackettstown, and yielded a good ore.

French's Place..—The openings on this property have not been continued, and have not developed into mining operations.

Smith, or Cascade Mine.—The Cascade Mine was described in the Report for 1873. It was in operation from 1869 to 1877. It belongs to the Peter Smith estate, and is near the Sussex railroad and one and a half miles northeast of Waterloo.

Allis' Openings.—The work of opening the line of ore on the Allis property, northeast of the Smith tract, has been discontinued.

Hude, or Stanhope Mine.—The Hude Mine tract is owned by the Dickerson estate, and is now worked by John M. Barnes, of Ironia. There are fifty distinct openings on the property, and all on the western end of the ridge known as Mine Hill. The deepest of these does not exceed 50 feet in depth. The openings have been made so as to get out the surface ore most economically. There seem to be a number of shoots of ore, which pitch easterly at a small angle. Short anticlinal and synclinal folds of ore have been worked out in several of the openings. Thus, in openings Nos. 11 and 26, the dips are towards an axis between them. Nos. 13 and 9 show a synclinal. In No. 1 there is more regularity, and the vein dips towards the southeast. But in the absence of any survey it is almost impossible to understand the relations of the several exposures of ore to one another. The vein worked at the time the mine was visited dipped 30° towards the east, and was 12 feet thick, but the walls are not well defined. In a part of this vein the ore was very rich and pure, whereas another portion carried pyrite. The ore from this opening is black, and has a lustrous fracture. The pyritous ore is harder. In several of the openings the first ore taken out was found to have lost the sulphur by oxidation of the pyrite. This variation in the nature of the ore has made it necessary to sell it in separate lots, according to quality. The best ores have been used at Bethlehem, Pa., for Bessemer steel; those carrying more phosphorus have been carted to the Stanhope furnaces. In mining, the walls have generally been found firm, and consequently little timber has been needed. The only water is that from the surface, which the rains pour in—in some cases enough to interfere temporarily with the working; but generally the mining has been done

with economy, and thousands of tons of ore have been obtained from these shallow openings. Mr. Barnes started a tunnel from the foot of the hill on the south and near the property line, but it was stopped when in about 100 feet. It cut the vein of opening No. 1 only. The extension of this tunnel into the hill might discover other veins, and very probably would do so, as it seems hardly possible that so many outcrops are one connected ore body.

This mine is interesting to mineralogists as the locality of molybdenite and molybdic ochre. It occurs in the ore, scattered through the mass, and, more rarely, in the rock. Good specimens are not common. They are found at Nos. 6, 24 and 1.

The mine has been worked at intervals. The present operations were begun the 1st of October. As it is only a mile to the canal and railroad and to the Stanhope furnaces, the location is very convenient. The further exploration and opening of the ore at this place are both promising, and, geologically, very interesting.

On the same hill, and on both the northwest and the southeast slopes, Cooper, Hewitt & Co., have lately sunk several trial pits in search of ore, but without finding any of workable extent. There is a light, positive attraction on their leasehold close to the Hude lot. And the southeast dip of the veins ought to bring some of them on to their property.

Wright Mine, or Budd Mine.—This locality is named from the land-owner, Wm. Wright. It is a quarter of a mile east of the Hude Mine, and two miles from the Stanhope depot. It is on the north slope of a rocky hill. There are four openings. That to the southwest is from 15 to 20 feet deep, and is an old trial pit. About 500 feet towards the northeast is the main working shaft. This shaft is not less than 60 feet deep, descending on the foot-wall of the vein. A drift 40 feet long connects it with the western (ladder) shaft. The northeast heading is about the same distance from the shaft, making a length of 80 feet opened on the vein. The dip averages 50° towards the southeast. In the sink the breadth of the ore body is 9 feet. But in it there is some rock. The ore is blue, hard, and contains pyrite. That from the top of the vein had a brownish red color, due to the oxidation of the pyrite.

There is another trial pit 50 feet northeast of the whim shaft, and which is 25 feet deep. On the strike of the vein between the shafts,

and prolonged 200 yards towards the northeast, there is a belt of attraction, which is negative, and which varies in intensity from 10° to 50°.

The present lessees of this property are Smith & Rusling, of New York city, and S. B. Sahler is superintendent.

Silver Mine.—This old mine continues idle.

Haggerty Mine.—This mine also continues idle.

Lawrence Farm.—The long line of attraction on this property has not been tested, except in the old mine holes which were dug many years ago.

Gaffney Mine.—This mine is on the farm of the Rutherfurd estate, adjoining the Lawrence on the northeast, and near the Sparta line. A small map of the attraction on the line of the old holes was printed in the Report for 1873. In the following year the place was opened, and subsequently it was taken by the Harrisburg Steel Company, and worked by them in 1876. It had reached a depth of 90 feet, and the vein of ore was 6 to 8 feet wide. The ore was of good quality. It was carted to Andover, six miles distant. The existence of a workable vein of ore at this place confirms the indications as they were represented in the little sketch map made in 1873. The distance to railroad is a serious drawback in working the mine. It is now idle, but is about to be opened again, by McCormick & Co., of Harrisburg.

Sickles Mine.—This mine was worked for a short time in 1870 and 1871 by the Bethlehem Iron Company. The mine, as opened at that time, was described in the Report for 1873. Subsequently it was worked by Gen. Stahl and a New York company. Last November a lease of the mine was taken by the Blooming Ridge Iron Company, and it is now worked by them, under the superintendence of A. H. Harris.

Goble Mine.

Boss Mine.

These mines are still idle.

Sherman Farm.—This locality is one mile east of Sparta and a quarter of a mile north of the Dover turnpike, and on the west of the road to the Ogden Mine. It was visited in 1875, but there has been no work done since that time. About 100 tons of ore had been taken out of a large open cut, 50 feet long and 35 feet deep. There is no regular vein and no plainly stratified rocks, but a large body of lean ore.

Bunker Farm.—The opening on this farm is about 50 yards south of the Sherman opening. And the open cut is with that the same size. The dip of the strata is 30° towards the south. Next to the foot-wall there is a breadth of 5 to 7 feet of ore, mixed with rock; then gneiss for 5 feet; then ore 5 feet. The locality is within carting distance of the Ogden Mine railroad.

Ogden Mines.—Two companies are here at work, viz., the Musconetcong Iron Works and the Allentown Rolling Mill Company. The southwestern mine of the group, known as the *Davenport Mine*, is owned by the Sussex Iron Company. It is not in operation. The *Roberts Mine* is worked by the Allentown Rolling Mill Company. Adjoining it on the northeast is the *Pardee Mine*, worked by the Musconetcong Iron Works. Both the Roberts and the Pardee Mines belong to the Ogden Iron Company. The Ogden Mine railroad and the Morris canal afford direct means of transportation to the furnaces at Stanhope and to the Lehigh region.

Greer Farm and Franklin Iron Company's Tract.—The line of attraction on these tracts, in Hardyston township, has not been further explored.

Hopewell Forge Tract.—There have been no further developments on this tract.

Cannistear Mine.—This mine has heen in operation during a part of the year and several thousand tons of ore have been mined and stacked at the mine. The vein is large but the ore is rather lean. The mine is owned and worked by the Franklin Iron Company.

Tracey and Crane Farms.—These openings have not been worked lately.

Henderson Farm.—These openings have not been worked lately.

Williams Mine.—The Williams Mine was worked last by John Linn and others, in 1876, since which date it has been idle. It had attained a depth of 135 feet. There were three shafts on a line of about 100 yards. The ore was shipped at Snufftown station, five miles from the mine. The completion of the McAfee Valley and Warwick railroad will bring this mine a little nearer to market.

Rutherfurd Estate.—This line has not been further opened since our last Report.

Hunt Farm.—This line has not been further opened since our last Report.

Wawayanda Mine.—The Thomas Iron Company own this mine and the Wawayanda furnace tract. As soon as the new railroad in the Vernon Valley is done, the working of this mine is to be resumed. It has been idle for over two years.

Green Mine.—This mine also is owned by the Thomas Iron Company and is not in operation.

Welling, or Ten Eyck's Mine.—The locality here styled the Welling Mine is a new opening on the lands of John and Thomas Welling, in Vernon township, Sussex county. The place was worked about twenty-five years ago, and the ore was used in the Wawayanda furnace. It was said that it made a very superior iron. A new opening has been recently made by M. F. Ten Eyck, of Warwick, N. Y. An average sample of the ore was sent to the Survey office and was analyzed. The analysis shows:

Metallic iron	54.23 per cent.
Phosphorus	0.033 "
Sulphur	trace.
Titanium	none.
Manganese	none.

The low percentage of phosphorus and the absence of titanium indicate a good ore.

Kimble Farm.

Budd and Hunt Tract.

Scranton and Rutherford Tract.

Jennings and Rutherford Line.

The above-named localities in *West Milford township, Passaic county,* were described in the Report for 1873. The attraction at these places indicated veins of considerable size and length, and the openings discovered workable veins, but they have not been further tested. The distance from railroad transportation has been one of the causes which has retarded their development.

Clinton Furnace Tract Mine Lot.—The openings or mines on the Clinton furnace tract are a mile northwest of the furnace. This vein of ore was opened many years ago. Wm. S. De Camp, of Powerville, re-opened it in 1872–3. In cutting a drift, an old tunnel was discovered. In cleaning out the old shafts ore was uncovered in all of them, and also in several trenches or cuts made across the vein. But in all of them there was some pyrite in the ore. In places there was considerable quartz in it. The dip is 85° towards east-southeast. No

further work has been done since that of Mr. De Camp. From the mine holes to the N. J. Midland railroad at Newfoundland, the distance is three miles, and the road is an easy one.

Wallace Property.—The Wallace Mine is about three miles north of the old Clinton furnace, and in West Milford township, Passaic county. The place was worked in 1874 by Wm. Cisco, and 1500 tons of ore were sent away. The deepest shaft went down 35 feet. The ore was lean. The lease is held by Wm. Cisco.

Squier's Mine.—A full description of the long line of attraction, and the opening made in 1876, appeared in the Report for that year. The mine was worked up to the present year. The ore was used at the Greenwood furnace.

PEQUEST BELT.

Mines in Warren County, Oxford Township.—Schuler, Roseberry, Barton, Shoemaker, Redell, Little, Raub, Pequest, Hoit.

Hope Township.—Smith, Deats, Hendershot, Kishpaugh, Inschow, Stiff.

Independence Township.—Potter, Stinson, Garrison, Davis, Albertson, Shaw, Howell, Carroll, Cummins, Schæffer.

Allamuchy Township.—Maring, Livsey, Haggerty.

Sussex County, Green Township.—Glendon.

Byram Township.—McKean, Byerly, Roseville.

Andover Township.—Andover, Sulphur Hill, Tar Hill, Longcore.

Sparta Township.—Stirling Hill.

Hardyston Township.—Hill, Furnace.

Vernon Township.—Green, Bird.

Schuler Mine.—The Schuler Mine is owned by Samuel Vannatta, of Roxburgh. In 1873 Vannatta & Sherred opened some old holes and took out 50 to 100 tons of ore. The place has not been worked since that time. The ore is manganiferous, and occurs in a grayish-white crystalline limestone. It is said that the mine is about to be opened again.

Roseberry Mine.—This mine has been idle since 1875. It is leased to Peter Fry, who is about commencing work there.

Barton Mine.—When mentioned in 1873, the Barton Mine was not in operation, and the openings were scarcely more than a trial shaft

and pits or trenches. Subsequently the place was leased by Cooper, Hewitt & Co., who worked it until 1876 or 1877, and mined a considerable amount of ore. It has not been going since it was left by them.

Shoemaker Mine.—This place has been idle for some time.

Redell Mine.—This mine has been idle for several years. It has lately been leased to the Bethlehem Iron Company. The ore obtained in 1872, when the mine was in operation, was of superior quality. The veins are very close to the crystalline limestone.

Little Mine.—This place was described at length in the Report of 1873. It has not been worked much since that time. It has been leased recently by the Bethlehem Iron Company.

Raub Farm.—The Report in 1873 gave a full account of the openings made on this place. The Bethlehem Iron Company worked until 1875. One shaft was reported to be 90 feet deep. From this drifts were cut each way—in all nearly 200 feet—on the course of the ore, which is a few degrees south of west. Some fine, earthy, manganiferous ore was mined, and a part of it was used for paint by Wade & Buckley, of Easton. In the shaft southwest of the farm-house, sunk in white limestone, some zinc blende was discovered.

Pequest Mine.—The Pequest Mine was described at length in 1873. It was worked until about four years ago. There seems to have been a large and quite irregular body or shoot of lean ore, which was worked out to the bottom rock on the south and west sides of the opening. The last reports of the working speak of a thin vein at the bottom and under the tunnel. The *Henry tunnel vein,* on the hill-side, north-northwest of the old mine, has not been opened to any greater extent than it was when last described, in 1873. Preparations are making for further mining here.

Hoit Farm Mine.—There has been no mining on this place in four years. Here, as at the Pequest Mine and in the Henry tunnel vein, there appears to be a large body of lean ore. They all have advantages in nearness to railroad and to furnaces.

Smith Mine.

Deats Farm.

Hendershot Farm.

The Smith, Deats, and Hendershot places have not been worked to any extent. They have been idle for four or five years.

Kishpaugh Mine.—The Kishpaugh Mine is one of the most pro-

ductive of those opened of late years. Unknown at the time of the publication of the "Geology of New Jersey," it was first mentioned in the Report for 1873. It has been steadily worked from that time by its owners—the Crane Iron Co. And since that there have been two new slopes put down 100 yards further to the southwest. At the surface of the ground they are 40 feet apart, but, as they diverge, they are 200 feet apart at the bottom. They afford ventilation and safety in case of accident to one. The breadth of ore continues to be large, and it occurs in shoots which pitch to the southwest. The dip is towards the southeast. What is known as a slide of rock separates the old working from the shoots now worked. Scarcely any blasting is needed, as the ore can be picked out. The water is raised by a steam pump (3 inch pipe.) A thousand tons of ore per month are now mined, which is carted seven miles to the D., L. & W. R. R., and thence sent to the furnaces at Catasauqua, Pa.

Inschow Lot.—A specimen of ore from the openings on the Inschow lot was received from Charles Scranton, and was analyzed. The ore is lean, and contains garnet, hornblende, and calcite, with the magnetite. The analysis gave:

Metallic iron	51.40 per cent
Phosphorus	0.017 "
Sulphur	none.
Manganese	0.79 "

Stiff Farm.—Nothing additional to the account given in 1873 has been reported.

Potter Farm.—The last work in the way of mining on this place was done in September, 1873. The vein is 4 feet wide at the outcrop in one shaft, which is 35 feet deep. It is owned by the Crane Iron Co.

Stinson Mine.—Considerable work in exploring and in opening a mine on this property has been done during the past season by Chas. Scranton, of Oxford. The main shaft was partly filled with water when visited, and consequently the extent of the openings and the size of the vein were not ascertained. The outcropping ledges on the hill near the mine and about the mine holes, consist of impure, crystalline limestones, and epidotic gneiss. They resemble the rocks at the Inschow place, and they occupy the same relative position, lying in and forming the foot hills on the eastern side of the main Jenny Jump mountain range. Some of the ore is black and earthy. Three analyses of ores from this farm have been made for Mr. Scranton:

NUMBER OF SAMPLE.	1	2	3
Metallic Iron	63.12	60.66	49.79
Phosphorus	0.017	0.006	0.02
Sulphur	——	traces.	none.
Manganese	0.65	0.40	2.74

These examinations show some variation in the percentage of iron, a low percentage of phosphorus, and a notable quantity of manganese. The quality of the ore represented by them is very superior; and the presence of calcite and garnet tend to make it work easily in the furnace. A serious drawback to the place is its distance from any railroad lines or from furnaces.

Garrison Farm.—On eastern slope of Jenny Jump Mountain.

Davis Property.—On eastern slope of Jenny Jump Mountain.

Albertson Place.—On eastern slope of Jenny Jump Mountain.

Shaw Mine.—On eastern slope of Jenny Jump Mountain.

Howell Farm Openings.—On eastern slope of Jenny Jump Mountain.

The above-mentioned localities, on the eastern slope of the Jenny Jump Mountain, were mentioned in the Report for 1873. Very little work has been done at any of them since that Report was printed. Good ore in workable quantity has been found at each one, but they are too far from any railroad lines (eight to ten miles) to be worked profitably at present prices.

Carroll Place.

Cummins Farm.

Schæffer Farm.

Maring Farm.

No work has been done in several years.

The line of attraction on the Maring farm is remarkable for its length and constancy. The lease is held by Thos. Haggerty and the heirs of Richard Stephens, and the development of the locality has been delayed in consequence of business arrangements.

Livesey's Mine, or Hibler Farm.—Since the report of 1873 another vein has been opened on this property, and about 70 rods west of the Hibler house a shaft 70 feet deep was sunk on it. The vein was 7 to 8 feet wide, but it included some rock in thin layers, alternating with the ore. The attraction is traceable from this shaft, in a west-

southwest course on to the Maring property. The shaft at the house failed to strike any vein of workable size or of good ore.

Haggerty's Openings.—The lessee, Thos. Haggerty, of Alamuche, reports the deepest shaft as 40 feet deep, and a good vein of ore. The openings were made four or five years ago.

Glendon Mine.—This place, opened by the Glendon Iron Company, has been idle for at least ten years.

McKean Farm.—This locality was described in the Report for 1874. It has been in operation more or less since it was opened in 1874, and has been worked by Clarkson Bird & Son. The ore is carted about two miles to the Sussex railroad, near the Cranberry reservoir.

Byerly Openings.—These openings are on lands of Robert N. Byerly, one mile west of his residence, and about half a mile southwest of the old Roseville Mine. The openings were made at the beginning of the hard times, and were 5 to 15 feet deep. They are on the western slope of a high ridge of gneissic rock. When visited at the end of last autumn they had so fallen in that the strata could not be seen. There is a line of attraction in a northeasterly and southwesterly direction, and of 10° to 20° negative. In all of the holes a red hematite was found, in small lumps, in the earth. Some of them appear to be quite siliceous.

An analysis of the ore as found in the earth at the holes, gave:

Metallic iron	66.98 per cent.
Phosphorus	0.032 "
Sulphur	trace.
Titanium	none.
Manganese	none.

These figures indicate a very rich and pure ore.

Roseville Mine.—The mine continues idle.

Andover Mine.—This old mine is abandoned.

Sulphur Hill Mine.—The northeast extension of the old Andover Mine is generally known as the Sulphur Hill opening or mine. This place was worked one season by Wm. J. Hance, of Dover. Last April Wm. J. Taylor & Co. began working it. As now opened there are two parallel veins, or ore deposits, although deeper and longer openings may show that the rock lying between them is a horse enclosed by the ore. The strike of the veins is northeast and southwest. The line of strike prolonged to the southwest, passes to the north of

the old mine. The elevation of the outcrop here may account for a part, if not all, of this difference. The main excavation is 65 to 70 feet deep. A tunnel 175 feet long runs in from near the foot of the hill to it and affords a way out for the ore. Cars loaded in the mine run through the tunnel and out on a trestlework dump. At the southwest end of the open cut the bottom rock of the shoot constitutes the end of the opening, and pitching towards the northeast at an angle of about 30°. The hanging-wall is smooth, and dips, at a high angle, towards the southeast. On the other side of the opening the rock is replaced at the bottom by ore. It may be a part of the same body which is opened in the northern or northwest pit. The main opening is now about 100 feet long and about 30 feet wide. The northwest pit, on what is termed the *back vein*, is only 20 feet deep, and not so wide as the other. Towards the northeast a few rods both lines of ore have been uncovered, and on the southeastern a pit 15 feet deep has been excavated in the ore. The rocks associated with the ore in this mine are not of the ordinary types of gneiss, but mixtures of garnet, calcite and some hornblende. In the hanging-wall garnet predominates, and gives the mass a brownish color. In the horse, or rock between the two veins, galena, pyrite and chalcopyrite are common. Some of the lumps of galena are large aggregates of good crystals. These minerals seem to be irregularly distributed through the rock mass, and do not constitute a vein. The ores generally are rather lean. Pyrite appears in seams and bunches in it. Some of the surface ore is weathered reddish in color. L. W. Langdon is superintendent. The greater part of the ore is shipped to Chester, where it is roasted. It will be used in the Taylor furnace at that place. Some ore is sold to furnace companies in Pennsylvania.

Mr. Langdon reports a strong attraction for a distance of 400 to 500 feet northeastward from the openings, and in a belt between two parallel, rocky ledges. The company design repairing the mine railroad, so that the cars can be loaded at once at the dump, and in that way avoid carting to Andover.

Tar Hill Mine.—The Crane Iron Company owns this mine. It has not been in operation since November, 1873.

Longcore's Mine.—This place is not worked.

Stirling Hill Mine of Manganese Iron Company.—This locality was referred to in the Survey Report for 1877, and two analyses were given

of the ores mined there. The property of the Manganese Iron Company is bounded on the north by that of the Passaic Zinc Company, and the openings of the two companies are close together. The mine is reached by a tunnel, 317 feet in length, which runs from the public road, near the eastern foot of the hill, a northwest course, across the strata of white limestone to the ore. The hanging-wall is vertical and strikes south, 82° west. A large body of zinc ore, consisting of silicates of zinc, was found near this wall and at the end of the tunnel. And the mine at this point is 86 feet deep, below the level of the tunnel. West of it, and on the north, occurs the mass of iron ore which is known as franklinite iron ore. Zinc ore lies on the foot-wall on the west of the franklinite. The richer ore resembles massive franklinite. But there is a large proportion of ore which contains some calcite, and other still less rich, wherein the calcite, as a matrix, holds the scattered crystalline masses of ore. The opening, 225 feet long and 160 feet wide, (from the hanging-wall to the Passaic Zinc Company's line,) has uncovered a very large body of ore above the tunnel level. Mr. Martin, the manager, reports the product of the mine for the two years since it was opened, to be 45,000 tons of iron ore, 3000 tons of silicates of zinc, and 1500 tons of franklinite. The ore is said to average 12 to 14 per cent. of manganese and 4 per cent. of zinc. It is a valuable ore for Bessemer metal, and is used largely by the Bethlehem Iron Company, the Cambria Iron Company at Johnstown, Pa.; Atkins Bros., at Pottsville, Pa., and by the Reading Iron Company. On account of the percentage of zinc it cannot be used alone, or in large proportions in a mixture, in an ordinary blast furnace. It is used up to 20 per cent. of the charge without any special contrivance for catching or collecting the zinc. The further working of this mine, in connection with the southwestern working of the Passaic Zinc Company, is looked forward to with interest, as going to prove the existence of one vein, continuous but strangely varying in its mineral composition, from the one mine to the other.

There is said to be a line of attraction towards the southwest, beyond this mine. It may indicate another ore body or shoot.

A branch railroad runs from the mine, passing the Passaic Zinc Company's works and the New Jersey Zinc Company's mine, to the Midland railway, affording easy transportation.

Franklin Mines.—The *Hill* and *Furnace Veins*, at *Franklin*, continue

to be worked by the Franklin Iron Company. The *Hill Vein* mine has reached a depth of 190 feet in the shaft near the furnace. Very little work is done in that part of the vein, as it has become narrow in the bottom. A new opening further southwest than any of the present workings has shown a good vein of ore. The mining on this vein has demonstrated the existence of shoots and intervening pinches. The walls are of gneissic rocks. The ore is adapted to Bessemer metal.

The *Furnace Vein* is in the white crystalline limestone. It is worked northeast of the Wallkill. The principal slope is on the southwest point of Mine Hill, a few rods from the creek. It is 300 feet long, and descends on the foot-wall at an angle of about 60°. The workings in it have thus far opened three shoots, one above the other, and pitching towards the northeast. Between them the vein is narrow, or *pinches*. The horizontal drifts show very plainly these variations in size, as one goes from southwest towards the northeast. There are no clean, well-defined walls, but ore and limestone are mixed, and the mining stops where the latter predominates. They stand up firmly, and no timbering is necessary. At the bottom, Mr. Pierce, the manager, is driving westerly, and expects to strike the Hill vein. It will be interesting to ascertain the distance between these veins at the depth of 300 feet, as near the surface they are close together. The ore contains calcite, which assists as a flux in the furnace. The phosphorus is low. The product of these veins for the year is estimated by the manager to be 14,000 tons. Before the furnace was put in blast (July 5th) a little of the ore was sent to Scranton. At present it is smelted here, mixed with Tilly Foster, Combs, Baker, Spanish and other ores, for Bessemer metal.

Green's Mine.—This mine has not been worked in many years.

Bird's Mine.—This place was abandoned several years ago.

HEMATITE IRON ORES.

Radley Mine—Lebanon, Hunterdon County.—It is worked as a paint mine.

Nolf Farm.—A sample of specular ore from this place, on the Musconetcong Mountain, near the Delaware river, was taken from the surface and was analyzed. The analysis was as follows:

Metallic iron	39.07	per cent.
Sulphur	0.055	"
Phosphorus	0.039	"
Manganese	none.	
Titanium	traces.	
Insoluble in acid	43.60	"

The ore contains grayish-white quartz, mixed with the hematite, and is found in angular pieces in the soil. It occurs over an area of several acres. The quantity in the soil indicates the existence of strata or veins of mineral. The extent of the ore is about to be tested by the lessees of the property. The farm is less than a mile from the Durham furnace.

Marble Mountain.—This mine is on the southwestern point of Marble Mountain, Warren county. It has not been worked to any extent, and it has been idle for nearly twenty years.

Titman Shaft—Oxford Township, Warren County.—This locality is near Bridgeville. It is scarcely more than a locality of the mineral.

Ayers Farm.—A little hematite was found a few years ago on the Ayers farm, one mile southwest of Alamuche, Warren county.

Simpson Mine—Vernon Township, Sussex County.—No work has been done at this mine in a dozen years.

Cedar Hill Mine—Vernon Township, Sussex County.—The Ten Eyck, or Cedar Hill Mine (as it is sometimes called) has not been in operation since the Report of 1873.

Cooley's Mine—West Milford Township, Passaic County.—The work done on the Cooley farm, near Greenwood Lake, several years ago, was of the nature of exploration, and no considerable quantity of ore was obtained. The locality is of more interest geologically than economically.

Bird Mine—Union Township, Hunterdon County.—The Bird Mine has remained idle since 1873.

German Valley.—The searches in this valley have not been followed by any mining operations. The Report of 1872 referred at length to the explorations.

Wean Mine.—A notice of this mine appeared in the annual Report of the State Geologist for 1874. In the Report for 1878 it was reported to be yielding 90 tons per month, and an analysis of a sample received from Brewer, Mellick & Co. indicated a rich, good ore. The locality was visited during the season. It is interesting, geologically, as the country rock is a disintegrated gneiss. Mr. Hartpence, one of

the party who worked it, reports the deepest shaft as down 60 feet, and connected by a drift with another, 200 feet to the southwest. The ore appeared to be in pockets and irregular masses, and associated with yellow clays and ochre. About two-thirds of the ore was wash-ore, of bright red color. It was sold to paint works. The total product of the mine is estimated to have been 1500 tons. There is no water in the mine, and no pumps have been needed. The locality is so near to both the Central and the Lehigh Valley railroad stations that it has advantages of cheap transportation. The further opening is awaited with interest, as it is possible that the hematite may be connected with magnetite, although there are no indications of the latter ore, except the general fact of such ores occurring in the gneissic rocks.

Silver Hill.—Hematite has been found in several trial pits on lands of Wm. Carpenter, near the Lehigh Valley railroad, and on the northern foot of Silver Hill. It is in Greenwich township, Warren county.

Woolverton Farm.—This locality is on the west side of the Bloomsbury road, and two miles southwest of Asbury, Hunterdon county. A few holes have been dug in searching the ground, by the lessees—the Crane Iron Co.

Hazard Mine.—Hematite was mined at this place several years ago. It is on land of Chas. Hazard, and 1½ miles southwest of Asbury, in Hunterdon county. In the large heap of earth on the bank some very white and fine sandy clay, much like that found at Hulsizer's, near Stewartsville, was noticed. Also lumps of white quartzite were observed.

Shield's or Beattyestown Mines.—These mines are a short distance west of Beattyestown, Warren county, and on lands of Thomas Shields. The ore deposit appears to be one, although worked by different companies.

The northeast opening is that of the Thomas Iron Co. Work was stopped there about three years ago.

The next openings to the southwest are those of A. Pardee & Co., owners of the Musconetcong Iron Works. Of these, the eastern and old pit was 80 feet. The ore body was reported to be 10 feet wide at the bottom, and lying against a wall of blue limestone on the east. This pit was abandoned in the fall of 1877, and the working was transferred to a new pit about 30 yards further to the west. The depth of the present workings is about 60 feet. They are at least 400 feet long and about 80 feet wide. The stripping has been from 6 to 30

feet thick. The ore occurs associated with yellow clay, and is more in solid lumps than in the form of *bombs*. In places the working breadth has been 60 feet. The blue limestone is reached on the east and southeast sides of the pit. A slope extends from the washing works to the bottom of the pit, and the track runs thence to the south end of the opening. The water which is raised from it is used in washing. Of the whole amount mined, about ninety per cent. needs to be washed. A royalty of 45 cents per ton is paid to the land owner, and the cartage to the railroad depot at Hackettstown costs 50 cents. When visited, the production was about 1900 tons per month. It is shipped to Stanhope, and used in the furnaces of the Musconetcong Iron Works. The product for the past year is 9454 tons.

Adjoining this mine on the southwest, the same ore body was worked several years ago by the Boonton Iron Co. The openings are not deep nor extensive. It is reported that this property is to be re-opened by the Musconetcong Iron Works.

Carpentersville Mine.—This mine, near the mouth of the Pohatcong creek, and one mile south of Carpentersville, is not worked at present.

Hamlen Mine.—The Hamlen Hematite Mine is two miles east of Phillipsburg, near the Lopatcong creek, and on the farm of William Hamlen. The openings for ore were made several years ago. It was again worked for a short time in 1876. At the present time parties are digging yellow ochre for the Bushkill Paint Works, near Easton, Pa. The pit is approximately 200 feet long and 100 feet wide. The ochre is found on the east side of the ore deposit, and under it. It has a maximum thickness of 15 feet, and, in places, comes within 2 feet of the surface of the ground. The ore in this mine was found close to the surface. The water pumped out of the pit is used for washing the ochre.

Thatcher Mine, or Stewartsville Mine—Franklin Township, Warren County.—Work here stopped three or four years ago.

New Village, or Cline Mine.—The mine is idle.

Broadway.—The hematite locality near Broadway, Warren county has not been visited. There is no mining at the place.

Shiloh.—Of the hematite near Shiloh, *Hope township, Warren county*, there is no account of any recent opening or mining.

Swayze Mine—Hope Township, Warren County.—The mine is not in operation. It was fully described in the Report for 1877.

Van Kirk Farm.—Clarkson Bird, of Hamburgh, has recently opened a deposit of hematite on the Van Kirk farm, near the Ogdensburg and Sparta road, and about two miles from the former place. Of the probable extent of the ore, &c., nothing is known, as the place was not visited.

Scott Farm.—A brown hematite ore has been opened on lands of C. K. Scott, on the west foot of Pochuck Mountain, and two miles north of Hamburg, Sussex county. The deposit is reported to be small. A sample from the owner was examined, and found to contain of metallic iron 43.85 per cent.; of sulphur 0.84 per cent., and of phosphorus 0.021 per cent. A workable body of ore such as this analysis indicates would find a market.

Pochuck Mine.—The Pochuck Mine was at first worked as an open cut, and a large amount of ore was taken out. In 1873 a new slope was put down, and a gravity road was constructed to carry the ore to the railroad at McAfee Valley. Mining was actively carried on until 1876, since which date it has been idle. The mine has been an interesting geological locality, as the ore occurred in small lumps and masses in earths, and the ore-mass was bounded on the northwest and southeast sides by rotten gneissic rocks, which appeared to be true walls. These soft strata continued for over 100 feet in depth and 500 to 600 in length.

Edsall Mine.—This mine has been idle for many years. It is in Vernon township, Sussex county.

EXPLORING FOR NEW BEDS OF IRON ORE.

The demand for iron ore is constantly increasing, and this creates a very earnest inquiry for new and increased sources of supply. To answer this inquiry, there is an active search going on for other localities for mines; and increased facilities for transportation enable the searches to be carried into districts which have heretofore been so remote from market as to be worthless. The owners of old and established mines pursue their inquiries and searches with prudence and intelligence; but a great deal of money is wasted in useless or injudicious explorations by inexperienced and sanguine persons, who know the value of mines, but have not learned the difficulties of finding them. The following directions to those who are looking for iron ore deposits may be useful:

1. *The magnetic iron ore is always found in the Azoic rocks;* generally in gneiss, but in a few instances in the white crystalline limestones. It is not found in the blue limestones, or slates or sandstones; neither is it found in the trap rocks, though there is very strongly developed local attraction observed on the surface over many of the rocks of this kind. There is disseminated through the rock a little magnetite and metallic iron, but it is probably not one per cent. of the whole, and not enough to be of any commercial value; so that the search may be limited to the rocks above mentioned.

2. *The magnetic iron ore is all in beds interposed between the layers of the gneiss, and conformable to them.* It is never in veins which cut across the layers of the rock; it has no gangue rock of calc spar, fluor spar, quartz, or any other mineral different from the common minerals of the adjacent rock layers; it has no rock walls by which the ore is separated from the adjacent rock, which at all differ from any other two adjoining beds of rock which are separated by a seam of softer or otherwise different mineral, and in many cases there is no seam at all, but the ore adheres firmly to the rock; and in many instances it passes into rock by a gradual diminution of magnetite in the mass. These

beds of magnetite, like the rocks among which they occur, are highly inclined or almost vertical. In this respect they have an accidental resemblance to true veins, which has led to their being commonly called by that name; and if the word vein means only a flattened mass of ore standing on edge, it is properly applied to these beds of ore.

3. *The beds of ore come to the surface of the rock in almost all cases,* so that it is only needful to remove the covering of earth and the bed of ore can be seen. These beds of ore are not continuous like the layers of rock, though interposed between them, but are of limited extent. The outcropping edges of the beds may extend along between the layers of rock for from 10 to 1000 or more feet, and of a breadth varying from a few inches up to twenty feet or more. The most common direction in which these beds extend is from southwest to northeast, and at their extremities they sometimes thin out to nothing; and in other cases they grow leaner and are replaced by rock. They usually dip down steeply towards the southeast, and at their extremities the ore, instead of descending straight down the slope, slants off or *pitches* towards the northeast. It is remarkable that the beds of ore which outcrop for a considerable distance have frequent narrowings and widenings, and these narrow or wide places in the veins *pitch* towards the northeast just as the extremities of the bed do. Some beds have been worked to their termination at the bottom, but most of the large beds show no apparent diminution.

Such being the mode of occurrence of the ore, it is only necessary to remove the loose earth, in order to determine whether the ore is there. Blasting out or sinking expensive shafts in rock is not necessary, and such expense should not be incurred in ordinary explorations.

4. *The direction in which the beds of ore range* is the same as the strike of the rock, and the extension of worked beds of ore is frequently proved by ranging, and many successful searches for *new* openings upon ore have been made in this way. In some cases, however, the rock has curves in the stratification, and then the ore veins curve with it.

5. *In ordinary cases, where the surface is covered with loose earth, it is common to search for ore with a magnetic needle or a miner's compass,* and for preliminary examinations it is now the chief reliance. In using this instrument much practice is required; but this joined to

good judgment gives indications of the presence of ore which are almost infallible.

There has been very great improvement, within a few years past, in the methods of searching for magnetic ore, as well as in the instruments to be used for that purpose, and the work is now well done by many persons. But as there are still many others who are not familiar with the methods or instruments, we again repeat them here, varying only as experience has shown to be desirable, from the directions given by the late Dr. Wm. Kitchell, in his annual Report on the Geological Survey of New Jersey for 1855, pp. 236–7–8; in the "Geology of New Jersey" of 1868, pp. 535–9, and in the annual Report on the Geological Survey for the year 1873, pp. 90–97. Maps, locating and recording the attractions accompanied the latter report. This year, with the directions again given, we present a map of a magnetic survey made at Oxford, Warren county, by W. H. Scranton, M. E., to determine the location of a vein, and the proper places to sink shafts. The work is admirably done, and it is hoped that the study of the map and the practice of the directions here given will help to increase the number of intelligent men who search judiciously for iron ore.

SURVEY OF THE WASHINGTON MINES AT OXFORD, BY W. H. SCRANTON, M. E.

"I inclose the map herewith, and would say, in explanation of the system used, that a line is first ranged out over the centre of the vein as nearly as it can be determined, by a rough examination with the dipping compass. This ranged line then becomes the centre line of the *survey*, whether it corresponds with the 'centre of the vein' or not. On this line stations are to be measured off, say 50 feet apart. Each station should be marked with a stake, and each stake numbered, to avoid subsequent errors.

"On the accompanying map the centre line is drawn heavier than the others. The stations are located fifty feet apart, and are marked respectively 0, 50, 100, 150, etc., up to 1750 feet, the limit of the survey.

"In making field-notes, I find it convenient to use topographical paper on which the squares of one inch are ruled with red lines, and those lines subdivided into fifths by blue lines; the intersections of

the red lines correspond to fifty feet, and those of the blue lines to ten feet.

"Having first marked off the stations of the centre line of the sheet to correspond with those of the centre line of the survey, commence at any station and note the dip indicated by the compass, record it on the centre line of the sheet at the proper station; then, moving to the right of the centre line ten feet, and at a right angle with it, note the dip and record it on the first blue line to the right of the station on the paper. In this way make and note these observations every 10 feet, both to the right and left of the centre line, as far as may be desired.

"In the same way, record the *variation* of the horizontal needle. I find a small solar compass most convenient for this purpose. The neutral line of the vein (marked by a double black line), determined in this way, corresponds *very nearly* with the actual centre of the vein, as you will notice by the cross section, A B, on the accompanying map. The section is taken at A B on the plan. The veins (of which there are two, in contact with each other) are inclined at an angle of about 60°. The centre line determined on the surface (shown by a vertical line) passes through the centre of the vein at about 70 feet from the surface, and the ore commences at 40 feet from the ground. You will notice a zigzag line extending from one shaft to the other. This is a transit line run through the heading at varying levels; it passes through several centre stations, and corresponds very nearly with the neutral line, proving that considerable reliance can be placed on this method of determining the centre of the vein.

"The sheet of cross-section paper, when filled, becomes at once *a map* from which to draw deductions. For instance, the neutral line is determined and can be readily marked on the ground from the stations of the centre line of the survey. So can all the points of heaviest attraction. By drawing lines through the stations of heaviest dips, areas including the strongest attraction are determined, as shown on the map, where such lines are drawn through the dips of 53°, (this number was selected as being 10° more than is found on any part of the *developed* vein) indicating two places on the vein, of appreciable extent, that are considerably more magnetic than the rest of it. Within these lines is evidently the proper place to sink. It would seem, from the magnetic indications that two shoots of ore are thrown up

at this point, and that at the highest point of dip, near the centre of each of these, is the heaviest body of ore.

"I find Gurley's Norwegian compass the best, though the slowest to work with."

"The indications from the magnetic needle, in searching for ore, as it usually occurs in our State, are as follows:

"An attraction which is confined to a very small spot and is lost in passing a few feet from it, is most likely to be caused by a boulder of ore, or particles of magnetite in the rock.

"An attraction which continues on steadily in the direction of the strike of the rock for a distance of many feet or rods, indicates a vein of ore; and if it is positive and strongest towards the southwest, it is reasonable to conclude that the vein begins with the attraction there; if the attraction diminishes in going northeast, and finally dies out without becoming negative, it indicates that the vein has continued on without break or ending until too far off to move the compass needle. If, on passing towards the northeast, along the line of attraction, the south pole is drawn down, it indicates the end of the vein or an offset. If, on continuing farther still in the same direction, positive attraction is found, it shows that the vein is not ended; but if no attraction is shown, there is no indication as to the further continuance of the ore.

"In crossing veins of ore from southeast to northwest, when the dip of the rock and ore is as usual to the southeast, positive attraction is first observed to come on gradually, as the ore is nearer and nearer to the surface, and the northwest edge of the vein is indicated by the needle suddenly showing negative attraction just at the point of passing off it. This change of attraction will be less marked as the depth of the vein is greater, or as the strike is nearer north and south. The steadiness and continuance of the attraction is a much better indication of ore than the strength or amount of attraction is. The ore may vary in its susceptibility to the magnetic influence from impurities in its substance; it does vary according to the position in which it lies—that is, according to its dip and strike; and it also varies very much according to its distance beneath the surface.

"*Method of Using the Compass in Searching for Ore.*—It is sufficient to say that the first examinations are made by passing over the ground with the compass, in a northwest and southeast direc-

tion, at intervals of a few rods, until indications of ore are found. Then the ground should be examined more carefully by crossing the line of attraction at intervals of a few feet, and marking the points upon which observations have been made, and recording the amount of attraction. Observations with the ordinary compass should be made, and the variation of the horizontal needle be noted. In this way materials may soon be accumulated for staking out the line of attraction, or for constructing a map for study and reference.

"After sufficient exploration with the magnetic needle, it still remains to prove the value of the vein by uncovering the ore, examining its quality, measuring the size of the vein, and estimating the cost of mining and marketing it. Uncovering should first be done in trenches dug across the line of attraction, and carried quite down to the rock. When the ore is in this way proved to be of value, regular mining operations may begin.

"In places where there are offsets in the ore, or where it has been subject to bends, folds or other irregularities, so that the miner is at fault in what direction to proceed, explorations may be made with the diamond drill."

1. In the application of the above-mentioned directions, or rules, it is advisable to consult the geological map of the State to ascertain the extent and location of the Azoic rocks. The small map accompanying this report shows the boundaries of the rocks.

2. The effects of the glacial drift are also to be considered. The southern limit of that formation is indicated on the State map. Over all of the country lying north of that line the original surface has been modified by the great continental glacier which moved over it. The rock outcrops have been ground down, grooved and polished, and, in part, covered by earth, gravel, cobblestones and boulders, which have been pushed along by the ice. These deposits, lying upon the abraded strata, are of two kinds: one is unstratified; the other has its materials sorted, and in layers. But in both cases the materials differ from the underlying rock strata. They represent the rocks from the outcrops to the northward, and have been gathered from the district over which the ice moved. Hence, north of this glacial drift or moraine line the boulders and gravel found in the earth are not always characteristic of the strata under it. There may be fragments of hematite, or of magnetic iron ore, or of zinc ores, which have traveled

several miles from the parent ledges. The boulders of franklinite common in the drift-bank and moraine at Ogdensburg, in Sussex county, have come from Mine Hill, Franklin, and others of them have been found some miles farther southwest. It is not safe to draw conclusions from boulders.

South of the terminal moraine line there has not been any such abrasion of the surface, nor such accumulations of unsorted drift. The strata have been exposed to the longer and more gentle action of atmospheric agencies, as frosts and rains. These working throughout the long geological periods, have disintegrated the rocks and changed them, in many cases, into earth-like masses, sometimes termed *rotten rock*. The earthy covering is here derived from the rocks in place, and, excepting what may have washed from hill sides above, represents the underlying strata; and the rocks in it may serve as a guide in searches for ore. These are sometimes known as float ore,* and are good indications. On account of the great depth to which this disintegration has in some places reached, it may be necessary to sink many feet to test ground thoroughly and to reach the harder strata, although the lines of bedding may be seen in the rotten rock and earth quite near the surface. It appears as if there was in this fact of the drift an explanation of the greater number of early locations of mines in the northern, rather than in the southern parts of our Highland range. The disintegration in the latter has crumbled the original ledges, and concealed them beneath their own debris. Further to the north, the ice-polished ledges have not been so long exposed to the action of the elements, and they stand out plainly wherever they are not covered by drift. Attention to these differences in the nature of the over-lying earths and of the undisturbed strata, will enable the careful prospecter to search more intelligently and more successfully. In using the compass, the same precautions are advisable. A great thickness of earth may prevent the tracing of the line of attraction, or a great variation in it from point to point may, in part, account for varying intensity in the attraction. Large boulders of magnetic iron ore in glacial drift may affect the needle, and give a very irregular and unsteady attraction. In general, it may be said that there is greater need of careful attention to the indications in a drift-covered district or area, than in

*The term *float ore* is occasionally used to designate any loose ore on the surface. When in glacial drift, it may be boulders.

one not so covered. Some remarkable examples of inattention to the indications of the surface earths, and failures to find workable veins of ore, could be given, if they were not at once apparent to all who are familiar with the iron ore district.

3. The value of the compass as a guide in searching for magnetic iron ores has been so frequently proved in the discovery of veins of ore and the opening of large and profitable mines, that it is unnecessary to give examples. The Geological Survey has accumulated a large amount of material in this direction. And in a future report it may be desirable to put together the records of surface indications and the developments, and show how far they correspond with one another. A more careful survey, and the construction of an accurate map of the iron-ore district ought to give us a clew to the geological structure, and indicate the *ore-bearing belts or ranges*, as distinguished from barren areas. At present the compass is our best guide over the whole district.

SEARCHING FOR HEMATITE.

The brown hematite mines in our State are either on the line of the gneissic and magnesian limestone rocks, or along the border of the latter and the slate. And searches should be directed along these geological boundaries. Yellow and yellowish-white clays and ochrey earths accompany this ore, and they are good indications. The compass cannot be used. But the same examination of the overlying earths and stones in the soil is more important in looking for this than it is in searching for magnetic iron ore. The fragments of ore among the stone or gravel of the surface may have been carried by ice from ledges miles away. Such indications would be altogether misleading. The first inquiry should be as to the nature of the earth or surface covering. If on a slope, the ore may have washed down hill from a deposit above; or, if in a smooth valley, where the earth is stratified with sand and gravel, it may have been carried a long distance by streams or floods of water coming from the melting of the glacier ages ago. The occurrence of hematites in these diluvial strata, as for example in the gravels of Succasunna Plains, Morris Plains and the flats along the Pequest creek and other streams, indicates the existence of such ores whence these materials come, and not necessarily in the locality where they are found. The frequency and quantity

may enable one to trace them to their source—*to follow up the old stream.* In contrast to the magnetic iron ores, the hematite mines of our State are mostly south of the glacial drift, although the extent of country in which searches are to be made south of that limit is less than that to the north of the same. The glacial drift, as also the terrace drift, has so altered the surface as to conceal more effectually the few deposits which may have escaped the grinding force of the glacial ice.

6. THE SOILS OF NEW JERSEY.

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

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

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

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

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

The classification we shall use for the description of the soils of the State is one based on their geological origin, as follows:

1. *Granitic*—The soils on the Azoic rocks, and which have evidently been formed from the decomposition or disintegration of the gneiss hornblende and granite rocks of this formation. They are designated on the map by a crimson or carmine color.

2. *Limestone*—The soils which overlie the white, magnesia, and Helderberg lime-rocks, and have been formed from these rocks by the solution and removal of most of the lime, leaving the earths and impurities of the stone for the soil. Each of these soils and rocks is designated by a blue color.

3. *Slate*—The soils which are on the Hudson river slate, the Oriskany sandstone, and the Cauda-galli grit, and have been formed by the

simple disintegration of those rocks. These soils are usually more or less clayey. They are colored on the map of a neutral tint.

4. *Red Sandstone and Shale.*—These soils have been formed by the disintegration of the rocks on which they are found. The color on the map shows their location.

5. *Trap*—Is the soil which is formed by the decomposition of trap-rocks, and is found on them. An olive-green color is used on the map to designate this soil.

6. *Clay and Sand*—Designates the soils which are found on the outcrop of the formations of white clays and sands of the lower member of the Cretaceous period. These soils are designated by a yellowish color.

7. *Marl Soils*—Are those which are on the outcrops of the clay marls, lower marl bed, red sand, middle marl bed, yellow sand, and upper marl bed. They are formed by the mixing together of these different strata. On the map they are colored different shades of green.

8. *Silicious Soils*—Include all those in which quartz ore or silicious matter largely predominates. They are designated on the map by a yellow color of different shades, and the following subdivisions are distinguished:

a. Quartz-rock—Soil which is on the conglomerate of the Green Pond Mountain, and on the Oneida conglomerate and the Medina sandstone of the Kittatinny Mountain. These lands are all in forest.

b. Pine-land—That soil which is found in portions of Southern New Jersey, and on which *only* yellow pine ever grows. It is formed from the glass-sand and the water-sorted, gravelly earth.

c. Oak-land—That soil which is found in portions of Southeastern New Jersey, and on which oak timber grows. It is the unsorted gravelly earth of the Post-Tertiary Age.

d. Miocene—The soil found on the miocene marl of Cumberland county.

9. *Glacial-drift Soils*—Are designated on the map over all the northern part of the State by small black dots. These soils are somewhat like the rocks on which they lie, but their composition is changed by the addition of earth brought by the glaciers from the rocks farther north.

10. *Alluvial*—Is the name given to the soils which make the tide marshes—those which are along the borders of the uplands and only

a few feet above tide-level, and also to those which make up river flats. They are designated to some extent on the map by fine-ruled black lines.

Samples of all these varieties of soils have been collected, and as many as the other work of the laboratory would allow of, have been analyzed. The analyses have been made by digesting in acids, and not by fusion. From an extensive acquaintance with the farms and farming of all parts of the State, it is believed that these analyses are in accordance with the results of farm practice, and that they may be studied and used with profit.

ANALYSES OF SOILS.*

Granitic Soils.

	Water. (Moisture.)	Sand. (Insoluble in acid.)	Alumina.	Oxide of Iron.	Magnesia.	Potash.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Carbonic Acid.	Organic Matter	Total.	Nitrogen.
1 Soil— Chester, Morris county....	2.100	77.100	7.820	3.580	1.160	0.080	0.301	0.230	0.021	.....	0.055	7.000	99.447	0.194
2 Subsoil— Flanders, Morris county....	2.300	63.300	16.490	9.200	0.252	0.070	0.041	0.198	traces	traces	.....	8.500	100.351	0.044
3 Soil— Washington, Warren co....	1.550	72.250	19.573		0.312	0.130	0.014	0.127	0.005	0.002	0.019	5.850	99.832	0.034
4 Soil— Pohatcong Mt., Warren co.	2.000	63.800	16.150	8.840	0.504	0.190	0.120	0.154	traces	0.017	0.014	8.850	100.640	0.022

Limestone Soils.

5 Soil—Wm. Shields, New Hampton.....	1.900	77.350	7.959	4.175	0.792	0.450	0.548	0.174	0.031	.....	0.250	6.350	99.979	0.118
6 Soil—Wm. Shields, New Hampton	1.850	79.400	7.209	4.124	0.720	0.235	0.540	0.191	0.027	.....	0.117	5.500	99.913	0.130
7 Soil—Wm. Shields, New Hampton.....	1.800	79.450	7.370	3.520	0.756	0.505	0.475	0.160	0.031	.....	0.082	5.850	99.999	0.153
8 Soil—Oliver Kline, Musconetcong Valley.....	1.450	82.050	6.547	5.037	0.432	0.215	0.250	0.115	0.014	.....	0.097	3.600	99.807	0.094
9 Soil—Oliver Kline, Musconetcong Valley.....	1.700	79.200	7.545	4.590	0.796	0.470	0.306	0.115	0.021	.....	0.079	5.350	100.171	0.132
10 Soil—W. H. Drake, Musconetcong Valley.....	1.900	81.550	6.181	3.715	0.918	0.372	0.363	0.154	0.026	.....	0.097	5.150	100.426	0.134
11 Soil—Robert I. Smith, Bloomsbury.....	1.900	74.650	8.730	4.560	0.540	0.470	0.329	0.160	0.024	.....	0.061	8.250	99.674	0.206

*The analyses were made by digesting the soils in acids, and not by fusion.

ANALYSES OF SOILS—(CONTINUED.)

	Water. (Moisture.)	Sand. (Insoluble.)	Alumina.	Oxide of Iron.	Magnesia.	Potash.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Carbonic Acid.	Organic Matter	Total.	Nitrogen.
12 Soil—Robt. I. Smith, Bloomsbury	1.200	79.900	7.379	4.817	0.514	0.343	0.362	0.141	0.027	.....	0 065	5.350	100.098	0.120
13 Subsoil—Johnsonburg, Warren co...	1.400	70.160	3.877	5.016	0.576	0.240	4.235	0.307	traces	traces	5.380	8.050	99.241	0.131
14 Soil—John T. Leigh, Clinton	1.550	79.500	7.195	3.555	0.763	0.075	0.371	0.166	0.027	.....	0.132	6.550	99.884	0.176
15 Soil—Robert Craig, New Germantown	2.200	77.200	7.149	6.219	0.343	0.140	0.453	0.282	0.015	.....	0.823	5.550	100.374	0.107
Slate Soils.														
16 Soil—Deckerton	0.750	76.050	10.888	5.534	1.638	0.250	0.072	0.128	0.005	.....	.....	3.700	99.015	0.069
17 Soil—Wm. P. Nicholas, Newton	1.400	74.100	8.837	5.175	1.850	0.650	0.618	0.288	0.012	.....	0.082	6.350	99.362	0.130
18 Soil—Asbury, Warren county	1.950	75.300	7.410	6.826	1.152	0.220	0.059	0.064	0.010	.....	0.054	7.050	100.095	0.131
Red Sandstone and Shale Soils.														
19 Soil—John T. Leigh, Clinton	1.250	83.250	5.673	4.641	0.306	0.155	0.140	0.086	0.017	.....	0 048	4.250	99.816	.0.095
20 Soil—Kingwood, Hunterdon co.,	2.750	75.550	9.318	2.504	0.605	0.120	0.067	0.077	0.019	.....	0.024	8.950	99.984	0.182
21 Soil—College Farm, N. Brunsw'k	3.000	83.400	3.311	2.044	0.180	0.090	0.013	0.046	0.024	.....	0.055	7.200	99.363	0.119
22 Subsoil—Under No. 21	1.300	88.600	3.991	2.575	0.324	0.015	0.003	0.034	0.011	.....	0.013	3.500	100.366	0.048

23 Soil— College Farm, N. Brunsw'k	1.900	80.500	6.495	4.472	0.468	0.325	0.221	0.083	0.029	.....	0.032	5.600	100.125	0.161
24 Subsoil— Under No. 23.....	2.075	84.150	3.944	5.096	0.576	0.270	0.189	0.060	0.021	.....	0.012	4.125	100.518	0.053
25 Soil— Commons, New Brunswick	3.80	71.070	9.260	6.560	2.020	0.810	0.220	0.140	0.030	.....	.....	5.000	98.910	0.074
Trap Soils.														
26 Soil— Palisades Mt., Bergen co...	3.700	76.300	6.186	8.510	0.288	0.145	0.140	0.089	0.004	0.012	0.150	4.750	100.274	0.041
27 Soil— Washington Rock.....	6.800	52.100	16.310	13.512	1.600	0.125	0.357	0.078	0.008	.....	0.012	8.550	99.452	0.041
28 Soil— Mt. Horeb, Somerset co.....	4.150	70.250	7.790	9.672	1.512	0.150	0.268	0.038	0.012	.....	0.005	6.410	100.257	0.054
29 Soil—Ten Mile Run Mountain, Middlesex county.....	3.250	52.200	23.050	11.320	0.304	0.190	0.120	0.077	traces	0.020	0.025	9.500	100.056	0.023
30 Soil— Rocky Hill, Mercer co.....	1.650	72.200	18.370		0.302	0.130	0.100	0 131	0.014	traces	0.029	7.000	99.926	0.051
Marl Soils.														
31 Soil— Holmdel, Monmouth co....	1.700	88.450	1.668	4.677	0.360	0.470	0.029	0.205	0.010	.....	0.010	3.500	101.079	0.069
32 Soil— Edinburgh, Monmouth co..	1.400	86.250	2.397	6.968	0.108	0.076	0.016	0.186	0.034	.....	0.008	2.400	99.843	0.026
33 Soil (No. 1)— Thorofare, Gloucester co...	0.400	96.050	0.904	0.860	0.065	0.095	0.105	0.106	0.024	.....	.....	1.330	99.940	0.053
34 Soil (No. 2) Thorofare, Gloucester co....	0.450	94.200	0.624	1.080	0.132	0.133	0.110	0.096	0.027	.....	.....	3.600	100.450	0.085
Silicious Soils.														
35 Soil— Shiloh, Cumberland co.....	2.00	83.10	5.45	2.25	0.74	0.19	traces	0.05	traces	.....	.....	6.60	100.38	0.114

ANALYSES OF SOILS.—(CONTINUED.)

Oak-land Soils.

		Water. (Moisture.)	Sand. (Insoluble.)	Alumina.	Oxide of Iron.	Magnesia.	Potash.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Carbonic Acid.	Organic Matter.	Total.	Nitrogen.
36	Soil—Bricksburg, Ocean county..	0.214	97.050	0.774	0.312	0.058	0.042	0.019	0.015	0.002	.....	0.011	1.146	99.643	0.025
37	Soil—Chas. H. Irons, White Oak Bottom, Ocean co.....	0.600	94.200	2.344	1.130	0.018	0.038	0.021	0.026	0.010	.....	0.010	1.400	99.797	0.039
38	Soil—White Oak Bottom, Ocean county.....	1.500	89.250	4.797	2.014	0.216	0.080	0.015	0.084	0.005	trace	0.017	2.300	100.278	0.035
39	Soil—George W. Cowperthwaite, Toms River.....	0.350	94.300	1.070	1.400	0.252	0.040	0.021	0.031	0 021	0.002	.....	2.150	99.640	0.042
40	Subsoil—Under No. 39.....	0.450	92.450	1.814	1.966	0.200	0.045	0.014	0.020	0.012	.....	.....	2.250	99.220	0.028
41	Soil—East of Whiting's, Ocean county.....	0.250	94.500	1.705	1.870	0.114	0.025	0.007	0.025	traces	traces	0.017	1.650	100.160	0.027
42	Subsoil—Cedar Bridge Road, Ocean county.....	1.150	83.180	8 375	3.099	0.076	0.055	0.005	0.026	0 0014	0.0017	.....	3.950	99.921	.....
43	Soil—Egg Harbor City.....	0.225	96.160	1.206	0.796	0.056	0.036	0.011	0.019	0.C008	traces	.....	1.375	99.885	0.018
44	Soil—Weymouth Road, Vineland	0.550	91.900	2.124	3.399	0.126	0.055	0.025	0.077	0.015	.....	0.012	1.850	100.133	0.037
45	Soil—Dr. T. T. Price, Tuckerton.....	0.300	97.460	0.427	0.230	0.014	0.033	0.012	0.023	0.0017	traces	.....	1.500	100.000	0.015
46	Soil—Mauricetown.....	0.850	94.440	2.489		0.050	0.040	0.017	0.031	0.0007	0.0013	.....	1.975	99.890	0.030

Pine-land Soils.

47 Soil—														
Bricksburg tract	0.100	98.910	0.293	0.087	.....	0.001	6.0017	traces	traces	traces	.....	0.700	100.093	.....
48 Soil—Dillon's Island,														
Toms River	0.250	98.590	0.212	0.248	trace	trace	trace	trace	traces	trace	.....	0.650	99.950	0.017
49 Soil—Two miles south of														
Toms River	.....	99.420	0.318	0.024	0.010	0.014	trace	0.018	trace	.....	.....	0.200	100.000	.....
50 Subsoil—														
Under No. 49	0.500	98.120	0.472	0.510	0.011	0.007	0.018	0.028	.....	traces	traces	0.250	99.916	0.014
51 Soil—														
East Plains	0.200	98.440	0.269	0.452	traces	0.035	0.025	0 038	0.0007	0.0005	.....	0.200	99.660	.....
52 Subsoil—														
Under No. 51	0.200	97.020	0.663	0.792	0.054	0.031	0.012	0.045	0.017	traces	.....	1.050	99.884	.....

Alluvial Soils.

53 Soil—														
Greenwich, Cumberland co.	1.60	86.50	1.56	2.13	0.47	0.16	0.31	0.154	0.02	traces	.....	6.65	99.69	0.203
54 Soil—Downes Edmonds,														
Cape May	0.80	90.95	2.47	0.82	0.29	0.18	0.53	0.06	0.08	traces	.....	3.40	99.58	0.134

Of the soils in the above list, No. 11 may be taken as the model of naturally good soil. It is the virgin soil of the limestone valleys of Warren and the adjoining counties. These valleys have now been cleared and in cultivation for more than a hundred years, and they have always been noted for yielding large crops of wheat, rye, corn, and clover. Soil like this will yield 30 bushels of wheat to the acre, without any manure or other fertilizer. After these soils had been cropped for a good many years, it was found that an occasional crop of clover was essential to keeping up the fertility of the soil. And the practice of the farmers there is now to crop their lands in a four years' rotation, of clover, corn, fallow or oats, wheat, and then clover again, and to dress the ground before sowing wheat with a coat of fresh-slaked lime. Good crops are obtained in this way, but whenever the clover crop fails, the wheat, too, is a failure. Three or four such failures have recently occurred there; and this led to the analysis of the cultivated soils 7, 8, 9, 12, which were originally the same as 11, The only difference to be seen is in the amount of nitrogen in the soils. and this is no doubt the chief cause of the failure. The Hessian fly has been very troublesome there, but the soils rich in nitrogen withstood its attacks. The last season the crop of clover was better, and it is reported that the promise for wheat is good. It would be an improvement to lengthen the rotation by keeping the land in clover, or clover and timothy, two years instead of one, and so increasing the amount of nitrogen in the soil. This would allow of keeping twice as large a stock of cattle and sheep as is now kept, and of course of making twice as much nitrogenous manure. And four-fifths as much land as is now sown in wheat would be sure to produce more wheat than the whole now does. The land contains a store of lime, potash, and phosphoric acid, that is practically inexhaustible. All that is needed in the soil is a sufficient quantity of vegetable or other organic substance containing nitrogen, to make these mineral substances soluble.

The soils 31 and 32 are good examples of soils deficient in some essential constituents, while having others in abundance. These soils, when first cleared, would raise good crops of corn and rye, but wheat was not grown. Lime applied to them will cause them to bring good crops of clover, and with that fine crops of wheat can be grown; and the country where these soils are found, by skillful management is made to produce much larger aggregate returns from its farms than are at

present obtained in those like Nos. 5–11. The soils of this kind have, however, been still further improved by the use of greensand marl. But even with this, the lime and clover are still necessary.

An examination of the analyses of soils from different agricultural districts of the State will help the experienced farmer to judge of the deficiencies of his own soil, and may furnish hints for its improvement. But the analyses give no indication of the physical condition of the soil. It may be flat in its surface, and illy drained, or may have a close subsoil; in which cases, however rich it may be in all the constituents of a good soil, it will not yield good crops. For example: the soil 20 is a rich one, and it is covered with very heavy timber, but it is cold and wet, and can only be made fit for profitable tillage by being thoroughly and deeply underdrained.

The soils of the oak-lands of southern New Jersey are comparatively deficient in the elements which make a naturally fertile soil, and when first cleared they produce only very light crops of corn and rye, but when properly fertilized with marl or other manure, they can be made very productive. Excellent farms are to be found in various places on these lands, and the smaller cost of cultivation goes far to compensate for the extra cost for manures. Of these lands there is a large area which is still unimproved, waiting for enterprising and industrious settlers to locate on it. The means by which these soils can be easiest brought into productive cultivation were shown in last year's report, and as the subject is one of continued interest, the matter is repeated here.

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

1.—Number of pounds per acre of potash, lime, phosphoric acid and nitrogen, in various soils.

Granitic Soils.

		Potash, Pounds.	Lime, Pounds.	Phosphoric Acid, Pounds.	Nitrogen, Pounds.
1	Natural soil, woodland, Chester, Morris county	1,393	5,226	4,006	3,380
2	Subsoil, Flanders, Morris county	1,305	713	3,450	767
3	Uncultivated soil, Washington, Warren county	2,242	200	2,190	592
4	Uncultivated soil, Pohatcong Mountain, Warren Co.	3,276	2,069	2,656	383
	Limestone Soils.				
5	Soil, cultivated, Wm. Shields, Musconetcong Valley, Warren county	7,839	9,546	3,031	2,055
6	Soil, cultivated, Wm. Shields, Musconetcong Valley, Warren county	4,093	9,400	3,484	2,264
7	Soil, cultivated, Wm. Shields, Musconetcong Valley, Warren county	8,797	8,274	2,787	2,665
8	Soil, cultivated, Oliver Kline, Musconetcong Valley, Warren county	3,745	4,355	2,003	1,638
9	Soil, cultivated, Oliver Kline, Musconetcong Valley, Warren county	8,187	5,330	2,003	2,300
10	Soil, cultivated, W. H. Drake, Musconetcong Valley, Warren county	6,480	6,323	2,683	2,334
11	Soil, virgin, Robert I. Smith, Bloomsbury, Warren county	8,187	5,731	2,787	3,588
12	Soil, cultivated, Robert I. Smith, Bloomsbury, Warren county	5,975	6,305	2,456	2,090
13	Subsoil, Johnsonburg, Warren county	4,180	73,702	5,348	2,282
14	Soil, John T. Leigh, Clinton, Hunterdon county	1,306	6,462	2,891	3,065
15	Soil, Robt. Craig, New Germantown, Hunterdon Co.	2,439	7,891	4,913	1,864
	Slate Soils.				
16	Soil, natural, William S. Vanderuff, Deckertown, Sussex county	4,350	1,256	2,230	1,213
17	Soil, cultivated, William P. Nicholas, Newton, Sussex county	11,323	10,766	5,017	2,264
18	Soil, natural, near Asbury, Warren county	3,832	1,028	1,115	2,282
	Red Sandstone and Shale Soils.				
19	Soil, cultivated, John T. Leigh, Clinton, Hunterdon county	2,700	2,439	1,498	1,655
20	Soil, natural, Kingwood, Hunterdon county	2,090	2,211	1,341	3,170
21	Soil, natural, College farm, New Brunswick	1,568	226	801	2,073
22	Subsoil, under No. 21	261	52	592	837
23	Soil, cultivated, College farm, New Brunswick	5,661	3,849	1,446	2,805
24	Subsoil, under No. 23	4,703	3,293	1,045	923
25	Soil, uncultivated, unfenced commons	14,110	3,832	2,439	1,289
	Trap Soils.				
26	Subsoil, natural, Palisade Mountain, Bergen county	2,526	2,438	1,560	715
27	Soil, natural, Washington Rock, Somerset county	1,829	6,219	1,359	715
28	Soil, natural, Mount Horeb, Somerset county	2,613	4,670	662	941
29	Soil, natural, Ten Mile Run Mountain, Middlesex county	3,310	2,090	1,340	400
30	Soil, natural, Rocky Hill, Mercer county	2,258	1,724	2,242	888

TABLE I.—(CONTINUED.)

Marl Soils.

	Potash, Pounds.	Lime, Pounds.	Phosphoric Acid, Pounds.	Nitrogen, Pounds.
31 Soil, natural, Holmdel, Monmouth county	8,187	505	3,571	1,202
32 Soil, natural, Edinburgh, Monmouth county	1,324	278	3,240	418
33 Soil, cultivated, Thorofare, Gloucester county	1,655	1,829	1,846	923
34 Soil, cultivated, Thorofare, Gloucester county	2,323	1,916	1,672	1,480

Silicious Soils.

Miocene Soil.

35 Soil, natural, Shiloh, Cumberland county	3,310	5,400	871	1,983

Oak-land Soils.

36 Soil, natural, Bricksburg, Ocean county	732	331	261	435
37 Soil, uncultivated, Chas. H. Irons, White Oak Bottom, Ocean county	662	376	452	680
38 Soil, woodland, White Oak Bottom, Ocean county	1,380	258	1,448	610
39 Soil, Geo. W. Cowperthwaite, Toms River, Ocean co.	638	361	533	663
40 Subsoil, under No. 39	783	243	348	488
41 Soil, natural, east of Whiting's, Ocean county	431	120	431	471
42 Subsoil, Cedar Bridge, Ocean county	951	71	452	.....
43 Soil, Egg Harbor City, Atlantic county	627	191	330	279
44 Soil, natural, Weymouth Road, Vineland	958	435	1,341	645
45 Soil, natural, Dr. T. T. Price, Tuckerton, Burlington county	568	207	396	261
46 Soil, natural, Mauricetown, Cumberland county	690	292	534	522

Pine-land Soils.

47 Soil, Bricksburg tract, Ocean county	17	29	.....	.....
48 Soil, Dillon's Island, Toms River, Ocean county	.....	.....	.....	296
49 Soil, Stanton tract, 2 miles south of Toms River, Ocean county	241	.....	310	.....
50 Subsoil, under No. 49	129	310	432	244
51 Soil, East Plains, Burlington county	609	435	670	.....
52 Subsoil, under No. 51.	540	209	783	.....

Alluvial Soils.

53 Soil, Bacon Neck, Greenwich, Cumberland county	2,787	5,400	2,683	3,536
54 Soil, Downes Edmonds, Cape May	3,136	9,232	1,045	2,334

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

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

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

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

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

To replace the potash taken out from one acre in the five years' rotation, would at the lowest present prices of potash cost $40.67, and to replace the phosphoric acid would cost $17.90—or, per acre, nearly $12 a year. The value of land must then depend to a considerable extent on the amount of these constituents naturally in the soils, this value being modified by the condition of the soil and the ease with which it is managed and tilled.

The principle, however, must everywhere be admitted and acted on that crops take valuable substances from the soil, and these must be restored in some form, or the capability of the land for growing crops will be destroyed. Attention to this principle enables farmers on the lighter lands of southern New Jersey to raise as good crops as are grown in the northern part of the State.

The land needs in addition to barn-yard manure, however, other fertilizers to some extent in order to cultivate them to the best advantage. Of fertilizers, those which can be used to the best advantage in most places are muck and greensand marl. Every bushel of marl contains at least 5 pounds of potash, 1½ pounds of phosphoric acid, and it can be bought for from 4 to 10 cents, according to the distance from the marl pits. Twenty bushels of marl make a ton, and five tons are enough to supply the whole of the potash and phosphoric acid for the five years' rotation—or a ton a year, which may cost from $1 to $2. It is true the potash and phosphoric acid in the marl are both so combined in it that they do not dissolve in water, and so become fertilizing; but

under the influence of the vegetable matter in the soils, or of the farm-yard manures with which they may be composted, they gradually become soluble; and under the influence of muck or of muck and lime, they undergo the same change. There is, then, an abundant supply of potash and phosphoric acid to be had cheaply in greensand marl. Analyses of the marls most used are given in the table following:

TABLE.

	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	.....	.27	.39	.26	.22	.97	.31	1.89	.....
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.

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

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

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

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

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

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

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

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

10. Marl from the pits of the Vincentown Marl Company, near

Vincentown, Burlington county. This comes from the green marl layer of the Upper Bed.

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

Marls more or less calcareous, of the miocene age, are dug near Shiloh, in the western part of Cumberland county. They have been found very beneficial to the soils, and are used generally by farmers for miles around them. Their composition is shown in the following analyses. No. 1 is an average sample from Ayers' pits, and represents the grey, calcareous marl. No. 2 is from Hummell's pits, on the Horse Branch, and is a black marl.

	1.	2.
Silica and quartz	59.30	65.53
Alumina	2.84	5.59
Oxide of iron	3.07	6.08
Lime	15.30	2.71
Magnesia	0.69	2.65
Potash	0.97	1.12
Soda	0.58	
Sulphuric acid	3.56	6.70
Phosphoric acid	0.45	2.00
Carbonic acid	9.00	
Organic matter		2.12
Water	2.80	5.17
Total	98.56	99.67

Muck, or black earth, is abundant in all the swamps and wet grounds of southern New Jersey. It is vegetable matter partially decayed, and while in the swamp is undergoing no further change. It has then no fertilizing value, but when dug out and exposed to sun, air, moisture and to frost, it soon begins to change and decay. Its change can be hastened by the addition of lime, lime and salt, or barn-yard manure. It is then in good condition to apply to the soil. Its office appears to

be to improve the texture of the soil, to increase its power of absorbing moisture from the air, to furnish a solvent for the mineral substances in the soil and in mineral fertilizers, and to become the medium of communication between the soil and the growing crops. It does not contain more potash or phosphoric acid than is found in ordinary soils, and can of itself only help to exhaust them quicker, but mixed with marl or other fertilizers in the soil, it increases the crop very largely.

Analysis of muck from a pine swamp bottom, Toms River, Ocean county:

Organic matter	77.800
Water	7.950
Matters insoluble in acid	13.800
Alumina	0.174
Oxide of iron	0.250
Lime	0.031
Magnesia	0.216
Potash	0.070
Phosphoric acid	0.026
Carbonic acid	0.008
Chlorine	trace
Sulphuric acid	0.034
	100.359
Nitrogen	1.089

The sample was a good average, and was taken from a ditch bank. The bed of which it is a representative, has a depth of about three feet. Such beds are common throughout Ocean, the eastern part of Burlington, Atlantic, Cumberland and Cape May counties. Those of all other parts of the State are nearly the same. This muck, it will be seen, contains 20 pounds of nitrogen to the ton, so that it is capable of adding to the soil a very essential constituent, and one which is entirely wanting in the marl.

With these two fertilizers, both of which require little money, the tillage of the oak-lands can be begun in an economical way. The first crops upon them will be light, but gradually their fertility will develop, and with good management very satisfactory crops can be produced. The soils are rather deficient in lime; the marl may supply this deficiency, or common slaked lime may be applied. And there may be cases in which other fertilizers may be more available. But in all cases the fertilizers should be used so as to favor the growth of

a good crop of clover, and when this is attained, the greatest difficulty in cultitvating these hitherto neglected lands will have been overcome.

Nos. 47–52 are analyses of specimens from the pine lands. They are not farmed.

Nos. 53 and 54 are alluvial soils, and they are remarkably productive. They were cleared at the first settlement of the country, and have been cultivated ever since, without manure.

7. DRAINAGE.

The drainage works, on the Pequest, in the Great Meadows of Warren and Sussex counties, are completed. The channel is large enough and the current sufficiently rapid to carry all waters in a freshet without overflowing. There was an ice dam at the breaking up of the stream last spring, which caused the water to overflow the banks, but as soon as that broke the water fell at once within the banks of the stream. The drainage is a complete success, and is now ready for the remaining step in its improvement, viz., that of cutting the side drains and ditches which are needed to carry off quickly the water which falls on these flat grounds. The benefits of draining these rich lands promise to be as great as the owners of them could desire. It is to be regretted that the expense of improvements of as great public importance as this is, and so much to be desired for sanitary reasons, should all be thrown upon the owners of the wet lands. The whole country surrounding is made more attractive, salubrious, and valuable, and it should share the expense. The land is benefited all that it costs, but the owners find it burdensome to advance the expense before they have realized any profits from it.

The business of the commissioners is not yet closed, being delayed, and their expenses increased, by tedious and unnecessary litigation.

8. WATER SUPPLY.

The question of water supply continues to attract attention in many parts of our State. The increasing density of population and the consequent accumulation of waste, filth and decaying substances on the surface is liable to, and in many cases does contaminate well-waters so as to render them unfit for use. Then, too, the increasing wealth of our people leads them to seek for the larger supplies and greater comfort to be obtained by having water carried in pipes to all parts of a house, and drawn by the simple process of turning a faucet.

A large number of samples of well-water have been sent to the laboratory this year by anxious housekeepers, to learn whether they were wholesome and safe to use for drinking. We have tested many of these and returned answers to the inquiries, according to the best judgment we could arrive at. This judgment, however, has to be formed as much from the history of the water as from the chemical examination. To determine whether water is hard, we take a gill or thereabouts in a flask and add to it a clear solution of soap in alcohol. If the mixture is then shaken and remains clear with an abundance of soap bubbles over it, the water is soft, but if it becomes white, and curdy-looking masses form and float in it, and no bubbles appear on the surface, it is hard water.

The hardness is caused by salts of lime and magnesia which are in solution in the water. These salts render the water unfit for washing, as they destroy soap, and they are troublesome in tea kettles and in steam boilers, on account of the incrustation which is formed as the water boils away. But hard water is not specially unwholesome, and it is common to find well-waters containing from 10 to 60 or more grains of solid matter to the gallon, which have been used for years without any injurious effect, though sanitarians recommend that water containing more than 17 grains to the gallon be not used.

Waters containing a very little ammonia or albuminoid ammonia

have been said to be poisonous, and if this substance comes from sewage, filth, or decaying organic matter such as accumulates about dwellings, there is danger of its being so, especially in hot weather. But if it comes from partially decaying weeds, grass or other vegetable matter, such as is found in brook or river-water away from settled population, there is no danger to be apprehended from its use—it may be disagreeable but is not dangerous. The test for this substance is very delicate, and to estimate the amount requires much care on the part of the chemist. In brook, river or lake-waters in thick-settled countries this substance is to be regarded with suspicion, and well-waters containing it should not be used. The test, however, is not an easy one, and almost as satisfactory trials can be made by testing for chlorine or for common salt. Pure well-waters as well as common brook-waters contain scarcely a trace of chlorine, while it is always found in sewage water and amongst the organic and waste matters that are thrown on the ground about houses. The well-known test for chlorine, or for salt, is to take a clear solution of lunar caustic or nitrate of silver in pure rain-water, and add a few drops of it to the suspected water, and if it contains chlorine or salt a bluish-white cloud will form in the water. If the test shows chlorine it is safe to reject the water, or at least to boil it before drinking. Boiling water destroys the organic poisons which it contains.

The temperature of water in a well at different seasons of the year, will give indication as to whether the water is of surface origin or from some deeper source. At a depth of about 50 feet below the surface of the ground, the temperature of the earth is unchanged throughout the year, no warmer in summer, no colder in winter. This temperature is the mean, or average, for the year at the place of observation. In New Brunswick it is 52°, in Newark it is 51°, in Vineland 53°, and in some places in northern New Jersey as low as 48°. In deep wells, over 50 feet, the temperature is increased about 1° for every 50 feet in depth, but remains the same throughout the year. Wells supplied from surface water grow colder in winter and warmer in summer which those from deeper sources do not.

The following analyses of waters from Lambertville, Hunterdon county, were made at the suggestion of the Lambertville Water Company. The samples were collected by Dr. G. H. Larison, on the 9th of October of this year, at a time when streams and wells were very low,

and when water is likely to be more impure than at any other season of the year:

Analyses.

	AMMONIA IN 10,000,000 PARTS OF WATER.		Chlorine, number of grains in a gallon.
	Free.	Albuminoid.	
1 From Delaware river at the water-works pump on Island creek	10.70	10.55	.355
2 From Alexsauken creek	8.00	11.25	.150
3 From clay pit at brick-yard above reservoir	2.67	19.80	.050
4 From water-works pipe, at dead end	4.00	12.50	.100
5 From water-works pipe, 8-inch main at Dr. Lilly's	16.00	14.00	.200
6 From Union Fire Company's cistern	2.00	8.00	.100
7 From Dr. Lilly's well, at his residence	3 33.	7.25	1.400
8 From well in 1st ward, S. Main St	1.33	7.50	2.400
9 From John M. Matterson's well, east side of city	1.00	11.50	5.200
10 From C. W. Kitchin's well, at hotel	1.33	9.92	20.500
11 From new school-house well	8.00	8.25	3.350

	GRAINS OF SOLID MATTER IN 1 GALLON OF WATER.		Hardness, in grains of carb. lime in a gallon.
	Dried at 212°.	Burned.	
From Delaware river	6.50	3.50	3.90
From Alexsauken creek	8.50	5.75	4.10
From clay pit at brick-yard	7.50	4.25	4.68
From water-works pipe at dead end	6.35	3.80	2.56
From water-works pipe at Dr. Lilly's	6.50	4.00	3.10
From Union Fire Company's cistern	4.82	2.77	2.40
From well at Dr. Lilly's residence	17.15	10.50	6.60
From well in 1st ward, S. Main St	23.10	11.35	5.40
From John M. Matterson's well	42.50	22.50	15.50
From C. W. Kitchin's well, hotel	83.50	56.00	39.52
From well at new school-house	18.00	10.00	5.52

9. ARTESIAN AND DRIVEN WELLS.

At various places in the State a number of deep wells have been bored, with the hope of reaching water which would rise to the surface and flow over, forming true artesian wells. But very few have been successful to that degree; however, a number have been bored in which the water has risen nearly to the surface, and which have yielded a very satisfactory supply. So many such wells have been bored that public attention is strongly and favorably drawn to them.

The well of Messrs. E. Balbach & Son's smelting and refining establishment, in Newark,* is located near the Morris canal, and only a few feet above tide-level. It is 500 feet deep, of which about 100 feet were in sand and gravel, and the rest in red sandstone rock. It is tubed down to the rock, is 8 inches in diameter, and the water rises in it to a little above tide-level. The water is very clear, a little hard, and has a temperature of 55¼°. It yields 500 gallons a minute, and when pumped at that rate the water-surface in the well is lowered 6 or 8 feet. The ground around the well is dug away so as to allow the pump to be set within about 2 feet of the surface of the water.

The water is used for all purposes about the establishment, but is specially valued for its low temperature and its usefulness in cooling the heating furnaces.

The well of Messrs. P. Ballantine & Sons is at their brewery, on Freeman street, Newark, and not far from the well just mentioned, though the ground is perhaps 10 feet higher. It is an 8-inch bore, and is tubed through 90 feet of earth and 10 feet into the rock; the remaining 350 feet is without tube, being all in red sandstone. The water rises to within 24 feet of the surface. It has been tried for water, but is not yet in regular use. The quality of the water is good, being clear and cool. With the pump considerably above the surface of the water, it has yielded 200 gallons a minute, and is expected to

* The wells bored in Newark the past season have been put down by the North American Mining Company, H. M. Waddell, agent.

yield more than twice that when the pump is properly set near the surface of the water.

The well of the celluloid works in Newark is 250 feet deep, and yields a satisfactory quantity of water. This water was analyzed by Messrs. Ballantine, and found to contain in a gallon—

Chloride of sodium (common salt)	0.6 grains.
Sulphate of soda (Glauber salts)	11.7 "
Sulphate of lime (gypsum)	85.1 "
Sulphate of magnesia (Epsom salts)	18.7 "
Carbonate of magnesia	6.1 "
Silicic acid	2.0 "
Grains of solid matter	124.2

Messrs. Lister Brothers have recently bored a deep well at their works on the banks of the Passaic in Newark. It is 8 inches in diameter and 615 feet in depth. It was sunk 110 feet in earth and 505 feet in rock. The surface is but a few feet above tide, and the water rises to within 2 feet of the surface. It is in constant use, and is yielding at the rate of 800,000 gallons a day. The water is clear and cold, its temperature being 55½°. An analysis of the water shows it to contain 152.34 grains of solid matter to the gallon. The mineral matter in it is composed of the following substances:

ANALYSIS.

Sulphate of soda	15.94 grains
Sulphate of magnesia	25.87 "
Sulphate of lime	106.98 "
Carbonate of magnesia	1.55 "
Chloride of sodium (salt)	2.47 "
	152.81 "

A second analysis of the water from this well, after about six weeks' pumping, shows 145 grains of solid matter and 88.1 grains of sulphuric acid in a gallon, instead of 152.8 grains of solid matter and 89.1 grains of sulphuric acid in the first analysis. Sulphate of lime makes a hard scale in steam boilers, and the large amount of it in this water shows it to be unfit for use in steam boilers, or in any apparatus liable to be affected by an accumulation of scale or sediment. Such water is too hard for laundry purposes, and not to be recommended for drinking or household use. In these large manufacturing establishments it is, however, of great value on account of its being always clear and cold, so that it can be used for condensing or cooling hot substances, and for the ordinary washing and rinsing operations where neither heat nor soap is needed.

The amount of sulphate of lime in the water from all these deep-bored wells which are in the red sandstone is too much to make it desirable for steam boilers. The amount appears to be greatest in that from the deepest wells. Messrs. Balbach & Son report that the water from their well is not near so hard now as it was when they first began to pump it some months ago.

At Paterson, at the Passaic Rolling Mill Company's works, a very deep well has been bored. It is on the flat ground near the Erie railway, and south of the railroad station. This is an 8-inch well, and was bored 6 feet in earth, the rest in rock. Water was found in the rock within 20 or 30 feet of the surface, and it stands about 17 feet below the level of the ground. The well has been sunk 1400 feet, most of it in red sandstone. Some layers of red shale have been passed through, and at 1180 feet a layer of fine quicksand was met, which stopped the working of the drill and rose 8 or 10 feet in the bore. No trial to find how much water the well will supply has yet been made. The well is now tubed, and the work of sinking is continued.

The undertaking has been watched with much interest, for it was hoped that the thickness of the red sandstone formation would be ascertained. The proprietors have shown the heartiest interest in the work, hoping that, besides supplying themselves with a flowing well, they could solve a question of much importance to geology.

At *Hackensack* there are several bored wells now in operation. T. T. Crane, Esq., of that place, has courteously contributed the information in relation to them. He says there were put down some 5 to 7 years ago, wells for Wm. De Wolfe, Garret Ackerson, Jacob Hopper, Huyler & Rutan.

The well of Huyler & Rutan is located on their dock, about 75 feet from the water front, and is 105½ feet deep. It went through 10 to 12 feet of meadow mud; then through blue clay and thin seams of red clay to a depth of 104 feet. At the depth of 104 feet red shale 6 inches thick was struck. When the drill passed through this layer it dropped suddenly 6 inches, and then struck a second layer of shale 7 inches thick. After passing through the latter, water commenced to flow, and has flowed ever since, except when the tide in the Hackensack is out (low water) the flow ceases altogether. And when the tide is up it commences again. The river bed is 15 to 20 feet deep.

Mr. R. P. Terhune on the opposite side of the river, and some 650 feet or more from Huyler & Rutan's, has bored down 135 feet without getting a flow of water as yet.

An artesian well is being bored at the *Secaucus Iron Works*, and near the Hackensack river, in Hudson county. I. P. Pardee, Supt., has favored the Survey with the following account of the strata and the water: The surface of the ground is about five feet above tide.

From the surface down to red shale rock	18	feet.
Red shale	to 370	"
Shaly sandstone	to 395	"
Red, shaly sandstone	from 400 to 600	"
Total depth at date [February 7th, 1880]	600	"

The diameter of the bore is 6 inches. When the hole was down 210 feet they commenced to pump with a 4-inch pipe down 60 feet, and with a seed bag at lower end to keep out the surface water; pumped about fifteen gallons per minute of beautifully clear water, but decidedly brackish to taste.

When the bore had reached a depth of 304 feet they pumped with 4-inch pipe, with seed bag attached, and down 100 feet. The result was a large volume of water, but it was still brackish. On evaporation it gave 110.67 grains of solid matter per gallon, which tasted strongly of common salt. When at the depth of 600 feet they pumped with a regular oil-well pump, with the seed bag attached, and having a 4-inch pipe down 250 feet, attached to the end of which was the pump barrel 3⅝ inches in diameter, making a total length of pipe down, 257 feet. The result was only *one* gallon per minute. The 4-inch pipe and the pump barrel were then taken out and put down 200 feet. On pumping, got 20 gallons per minute of very clear water, which, when tested with nitrate of silver, gave a slight percipitate. The water, on evaporating, gave 12.37 grains of solid matter. The difference in the volume of water as 257 feet and 200 feet appears to show that about all the water (not salt), which they have obtained so far, comes in between 200 feet and 250 feet down.

They are now putting down the well 400 feet deeper, which will make a total depth of 1000 feet, when it is done.

By way of comparison, they had other waters there evaporated to dryness and weighed. The drinking-water from the well near the furnace contained 108.76 grains in a gallon; that from the Hackensack river had 307.45 grains to the gallon.

Bored Wells in Jersey City and Vicinity. By L. B. Ward, C. E., of Jersey City.

"Borings of considerable depth in search of water have been made within the past half century in various parts of Hudson county, and in locations differing widely as to topography and geological associations. A geological boundary which passes through Hoboken and Jersey City, and which is in its general bearing parallel with the Hudson river, has been closely touched by the borings made in the tract east of Bergen Hill, these having in every instance entered the underlying rocks. An example of rock-boring for water is also found upon the crown of the Bergen trap ridge.

"In the marshes west of the Hackensack river are a number of wells which have been bored through alluvium and boulder clay. Four of them, which were sunk in 1871, derive their supply from a sheet of water-bearing gravel, at a depth of nearly 200 feet, the water rising to the surface and flowing off in moderate quantity. The water, while it is palatable, has a noticeable taste, said to be of sulphur. The wells now mentioned are upon the line of the Newark plank road; an equal number of wells are to be found on the line of the old Newark turnpike; these are now disused and their origin and depth are unknown.

"Diligent inquiry has failed to find where any rock-borings have been made in that part of Hudson county south of Jersey city. The large works established upon the shores of Kill Von Kull depend for water either upon capacious shallow wells, or upon tubular [driven] wells. The need of suitable supply of water is felt here.

"Upon the smaller islands in the New York harbor, geologically related to Jersey City and Hoboken, no borings for water are known to have been made. On Staten Island a successful well was obtained a number of years since, at the silk mill in New Brighton, by boring to a depth of 400 feet in the underlying serpentine.

"*Notes of the Principal Rock Borings in Hudson County.*

"*Jersey City.*—At Mattheisen & Wiechers' sugar refinery on the south side of the Morris canal in Jersey City, a boring was begun in 1867, which was discontinued in 1872, at a total depth of 1000 feet, inclusive of 20 feet of surface earth, the diameter of which in the upper

180 feet of the rock was eight inches and in the lower 800 feet, four inches. The rocks penetrated were chiefly gneiss and quartz with white sandstone and thin bands of slate, occurring below 800 feet. Several veins of water were met with between 600 and 900 feet, of which the most important were at a depth of 720 feet. The yield was found to be 50 gallons per minute, when tested by pumping. The level in the well being 12 feet below tide, and the temperature of the water 52° Fah. The brackish quality of the water obtained has prevented its use and the well is closed.

"A boring of small diameter was made about 1842 by Mr. Andrew Clerke, in the marsh at the corner of Montgomery and Henderson streets, in Jersey City. Here the red sandstone was met with 15 feet below the surface, and was penetrated to a depth of 200 feet, when a stratum of very hard rock of whitish appearance was encountered, and the work abandoned. A liberal supply of clear, bright water, but strongly impregnated with magnesia and common salt, was found at the depth of 150 feet, which overflowed at the surface. The temperature was not noted.

"In the same marsh, and about 1000 feet northeast of the last, an unsuccessful boring was made a few years later, respecting which details have not been obtained.

"At Cox's brewery, on Grove street, between Seventh and Eighth streets, in Jersey City, the underlying sandstone is covered by about 70 feet of boulder clay and earth. A small boring of 100 feet in depth, was first made nearly thirty years ago, and was enlarged to 5 inches in diameter and carried down to a depth of 400 feet in 1872 and 1873. Small veins of water were met with in the rock at all depths. The water, though so hard as to form a heavy scale in a steam boiler, was of satisfactory quality for brewing purposes. Its temperature was 54° Fah. The well easily afforded 300 barrels of water per day, the water rising in the excavated well to the level of the tide, thence passing away through the earth to the street sewers. The boring intersected a number of seams in the sandstone, which contained fine earthy matter, and limited the capacity of the well to deliver clear water.

"At Limbech & Betz's brewery, on Ninth, between Grove and Henderson streets, in Jersey City, and 800 feet northeast of Cox's brewery, the sandstone is covered by 40 feet of boulder clay, with 30

feet of surface sand. A boring 8 inches in diameter was made here in 1875, penetrating the red sandstone rock 776½ feet to reach water, which was found at the bottom in a stratum of white or light-colored stone. At its completion, the well, when tested by pumping, yielded 33 gallons per minute continuously for 24 hours. The water * is sufficiently soft and sweet for brewing, but is ordinarily used only for cooling purposes, its temperature being 52½° Fah. The well affords 1000 barrels of water per day without difficulty, the level of the well being 10 feet below tide, or 25 feet below the surface of the ground.

"Borings made to rock at the Pavonia ferry, distant, viz., 2300 feet, 2850 feet, and 3300 feet nearly east from the last, came upon serpentine at 63 feet, 120 feet, and 179 feet below tide, respectively."

Hoboken and Union Hill.—In the marsh, and near the south end of Grand street, in Hoboken, a boring was made in 1828, which is mentioned in Mather's "Geology of New York" as 400 feet in depth, reaching rock at 40 feet, and has penetrated serpentine, sandstone, and supposed white marble. This boring probably did not come upon water, and the work was abandoned. Mr. Theodore Van Tassell recollects to have seen the boring apparatus remaining in position some years later.

"At the Palisade brewery, at the summit of the main ridge of Bergen Hill, and corner of Hudson avenue and Weehawken street, in the town of Union, a boring 7 inches in diameter was carried down in 1877 and 1878, through trap, to a depth of 297 feet from the surface, water being found in quantity, increasing with the progress of the work. The well is pumped from the bottom, and yields 250 barrels per day of very pure, soft water, of a temperature of 51° Fah. When not pumped it discharges a much smaller quantity, at a level of 161 feet above tide, into the bottom of an excavated well, 28 feet under ground and 12 feet below the surface of the rock."

At New Brunswick a number of wells were bored 20 or 30 years since; those on grounds not much above tide level were flowing wells,

**Analysis of Water of Well of Limbech & Betz.*

Soda	39.5	grains in	1 gallon.
Lime	6.95	"	"
Magnesia	9.36	"	"
Sulphuric acid	4.11	"	"
Chlorine	65.50	"	"
	125.42	"	"

while in those on higher ground the water does not rise to the surface. One bored in the old paper mill at Raritan landing, 303 feet deep, and on ground some 12 or 15 feet above tide, delivered 40,000 gallons a day, some 10 feet or more above the surface. It still continues to flow; the bore was not more than 4 inches in diameter. The water was clear and answered for paper-making, though it was very hard. Sulphate of lime was the chief mineral constituent. Two other flowing wells—one at the residence of Richard Johnson, Esq., the other in a field formerly belonging to Dr. H. Pool and near Mile Run—which were bored many years ago, are still to be seen. They were probably not so deep as the later wells, and the quantity of water they supply is not large.

The well bored by the late David Bishop, Esq., at his residence in New Brunswick, is 455 feet deep, all in red shale. It is on a hill 90 feet above tide and the water rises to within 10 feet of the surface. The water is clear but so charged with sulphate of lime as to be unfit for use. The quantity of water to be obtained from the well is inconsiderable.

Some other wells have been bored in the rock about New Brunswick for the supply of private dwellings. They are at depths of from 30 to 60 feet, and for the moderate quantity of water needed in a household have mostly been satisfactory. In some instances, however, they have failed to yield a supply.

Bored wells at Plainfield, Middlesex county.—Mr. Wm. S. Stillman informs me that there are several wells at that place. One "on the premises of Mr. Finch on Park avenue, about half a mile from the depot. It is on the flat or level ground of the city, and has a total depth of 102 feet, of which 60 feet was in earth and 42 feet in rock. The size of the bore is 2¼ inches. The supply of water is ample, and it rises to within 7 feet of the surface. The water is soft.

"Another well is on the premises of J. B. Brown, on Park avenue about three blocks from the depot. It is on the flat ground of the city. It is 107 feet deep, of which 60 feet were in earth and 47 feet in rock. The bore is 1¼ inches. The supply is all that is needed and the water very soft. It rises in the tube to within 14 or 15 feet of the surface. Mr. Brown says he struck the best vein of water at the depth of 65 feet.

At Perth Amboy a well was bored for the Easton and Amboy Rail-

road Company. It was sunk through successive beds of sand and clay of the Cretaceous formation to the depth of 130 feet, but no water was obtained. An account of the strata passed through is given in the Geological Report on Clays, p. 183.

The following clear and interesting account of the well at the terminus of the Easton and Amboy railroad at Perth Amboy, was furnished, at my request, by Alfred Hall, Esq., of that city. In his letter of December 11th, he says: "No supply of water was obtained from the bored well made by the railroad company; that is, from the bored part of it. I watched the progress of the well with much interest as far as it was excavated by digging, which I think was about 30 feet, to where the boring commenced. The well was about 20 feet in diameter, and the earth excavated was composed of a mixture of sand, loam, clay and gravel for a depth of about 17 feet; it was sufficiently compact to stand without support. At this depth water was struck, and a stratum of coarse gravel 3 to 4 feet thick, through which the water flowed abundantly. The gravel was rounded quartz pebbles, like that from Bonhamtown; below this gravel was fine sand, inclining to run like quicksand. At great expense a row of piles was driven close against each other, and tightened up so that they could excavate for a reservoir for the water. They succeeded in deepening the excavation about 7 feet, making the whole depth of the well 30 feet. Inside of the piles a stone wall was built and continued up about 10 feet above the surface of the ground, on top of which was placed a large tank. From the large flow of water through the gravel I supposed there would be a continuous and abundant supply, but in about one year the water gave out entirely. I was told this week, by the man in charge, that there was not one foot of water in the well.

"We use a large quantity of water at our terra-cotta factory—from 400 to 500 barrels daily. Our supply has been taken, principally, from a well sunk but little below low tide. This season we have used more than usual, which, with the long-continued dry weather, made our supply hardly sufficient, and we drove two 1¼-inch pipes from the bottom of the well 15 feet down, a large portion of the distance through a very fine quicksand. These pipes were connected with each other, and also connected with a 2-inch suction pipe attached to the pump. At the ordinary speed of our engine, about 1000 barrels of water in a day of 24 hours can be raised. Just below low tide there

appears to be a thick bed of quicksand. Water is found above and below this, but the water below is much purer than that above, being clear as crystal. It is hard water.

"The same experience was had at the metallurgical works, and the same two strata of water found at the same depth relative to tide-water. The water was tested and found to contain some alum and soda, very little iron, and no lime. The engineers say it makes no scale or deposit on the boiler; that the flues are bright and clean, and there is no sign of corrosion or injury to it. There is some difference in the water at different locations; from a pipe driven about 200 feet inland, the quicksand was struck on a higher level, and the water is softer, and a good water to drink, showing that it is affected by a difference in the strata through which it is filtered. This water question I consider an important one. I have long been of the opinion that we have an abundant supply of water for our city right under us."

At the State Reform School, Jamesburg, Middlesex county, a well 8 inches in diameter has been sunk to a depth of 285 feet. The tube was stopped by cemented earth at this depth, but the boring tool has been sunk some 15 or 20 feet further. The boring has passed through the successive layers of the clay formation, and a moderate supply of wholesome chalybeate water has been obtained; but the water being unfit for laundry purposes, on account of the iron in it, the boring is still in progress, in the hope of meeting solid rock, and perhaps soft, clear water.

The experience with water at Jamesburg is interesting. The former supply was from wells, and from springs which came out on the slope 15 or 20 feet below the level of the high ground on which the school is located. The spring water is evidently the drainage from the gravel and sandy loam which forms the top layer of the high ground, and of course the water, though soft and clear, must be polluted by the surface soil drainage, and this probably made still worse by the defective sewerage from the buildings. The school has about 270 boys, and the teachers and other attendants make the whole number of persons there over 300. In August, 1878, there was an outbreak of typhoid fever of a mild form; before it ended, more than seventy boys were attacked, and two died. The use of water from these wells and springs was discontinued, and this, with perhaps other sanitary regulations, soon checked the advance of the disease, and no new cases

occurred. This summer a case or two, like those of last season, occurred, but the use of the chalybeate water from the bored well put an end, at once, to the disease.

The section cut by this well is furnished by Mr. Eastman, superintendent of the school.

THICKNESS OF EACH STRATUM.		DESCRIPTION OF MATERIAL.	DEPTH FROM SURFACE.	
Feet.	Inches.		Feet.	Inches.
9	.....	Yellow sand..	9	.....
4	.....	Yellow sand and gravel (from 12 to 13 feet, water)	13	.....
30	.....	Black clay, containing very little sand—moist	43	.....
8	6	Dark sand, somewhat colored with green, containing a little clay. Rather dry. (From 46 to 47 feet, some whitish clay, rocks, lumps, and thin layers.)	51	6
	6	Sand rock	52	.....
12	.....	Dark and greenish sand, containing a little clay, and of a marl nature. Rather dry and crumbly	64	.....
1	6	Black clay	65	6
4	6	Dark and greenish sand, containing some clay, rock and thin sand crusts. Rather dry	70	.....
	6	Sandstone	70	6
5	.....	Black clay	75	6
4	6	Black clay, with some sand and a little stone in it	80	.....
12	6	Black clay containing very thin layers of white sand	92	6
1	.....	Hard, dry, whitish clay	93	6
15	.....	Black clay, with thin layers of white sand	108	6
1	6	Stiff, dark sand	110	.....
23	6	Fine beach sand, water-bearing, somewhat muddy, and partly of a quicksand nature, containing more or less wood, some floating sandstone, and clay lumps	133	6
1	.....	Black clay	134	6
12	6	Fine sand, water-bearing, containing wood, stone and mud, same as above	147	.....
3	6	Black clay, with thin layers of white sand	150	6
13	6	Fine sand, water-bearing, containing some mud, wood and stone	164	.....
14	6	Brown clay, very compact and solid, some wood, and its general appearance is of a vegetable nature	178	6
4	6	Brown clay, containing considerable sand and more wood. Rather dry. (At 173 feet 9 inches, and at 178 feet 6 inches, lumps of iron pyrites.)	183	.....
8	6	Fine sand, water-bearing, containing some mud, wood and floating sandstone	191	6
	6	Dark clay	192	
10	9	Coarser sand—a more free water stratum—a few floating clay lumps, iron pyrites, wood and blue clay	202	9
	3	Bluish clay (on top of it a thin sandstone crust and wood)	203	.....
1		Sharp sand; water	204	.....

THICKNESS OF EACH STRATUM.		DESCRIPTION OF MATERIAL.	DEPTH FROM SURFACE.	
Feet.	Inches.		Feet.	Inches.
	9	Fine, bluish clay	204	9
12	3	Sharp, clean sand, water-bearing	217	.....
	3	Wood, worm-eaten	217	3
1	.....	Coarse sand and fine gravel, well mixed, and with lumps of white clay	217	3
5	9	Sharp sand, with lumps of bluish clay. (At 223 feet 6 inches, crusts of iron pyrites.)	224	.....
7	.....	Fine beach sand	231	.....
2	3	Sharp sand, coarser	233	3
	3	Whitish clay	233	6
2	6	Sharp sand, with scattering whitish clay lumps	236	.....
1	.....	Coarse sand and fine gravel, well mixed with white clay lumps	237	.....
1	.....	Fine, lively sand	238	.....
1	9	Coarse sand and fine gravel, well mixed with white clay lumps	239	9
	3	Whitish clay	240	.....
	9	Sharp sand	240	9
	3	Whitish clay layer	241	.....
10	.....	Fine beach sand	251	.....
5	.....	Coarse sand	256	.....
		(The above 15 feet of sand clean and free from other substances.)		
2	6	Auger below pipe, and struck a sandstone crust	.....	.....

At Columbus, Burlington county, on the Rancocas stock farm of P Lorillard, Esq., a deep well has been bored. The following account of it has been furnished for this report by Mr. Willard Blasdell, of Philadelphia, who bored this and the Jamesburg wells:

THICKNESS OF EACH STRATUM.		DESCRIPTION OF MATERIAL.	DEPTHS FROM SURFACE.	
Feet.	Inches.		Feet.	Inches.
14	.....	Yellowish loam and sands	14	.....
34	6	Fine sand, somewhat mixed and colored with dark mud, water bearing	48	6
23	6	Stiff, black, sandy clay	72	.....
1	.....	Fine sand, muddy and water-bearing	73	.....
9	.....	Stiff, black, sandy clay	82	.....
34	.....	Fine sand, water-bearing, containing scattering layers of sandstone on clay or shell rock, from 3 to 5 inches thick, some of it quite porous and well bored with worms	116	.....
1	.....	Black, sandy clay	117	.....
7	.....	Fine sand, water-bearing	124	.....
1	.....	Black, sandy clay	125	.....
3	6	Fine sand, water-bearing	128	6
49	6	Dark, sandy clay, containing scattering layers of sandstone and shell rock, 3 to 5 inches thick	178	.....
128	.....	Dark, sandy clay, changeable to more sandy, with scattering layers of sandstone, shell rock, shells and wood	306	.....
8	.....	Fine sand, some gravel, sand crusts and floating brown clay lumps; water	314	.....
24	.....	Red and white variegated clay	338	.....
18	5	Sand and sand rock alternately, from five inches to two feet thick, with some thin clay veins and considerable wood	356	5

Shoved the pipe 338 feet 5 inches; bored with auger 18 feet below the pipe; a fair supply of good water was obtained between the sand-rock layers, which rose to within 45 feet of the surface of the ground. At 302 feet a perfect fish tooth was found.

Mr. D. E. Howatt, farm manager at the stock farm, writes that the water is tinctured with sulphur [sulphate of iron] to some extent. "The well is not running now, because the purpose for which it was bored is not yet completed. We tried it, however, with a very large 4-man pump, and could not reduce the height of water at all. From our 156-foot artesian well the flow is about 10 gallons per minute. This water is raised about 30 feet and is slightly tinctured with sulphur [sulphate of iron,] but is beautifully clear, very healthy (slightly laxative when first drank) and decidedly a great success. * * * There is a spring at Brown's Mills, about 6 miles from here, which is called fine for invalids, and to which they come from far and wide. Our water from the 156-foot well is very much like the Brown's Mill

water in taste, a little stronger if anything, and exactly like it to all outward appearance."

A well at the residence of Chas. S. Taylor, Esq., near Burlington, was sunk 200 feet, most of the distance in the dark clays of the lower part of the marl formation and the upper part of the clays. It ended in light-colored clay, but no good supply of water was met. The tube was 8 inches in diameter.

At the residence of Dr. Van Buren, at Shrewsbury, Monmouth county, a well was bored through several strata of the marl formation to the depth of 200 feet, but water was not found.

In the Great Swamp, Passaic township, Morris county, Dr. Van Wagenen, had a 2½-inch tube sunk at his farm-house near Myersville, to the depth of 64 feet. It is in clay with very little sand, and enters the red sandstone rock 8 feet. It is a flowing well, and yields a sufficient supply of water for his farm stock.

Hon. F. S. Lathrop, on his farm in the Great Swamp, near Madison, has sunk a 2½-inch pipe through strata of sand, clay sand, and fine sediment, to the depth of 165 feet. No water has been found and the rock has not yet been reached. The material appears to be too close for water to filter through it. The basin in which it is located is surrounded by a rocky rim, which in its lowest part is not 10 feet below the surface at the well, and there is no outlet for water below that level. If the material were sufficiently open for water to run through, it should rise in the tube up to very near the surface.

An artesian well was bored at Winslow for Hon. A. K. Hay, about twenty-five years ago, for water supply for steam engine at the Winslow Glass Works. The elevation of the surface is about 115 feet above mean tide. The well was bored 335 feet, 220 feet below the level of the sea. The following strata were passed through:

Surface earth	5 feet
Blue and black clay	15 "
Glass-sand, described as quicksand	95 "
Miocene clay, described as hard, black clay	35 "
Micaceous sand, described as quicksand	107 "
Brown clay, described as black, hard clay	43 "
A gum log, one foot in diameter, found here.	
Greensand marl and white shells, teeth, &c	20 "
Pure greensand—no fossils	15 "
	335

Water rose from the bottom of the greensand.

The geological relations of these beds are described on pp. 291 and 292 of the "Geology of New Jersey."

The analysis of the water of this well, as made for the report in 1868, is here given.

1000 parts of water gave:

Silica	.0140
Chlorine	.0002
Sulphuric acid	.0027
Carbonic acid	.0520
Peroxide of iron	.0030
Lime	.0202
Magnesia	.0079
Potash	.0100
Soda	.0554
Solid matter in 1000 parts of water	.1654

This well-water has much excess of carbonic acid, keeping in solution the alkaline earths as bicarbonates.

The well was bored 343 feet deep to get a supply of water which would not corrode a steam boiler. The experiment was entirely successful. Sufficient water was obtained, and the boiler has not corroded since.

The sediment deposited is a soft and sandy one, and without any tendency to incrust, and the water in the boiler finally becomes very strongly alkaline from the abundance of carbonates of potash and soda accumulated in it.

Well at Harrisville, Burlington county.—This was a well intended to supply pure water for the paper mill there. Mr. R. C. Harris says: "In 1866 I had an artesian well sunk at Harrisville, to obtain a supply of pure water, free from iron, from which ingredient we had a great deal of trouble, causing our wrought-iron boiler to rust out rapidly. The well was sunk to the depth of 306 feet, and lined with 6-inch tubing. Gravel, blue and gray clay were passed through, until a depth of 180 feet was reached; mud, sand, and what appeared to be decayed wood, were also encountered. Further on, a gravelly bed was found, and water suddenly spouted up, reaching the top of the tubing, 8 feet above the ground. Water continued to flow quite freely, and it seemed to be pure and free from iron. The party doing the work, thinking to do better, persuaded me to let him go on; and, after a great deal of labor, he reached the above depth of 306 feet. The result was, no water of any volume; and that which overflowed was impregnated with iron very strongly, which was the very thing I

wished to avoid. At this I concluded tc abandon the project, and declined to bore any further."

The occupation of the sand beaches on the Atlantic coast, from Sandy Hook to Cape May, as sites for summer hotels and residences, and the rapid increase in the population at Sea Bright, Ocean Grove, Ocean Beach, Beach Haven, Atlantic City, Cape May City, and other points on this coast line, brings up the question of water supplies; and several inquiries have been received, both as to quality and available sources of supply.

Jas. A. Bradley, at Asbury Park, writes: "The greater part of the water used here is obtained by driven wells. They are from 20 to 40 feet deep, and give a bountiful supply of water, and, in almost every instance, the water is most excellent. There are a few open wells, but the driven ones have the preference. No attempt has as yet been made to experiment with artesian wells, but the matter is talked of. Wells have been driven 76 feet, and still in marl substances. In some instances water is not good, on account of marl deposit."

The following paragraphs concerning water supply on the beaches, were written for the report of 1875. It is reprinted, as it is still applicable to nearly all points on them:

Water sufficiently fresh for drinking is obtained on all the sand beaches along the sea shore of New Jersey, by digging holes two or three feet deep in the hollows between the hillocks.

Wells, as they call them, are made by sinking a barrel or hogshead, from which the heads have been taken out, into the sand to the depth of from two to six feet, and removing the sand from the inside of the cask. The water rises in the inside of the cask to within a foot or two of the top, and the well is complete. It needs no bucket or pump, and is usually without cover or curb, so that the water can be dipped out with a pail. Wells of this kind, situated so that water from the sloughs or from the sea could not readily soak into them, were considered to be good enough, when but few people lived on the beaches, but as population increases, and waste matter, refuse and filth, of every sort, accumulate upon the surface, the products of their decay will naturally be carried into the sand with the rain, and so find their way into the wells. The necessary consequence of drinking water poisoned in this way is soon seen in the increased sickness and mortality among those who use it, especially in summer and autumn. The first and easiest means of

supplying *pure* water, is to collect rain, from roofs, into cisterns, and it has been resorted to with most satisfactory results. The large hotels, and the better class of houses, are being provided with cisterns, and are able to store water enough for all purposes of domestic consumption; and wherever such water is used there is an entire exemption from the diseases which afflict those who use water contaminated with putrefying organic matter. Cisterns, however, are not provided for the poorer class of dwellings, or for fires or steam.

The question of water supply has been largely discussed at Atlantic City, and various projects have been entertained. An account of the artesian wells, and the quality of the water, is reprinted from the report of 1875:

As early as 1858 the late Manasseh McClees sunk a well 185 feet deep, at Cottage Retreat, near the light-house, and between Atlantic and Pacific avenues. The ground was about six feet above the high-water mark. The materials passed through were:

Beach sand	50 feet.
Blue clay, like marsh mud	5 "
Beach sand	30 "
Very tough blue clay and salt water	5 "
Sand, more or less coarse; water, salt	90 "
Clay, yellow and blue, in streaks; water, salt	5 "
Beach sand and salt water	

The boring was lined with an iron tube eight and a half inches in diameter. The whole cost of this well was $1000. In 1874 the Atlantic City Gas and Water Company sunk two artesian wells on middle of the beach, at the south end of the city, and in ground eight feet above high water. One of these, ninety feet deep, passed through:

Beach sand	60 feet.
Mud and sand	15 "
Beach gravel, and fresh water	15 "

The materials passed through in the second well were:

Beach sand	56 feet.
Beach mud and sand	5 "
Beach sand, gravel and fresh water	57 "
Total depth	118 "

These wells were tubed with 12-inch pipe, and the water rose in them to within 10 feet of the surface. A steam pump was applied and water drawn steadily for 24 hours without lowering it more than three feet in the tube. A gallon of the artesian well-water left, on

evaporation, 24.20 grains of solid matter. This was mostly in the form of mineral carbonates. No nitrates or ammonia were found in it. The water was clear and without smell when examined, though persons present when the pumping was going on, say that it then had a disagreeable smell, which was perceptible at a distance of 60 feet. Water from the well of J. Adams, which is one of the best surface wells in the city, on being analyzed, was found to contain 15.74 grains of solid matter in a gallon. It contained less of carbonates and more of sulphates, and a trace of nitric acid. The water was slightly yellow, and the solid matter when burned, gave off a strong but not unpleasant odor.

The rain-water was, of course, unexceptionable.

The water from the surface wells there is contaminated with organic matter, and it is unsafe to use it. That from the artesian wells is palatable and contains no poisonous organic matter. I think there would be risk in depending upon it for a full supply; for it is apparent from the three borings that the material of the beach is the same from the surface to the bottom of the tubes, and if the wells are drawn hard the water from the sea is likely to be drawn in and spoil them, as it evidently did in the McClees well.

The safe and economical plan is to provide rain-water for domestic purposes, and to construct large surface wells for supplying water for fires, and other purposes not requiring pure water.

An abundant supply of pure and excellent water can be had from Absecon creek, which is a considerable stream on the mainland opposite Atlantic City. The expense of bringing this water across the marsh would be heavy, and may delay the execution of the work, though it will finally be done.

Bored Wells at Cape May City.—R. B. Swain, C. E., of Cape May City, furnishes the following account of the "Water Supply and Artesian Wells" there. He says: "Our supply is from wells of three kinds, viz., surface wells, tube or driven wells, and artesian wells. Before our town became closely built up we had an ample supply from what were quite uniformly good surface wells of depths varying from 5 to 12 feet. As building increased it was found that surface wells became contaminated with the contents of sinks and cesspools, when recourse was had to artesian and driven wells as the means of reaching the two lower strata of water.

"There have been seven 8-inch artesian wells made, at depths varying from 87 to 92 feet, according to the elevation of the land at the point where the well may be made, within a period of about 24 years; developing a stratum bearing fine fresh water, yielding about 75 gallons per minute. Two of said wells, however, were spoiled by the ignorance, carelessness or cupidity of the party who had the contract for making them, by driving them too far, or below the water-bearing stratum.

"The drive wells are 1¼-inch tubes driven from 25 to 30 feet, as may be required from the variable surface of the ground. They will yield from 7 to 10 gallons per minute.

"Water, in all deep wells, will rise to the point at which water will stand in an open or surface well.

"If a tube is driven to either the 2d or 3d stratum and opened, in a surface well, at any point below the point at which water will naturally stand, the water will continuously flow into the surface well, with a force in proportion to the distance at which the opening in the tube may be made below the surface of the water in the open well.

"This town is supplied from one artesian well of 8-inch diameter, settled 84 feet to contact with a cedar log 3 feet in diameter. The 8-inch pipe coming in direct contact with the log, it was necessary to drill inside of the pipe, which curtailed the hole through the log to 6 inches, making the well 87 feet deep. Also from one surface well 20 feet diameter and 19 4/12 feet deep, with three sub-wells in the bottom of it, each 3 feet diameter and 6 feet deep. From which sources of supply are distributed, during the summer, about 120,000 gallons daily.

"That you may more thoroughly understand the geological formation, I send you, per express, my specimens, or what is left of them taken from the *first* well made at the Columbia House (excepting the two bottles marked 2d well.) Also a specimen from the drilling of the log under the well at the city water works. Use whatever portion of specimens may suit you. You will find specimens from the surface to 224 feet depth. The exploration to this depth is due to the man employed to sink the well. I had the work suspended at the proper point, and a better well I never saw; but in my absence he drove it through the stratum, expecting to meet other strata; and, as

it could not be remedied, the owner of the property concluded to make an experiment of it to the depth indicated, where he struck salt water."

At the State Prison, in Trenton, a large well was dug last year, 12 feet 8 inches in diameter, and 52 feet deep, down to the solid gneiss rock. Water was first met with in the gravel, 21 feet down, in large quantity, but somewhat hard. The quantity did not increase much until the rock was reached, and then the water was quite soft. The water from the gravel contained about 50 grains of solid matter to the gallon, most of which was sulphate of lime and magnesia, and only a trace of chlorine, and no organic matter. The water from the rock contained less than two grains of solid matter, mostly carbonate of lime, to the gallon, and a very little carbonate of iron.

Several holes of 2 and 3 inches in diameter, and from 4 to 7 feet deep, were bored in the rock at the bottom of the well, and much of the rock water comes from these holes.

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

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

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

One foot in depth of water in the well is 943 gallons. Now if we take the time of filling this to be 20 minutes, which is the time required when about half the water is out, the well will supply 68,000 gallons in 24 hours, or if it is pumped down till the water is only 2½ feet deep, and kept at that, it will supply 135,000 gallons a day.

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

It is of some importance to notice that while the water in the red sandstone rocks is very hard, and that in the clay district is liable to be impregnated with iron, the water in the gneiss rock is pure and soft. A new well was sunk near Calvary Cemetery, in Brooklyn, this fall. It is about 80 feet above tide, was sunk 60 feet in boulder earth, 160 feet in clay and sand, and 386 feet in gneiss rock. The water is very soft, and with only a very little lime, magnesia, and chlorine in it. It yields about 70 gallons a minute.

The following account of four wells bored for Geo. G. Green, in and near Woodbury, has been furnished by I. C. Voorhies, of that city:

"No. 1. G. G. Green, who owns the steam flouring mill, and also a large sash, blind and planing-mill adjoining, has an artesian well 80 feet deep, cased in with wooden casing 12 inches in diameter. It is situated about 300 feet from Woodbury creek, on Main street. It supplies plenty of water for two stationary engines. The water is soft and good. The first 10 feet was yellow clay; next, 65 feet of green or bluish-colored clay, *oily*, and very tough. No water can penetrate it. The balance was gravel.

"Well No. 2 is bored at G. G. Green's handsome residence in this place. It is 163 feet deep; cased with 4½-inch iron pipe. The first 14 feet was yellow clay and sand; then came 90 feet of blue and greenish-colored clay, or marl; after that there were 59 feet of sand, or fine white gravel. The coarse sand, or gravel, has no clay or loam in it, and looks like sea-shore sand, but coarser; occasionally, a little lot of small pebbles, size of peas to ordinary marbles. Plenty of water was found after getting through the marl; also water in all distances through the sand, but it seems only to be saturation. There are no runs of water, and the supply can be exhausted by two days' pumping.

"Well No. 3 is situated about 600 feet from No. 2, and has wind-power attached to it, and belongs to the same property. It is 132

feet deep, cased with 4½-inch galvanized-iron pipe. The first 14 feet was yellow clay; then came 75 feet of blue or greenish-colored clay, or marl; balance sand, or fine white gravel. At bottom, struck a stratum of fine white clay, very hard, with iron crust at bottom of clay, and had to drill through this, when they struck the same kind of sand again. This will supply about 3000 gallons of water per day. Have some trouble with sand coming up the pipe.

"No. 4 well is situated about two miles south of Woodbury, on the farm of Mr. Green. The first 15 feet was clay; 105 feet of marl. They have never pumped this well, on account of the pump being out of order."

Mr. I. C. Voorhies, of Woodbury, furnished the following statement of wells bored by Caleb Risley, of Woodbury. They are located: two in Woodbury; one a mile north of Woodbury; one at Mount Ephraim, in Camden county; and one at West Creek, Cape May county:

"Messrs. Allen & Madane had a well bored, some four years ago, for the purpose of supplying their engine with water. They found a supply for all their purposes, at the depth of 113 feet. The first 10 feet was sand and clay; then 40 feet of blue mud, or marl; 50 feet of bar sand; the balance was sand and gravel mixed. The last foot had to be drilled. Mr. Caleb Risley, who bored this well, informs me that, after they got down 50 feet, they found plenty of sea-shells in the next 50 feet. It has 2½-inch pipe. Water comes to within 19 feet of the top.

"Lewis M. Green has had a well bored at his new and handsome residence, situated on Main street. This well has been used very extensively. It has furnished all the water necessary for building purposes, and it will be used in the new house when done. There is some talk of attaching an engine to it. It is 142 feet deep. The first 12 feet was yellow clay; then 108 feet of blue marl, mixed with green; 14 feet of sand and gravel; 4 feet of loose sand, and the balance, 4 feet, was hard clay and sand, mixed with shells—very hard, and had to be drilled. In this well, at the depth of 130 to 135 feet, they bored through two logs. It will furnish 500 gallons of water per hour. The supply is supposed to be inexhaustible, and water is within 50 feet of the top.

"Mrs. Deborah Cooper, who lives about one mile north of Wood-

bury, on the Red Bank road, about one year ago had a well bored, which, I am informed, gives entire satisfaction. It is 68 feet deep, The first 10 feet was sand and clay; 50 feet of blue mud, or marl; 8 feet of gravel and sand. The well furnishes plenty of water for use of home and stock on the farm. It has been pumped to 500 gallons per hour, and is supposed to be inexhaustible. Water comes to within 10 feet of the ground. It has a 4-inch pipe in it.

"There has just been a well bored near Mount Ephraim for Joseph Warrington. It is in Camden county. They are now down 130 feet. The first 10 feet was clay; then 100 feet of marl, or blue mud; 20 feet of clay, gravel and sand mixed. In this well were found sharks' teeth, at the depth of 116 to 129 feet, and magnolia roots were found at the depth of 130 feet.

"There is another well, three-quarters of a mile from the above, that is 80 feet deep, and furnishes plenty of good water for farm purposes.

"Messrs. Kirby & Smith, of Woodbury, have a well bored at West Creek, in Cape May county, to supply their engine and works there. This well is situated within 300 feet of Delaware bay shore, on the marsh. The first 18 feet was salt mud; 3 feet of blue clay; 3 feet of yellow clay; 3 feet of pink clay; 45 feet of quicksand; 14 feet of coarse gravel; 27 feet was sand and clay in layers of about 6 feet apart. Water is good and inexhaustible. This well flows nearly to the top, and, with a little ditching, could be made a flowing well. The pipe is 3-inch."

Some interesting trials with driven wells have been made in Newark and vicinity during the past year.

At the works of the Newark Aqueduct Company, in Belleville, trials as to the supply which can be obtained from such wells are now in progress. At our request, J. B. Ward, Esq., Secretary of the company, has furnished the following account of them:

"There are 20 wells, 3 inches in diameter and 28 feet apart. The wells were driven in a straight line across the valley towards the west. The first four wells were driven to a depth of 48 feet below the top of the coping of the filtering basins; the rest were driven to a depth of 42 feet.

"At the top of each well is a right-angled bend, then a pipe, 3 feet in length, connecting the well with the large pipe to which the pump

is attached. This large pipe is 24 inches in diameter at the pump, and gradually decreases to 6 inches in diameter at the end of the line of wells.

"The pumping began on the 8th of September, when the water-surface in the ground was 6 feet 8 inches below the top of the coping. The water in the river is 5 feet 3¾ inches at high tide, and 9 feet ¾ of an inch at low tide.

"The water-surface along the line of wells sank in the centre of the line to a depth of 13 feet 6 inches on the 9th of October; quantity of water pumped per day, 2,750,000 gallons. The water then rose in the ground, and on the 13th it stood 12 feet 11 inches; quantity pumped per day, 2,580,000 gallons.

"The quantity of water pumped has varied from 2,300,000 to 2,800,000 gallons per day. The pump was stopped from the third to the eleventh of November, when the water rose to 8 feet below the coping. Enclosed is a diagram showing the position of the test wells, and also a table showing the daily variation of water in these wells.

TABLE.

	TIME.	HIGH TIDE.	LOW TIDE.
River	5 P. M.	5′ 2½″	.....
	11 P. M.	....	8′ 8½″
Well No. 1	8 A. M.	13′ 3½″	.....
	2 P. M.	.....	13′ 7″
Well No. 2	8 A. M.	13′	.....
	4 P. M.	.....	13′ 2¾″
Well No. 3	8 A. M.	10′ 1½″	.....
	2 P. M.	.....	10′ 5¼″
Well No. 4	7 A. M.	8′ 11¾″	.....
	1 P. M.	.....	9′ 9¾″
Well No. 5	8 A. M.	9′ 9½″	.....
	3 P. M	.....	9′ 11½″

WM. A. THOMPSON,
Engineer in charge."

From these results it appears that the water in the wells rises and falls with the tide.

The observations show that when the pumping began, the surface of the water in the wells was nearly a foot above mean tide in the river, and that when the pump was stopped, after working a month, the level of the water in the wells was nearly 4 feet below low water mark. The pumping was resumed after stopping a few days,

and has been continued ever since, without very much further lowering of the water surface in the wells. The water must filter through from the river. The pump takes all that the wells now driven will yield. It will be interesting to see if the number of wells can be increased, and water caused to filter through from the river fast enough to supply all that is needed. There is a great deal of interest expressed in regard to these trials; the quantity of water supplied being large, the quality of it satisfactory, and the cost of it not too great.

Twenty-five driven wells were put down near the Newark bay shore, and at the end of Waverly avenue, Jersey City, in 1877, by Matthieson & Wiechers, to obtain a supply of water for their sugar refinery. The ground is 10 to 20 feet above tide level. The strata encountered in them were, in general, the following:

1. Yellow dune sand	1½– 8	feet.
2. Sand and gravel (water bearing)	4– 6	"
3. Bluish sandy clay	1	"
4. Sand and gravel, becoming quicksand at the bottom	15–16	"
5. Reddish, sandy clay, including some gravel, and very sandy at the bottom	15–18	"
6. Trap-rock at bottom.		

The wells were 3-inch bore, and were all connected with one main. When first put down, 324,000 gallons of water were pumped from them daily. The quantity was insufficient, and the quality of the water soon deteriorated, and the wells were abandoned.

North of these wells, and near Marion, several wells were driven. They went through 55 to 68 feet of earthy beds, and to the trap-rock.

At Gautier's steel works in Lafayette, Jersey City, and near the foot of the Bergen hill, the trap-rock was struck at a depth of 90 feet beneath the surface.

Another well, in Jersey avenue and near the Morris canal, and also near the hill, went through 40 feet of mud, then a beach sand 15 feet, and then quicksand 43 feet, and at bottom, lying on the trap-rock, a red sand and clay, 2 feet—in all, 100 feet.

The water in these wells in Jersey City was salt and hard.

10. LABORATORY AND OTHER MISCELLANEOUS WORK.

The work in the laboratory has been kept going constantly. The largest amount of work done has been in the analysis of soils, but besides these, there have been many iron ores analyzed, and some specimens of black lead; numerous samples of water have been tested; some marls, peats and limestones have also been analyzed. The results are given in this report.

So numerous have been the applications for information in regard to ores, mining properties, fertilizers, soils, &c., that we have been obliged to decline analyzing specimens sent by parties who did not own the land from which they were sent; also such as were sent without labels describing the locality, owner of property, &c. There is frequent disappointment expressed that we do not report favorably on specimens brought to us, but there can be no doubt that such advice given saves many men from engaging in enterprises which must have ended in ruinous losses. Information given in this way has in some instances been acknowledged as saving from very heavy expenses.

IRON ORES.

A small number of iron ores have been sent to the laboratory for examination. The recent revival in the ore-mining district, among the old mines and in the business of searching for new ore localities, is noticeable in the increasing number of ores which are now received. The very general demand for ores for making ordinary iron, does not put so much stress upon the presence of phosphorus as upon the percentage of metallic iron. The recent improvement in the methods of roasting ores and the elimination of phosphorus by the new Thomas-Gilchrist process, as also the washing of phosphoric irons for the open hearth and puddling processes, indicate the practicability of working many of our ores which have, until lately, been regarded as worthless. The presence of titanium remains to trouble the iron-

master, although careful examinations show that this element is rarely absent. And future analyses must determine it. Heretofore its determination has been frequently omitted. The analyses of ores which have been made will be found under their respective localities, as described on pages 41–93.

The determination of the titanium has not been generally made until this year. If suspected, it was looked for; otherwise, the examination was omitted. The very general presence of this element in our clays and in some of our gneissic rocks has led to the belief that it is rarely absent from our iron ores. And nearly all of our later analyses indicate its presence. It will be interesting to pursue the inquiry how largely it enters into the composition of some of our best ores. It is not believed that it is particularly injurious when present in a small percentage. It is well known that it makes ores more difficult to work, requiring more fuel and consequently rendering their reduction more expensive.*

NICKEL, COBALT, &C.

The laboratory receives from time to time specimens of pyrite, said to contain gold, silver, nickel, cobalt, &c. Many such specimens have been examined in previous years, and some of them have been mentioned in the reports. Thus far none of them have been found to contain any metals in workable quantity.

1. *Pyrite from lands of Wm. Witty, at Brasscastle, Warren County. Sent to the laboratory by C. F. Staats, of Washington.*—It was examined, and found to contain 0.4 per cent. of nickel and traces of cobalt.

2. *Pyrite from Califon, Hunterdon County. Sent by Theodore Lance, of High Bridge.*—Nickel in it was 0.3 per cent.

* In Norway the ores of Krageröe and Eger, containing 15.00 and 7.10 per cent., respectively, are worked. If ores do not contain more than 8 per cent. of titanium, their reduction is not difficult and the product is of good quality. They are best worked with non-titaniferous ores, and fluxed with quartz and limestone. An examination of the analyses in this report shows titanium present, from traces to nearly five per cent. These all are used successfully, and are said to make good iron.

BLACK-LEAD, PLUMBAGO, GRAPHITE.

This mineral is found disseminated in the Azoic rocks in many places in New Jersey. It finds a large and increasing use, in making crucibles, in stove-polish, and in lubricating machinery, and this has led to an increased inquiry for cheaper and more abundant supplies of it. Heretofore the chief part of that used has come from Ceylon, though a considerable quantity has been sent into market from Ticonderoga, N. Y., from Stouerbridge, Mass., and from Pennsylvania. Extensive mines have been found and worked to some extent near Ottawa, Canada.

The mineral occurs sometimes in veins, when large masses of it are obtained almost free from rock. The Ceylon mineral, that from Ticonderoga, and part of that from Canada are of this kind. The most common form of its occurrence, however, is in flakes, scales and grains, disseminated through the rock, of which it may form a very small part. The latter is the only form in which it has been found in this State. In the "Geology of New Jersey," it was mentioned as being found in the following places: In a vertical vein or bed of 4 or 5 feet thick in gneiss rock, on land of Elias Englemann, a mile and a half northeast of Peapack, Somerset county. Some of it had been mined out, but not successfully separated from the rock. On the farm of H. C. Saunders, a mile east of Mendham, Morris county. This vein has not been opened, but could be traced upon the surface for several hundred feet. Several shafts were sunk in searching for a vein of this mineral, on the farm of Mr. Betts, west of Morristown, where it appeared in the earth on the surface. There was not enough found, however, to warrant further work. At Bloomingdale, Passaic county, a bed of rock richly charged with this mineral was found, and extensive works were built to separate it and prepare it for market. The enterprise was soon abandoned. In the long cut on the Central Railroad of New Jersey, southeast of High Bridge, in Hunterdon county, some of the rock shows a large percentage of black lead, but it has not been worked.

The localities have been examined during the last year, and samples have been selected and analyzed, as follows:

1. *Bloomingdale.*—This mine was lately visited, and specimens were obtained for analysis. The property is now owned by Samuel Wild's

sons, of New York city. No work has been done in 12 or 15 years. The mine is about a mile south of the village, in Morris county. There are three openings on a northeast and southwest line, on the strike of the gneiss rock. The main one is said to be about 60 feet deep. It is now full of water. The rock, which crops out on the surface on both the northwest and the southeast of the opening, is a micaceous gneiss. From an examination of the material thrown out of this opening and lying about it, the graphite appears as a constituent mineral of the gneiss and of the coarse crystalline rock which is associated with it. The next opening towards the northeast is 80 yards distant. It is a shallow cut across the strata. The gneiss there dips 50° south 80° east. The northeast opening is about 50 yards from the latter, and is 18 to 20 feet deep. The rock dips 70° towards the south-southeast. It is here also a micaceous gneiss, which is traversed by a coarse crystalline, feldspathic rock, and the graphite is found in them both. A brown mica, in large plates, and pyrite occur in scattered bunches in the vein mass at all of the openings. The sample selected for examination represents the heaps at the mine. These appear to have been sorted for working. Analysis shows the sample to contain 11.2 per cent. of graphite.

The works are about 300 yards southeast of the mine, and on the west side of a small stream, which furnishes water-power. They contain the necessary stamps for crushing the ore, and other machinery for separating the plumbago from the rock; and with very little work they could be put in running order. The stream affords 130 feet head of running water, but the volume is insufficient for steady work; and the flume is out of repair. The present location is not as good as could be had on the Pequannock river, less than a mile from the mine; and the changes needed in the introduction of new methods of working could be as economically made at another location as in the present mill.

2. *Englemann Mine, Peapack.*—There have been no attempts to work this mine since it was first opened, which was about thirty years ago. The *vein*, as traced by the outcrop, is a long one, and is from 4 to 5 feet wide. It occurs in the gneissic rock. Two samples, collected several years ago, have been examined. They contain 13.04 and 14.95 per cent. respectively. The latter was above an average. This locality could be worked easily, as it has facilities for good drainage, and it is only four miles from railroad transportation, at Chester.

3. *George B. Sutton's Farm, Fairmount, Morris County.*—Graphite crops out in the fields and in the road about a quarter of a mile west of Fairmount, and in a belt which strikes northeast from the Califon road to the German Valley road. Lewis Barnes, of Philadelphia, holds a lease on the property for one year. Two trial pits, about 5 feet deep, have been dug on the side of the road. South of it, and a few rods away, there is a shaft 28 feet deep. The belt containing the graphite appears, from the outcrop, to be several yards wide. The lead occurs as one of the mineral components of the granitic rock. An average of the material got out of the shaft was tested, and found to contain 6.87 per cent. of graphite. The locality is 4 miles from the High Bridge railroad.

4. *Conover Farm, High Bridge, Hunterdon County.*—This locality is in Hunterdon county, and about half a mile south of High Bridge. It is on the farm of Charles Conover, and at the side of the road to Clinton. There are three openings, of which the deepest is not more than 20 feet down. The vein is narrow, and dips steeply towards the east-southeast, between walls of feldspathic gneiss.

5. *Peter A. Beavers' Farm, High Bridge, Hunterdon County.*—Graphite crops out in the road near the railroad, less than one-fourth mile west of the High Bridge station, and on the adjoining lands of Peter A. Beavers. The width of the outcrop in the road, as indicated by the color of the surface, is 20 feet. Two trial pits were dug last summer, in the field south of the road, by Theodore Hoffman, of Clinton, but they are not deep enough to test the ground fairly. A selected sample from the Beavers openings was found to contain 27.82 per cent. Another, taken as an average, had 10.09 per cent. The property has been leased by the Reading Graphite Company.

A quarter of a mile southerly from these openings, and on the eastern side of a small crook, the surface earth has in it many lumps of graphitic rock, which are as rich in black lead as the material dug by Mr. Hoffman. There is here an area of several square rods thus covered by graphite.

6. *Hackett Farm, Hunterdon County.*—The Hackett farm adjoins the Central railroad, between High Bridge and Annandale. Black lead has been discovered on it, and the property has been leased by the Reading Graphite Company.

7. *Chester, Morris County.*—Black lead is seen in the Mendham

road, about a quarter of a mile east of the residence of the late Gen. Nathan A. Cooper, and two miles east of Chester. The outcrop is several yards wide. There has been no digging to test the extent of the vein or stratum carrying it. From a careful examination of the surface outcrop it was judged to contain from 6 to 8 per cent.

8. *Morristown and Mendham.*—Rock containing graphite has been observed on the road, at two points, between Morristown and Mendham. One of these is near the township line; the other is near Mendham. The latter outcrop appears to be connected with that on the Saunders farm, south of the turnpike. A specimen from near Mendham was tested, and found to have 7.89 per cent. of graphite. A sample from the Betts farm, near Morristown, contained 6 per cent.

9. *Henry Mitchell Farm, Washington Township, Morris County.*—A sample of graphite from this place was sent to the laboratory by Lyman Kice, of German Valley. It contained 6.01 per cent.

Two or three other localities have been heard of since the above notes were written, but there is no further information in hand about them.

There has been difficulty found in the attempt to separate the mineral from the rock in which it occurs. For the uses to which it is to be applied, it is necessary that it should be entirely free from other minerals. Some of the methods tried have failed to get out all the rock, and others have failed to separate the principal part of the black lead. A cheap and effective method of separating this mineral from the rock, would be a benefit to the public.

CLAYS.

1. *Clay from Otto Ernst.*—A white, sandy clay from the salt works property of Otto Ernst, near Morgan station and the Chesquake creek. The sample is reported by Mr. Ernst to represent a bed which is 16 feet thick, 1 foot under the surface, and 60 to 80 feet above high water level. A boring down to tide level did not penetrate any other clay beds.

Insoluble matter	60.78
Alumina	24.00
Oxide of Iron	1.80
Potash	1.99
Water (combined and hygroscopic)	10.30
Total determined	98.87

This clay has been used by W. C. Coolidge & Co., at Poughkeepsie, in the manufacture of Portland cement, for the bridge piers at that place.

2. *Clay from Hulziser Farm, near Stewartsville, Warren County.*—Clay was discovered on lands of Hulziser, southeast of Stewartsville, and three-fourths of a mile northwest of Kennedy's mills, in digging for hematite. The pits are in a flat, 100 to 200 yards northwest of Hulziser's house, and on both sides of the public road. The deposit, as it has been opened, runs in a northwest and southeast direction The deepest pit goes down 35 feet. The top earth is a drift, including gravel and small cobblestones, and a little hematite. The clay-bed is 20 feet thick. Under it there is a yellowish and more sandy clay to the bottom of the pit. A drift, several yards in length, has been cut in the clay-bed. The deposit crops out in the field west of the road. It was found there also, in the pits dug for ore. A selected sample of clay from the main pit and shaft has been analyzed, and found to contain:

Alumina	27.31	per cent.
Silicic acid	56.95	"
Water (total)	6.40	"
Sesquioxide of iron	1.29	"
Lime	traces.	
Magnesia	1.66	"
Potash	5.56	"
Total	99.17	

It is remarkably white, and the sand in it is feldspar in fine particles. It does not burn white, on account of the iron oxide which it contains.

GREENSAND MARLS.

1. *Marls from the Farm of John E. Hunt, Manalapan, Monmouth County. Sent by D. Augustus Vanderveer.*—Three samples were received, of which two were examined for the lime and phosphoric acid. The vertical section at the pits, whence these came, has the following layers:

(1)	Top dirt	2 feet.
(2)	Cemented iron sand	1½ "
(3)	Gray marl	2 "
(4)	Black marl	4 "
(5)	Sand marl	4 "

The grey marl had 0.25 per cent. of lime and 1.83 per cent. of phosphoric acid. The black marl gave 4.9 per cent. of lime and 3.2 per cent. of phosphoric acid. The phosphate of lime is very light in the grey marl, while in the black marl it is unusually large. The pits are in the Lower Marl Bed. The results of these examinations show the great variation in the different layers of the marl and the importance of selecting the rich marls, especially for use at any long distance from the pits.

2. *Marl from the Pits of the Kirkwood Marl Co., at Kirkwood, Camden County.*—This specimen was sent to the laboratory in May, 1879, by P. V. Voorhees, Esq., of Camden.

ANALYSIS.

Phosphoric acid	0.70
Silicic acid and sand	50.30
Potash	6.30
Lime	1.15
Magnesia	3.60
Alumina	6.88
Oxide of iron	19.92
Water	10.50
Total	99.35

3. *Marls from Prospertown, Monmouth County.*—Two specimens were received from Hon. E. P. Emson, of Ocean county. They were examed for phosphoric acid only. The marl from Lyall's old mill, known as Old Pond Marl, contained 0.32 per cent. That from near mill had 0.13 per cent. These marls contain much less phosphoric acid than marls from a lower level. They are useful as additions to the soil, when applied in large quantity.

Peat.—Two samples of peat from the farm of Dr. Theo. T. Price, near Tuckerton, have been examined. One is from a fresh-water swamp; the other was obtained from an old pine swamp, at the border of the tide marsh.

	1.	2.
Ash	9.89	23.06
Insoluble in acid	7.10	18.80
Lime	0.27	0.25
Phosphoric acid	0.032	0.077
Nitrogen	0.764	0.829

1. Fresh-water swamp peat.
2. Tide-marsh border peat.

Of the muck found on the tide-marsh border, a large quantity has been advantageously used. It needs to be composted with barn-yard manure, or else with lime.

METEOROLOGY AND CLIMATE.

In 1868 there was published in the "Geology of New Jersey" an appendix of meteorological tables, which gave the temperature and rain-fall at a number of places in the State. Last spring the preparation of a report on the climate of New Jersey was begun, and a large amount of material was collected for it. The Smithsonian Institution and the United States Signal Service Bureau furnished copies of the records of temperature and rain-fall made at their stations in the State and at several places in New York, Pennsylvania, Delaware and Maryland, which are so near our borders as to be serviceable in making a correct exhibit for the whole State. Weather records, kept by private individuals and companies, have also been received. The following list gives the location and period of observation at these several places. These latter terminate with the year 1878, excepting a very few, where it is known that they have been continued throughout 1879.

STATIONS.	LOCATION.	PERIOD OF OBSERVATIONS.
Goshen	*Orange county, N. Y.*	11 years.
Newton	Sussex county.	2 years (incomplete).
Easton	*Pennsylvania.*	5 years.
Lake Hopatcong	Morris county.	(Rainfall, 24 years.)
Dover	Morris county.	2 years, 10 months.
New York city	*New York.*	30 years.
Fort Columbus	*New York.*	48 years, 8 months.
Jersey City	Hudson county.	7 years (incomplete).
Paterson	Passaic county.	9 years (incomplete).
Bloomfield	Essex county.	6 years.
East Orange	Essex county.	2 years (incomplete).
Orange	Essex county.	2 years, 6 months.
South Orange	Essex county.	9 years (incomplete).
Newark	Essex county.	36 years, 7 months.
Passaic Valley	Union county.	2 months.
Linden	Union county.	2 years, 2 months.
New Germantown	Hunterdon county.	9 years (incomplete).
Pleasant Run	Hunterdon county.	5 months.
Readington	Hunterdon county.	7 years (incomplete).
Lesser Cross Roads	Somerset county.	2 years (incomplete).
White House	Hunterdon county.	2 months.
Sergeantville	Hunterdon county.	1 year, 3 months.

STATIONS.	LOCATION.	PERIOD OF OBSERVATIONS.
Princeton	Mercer county.	
Pennington	Mercer county.	1 year (incomplete).
Roycefield	Somerset county.	2 years (incomplete).
New Brunswick	Middlesex county.	12 years (incomplete).
Lambertville	Hunterdon county.	19 years.
Trenton	Mercer county.	19 years (incomplete).
Morrisville	*Pennsylvania.*	67 years, 10 months.
Sandy Hook	Monmouth county.	5 years, 2 months.
Riceville	Monmouth county.	8 months.
Middletown	Monmouth county.	3 years, 2 months.
Long Branch	Monmouth county.	3 years (incomplete).
Ocean Grove	Monmouth county.	3 years (incomplete).
Squan Beach	Monmouth county.	3 years (incomplete).
Barnegat	Ocean county.	5 years, 3 months.
Atlantic City	Atlantic county.	5 years, 3 months.
Somers' Point	Atlantic county.	1 month.
Peck's Beach	Cape May county.	3 years (incomplete).
Freehold	Monmouth county.	12 years (incomplete).
Hightstown	Mercer county.	8 months.
Mount Holly	Burlington county.	11 years (incomplete).
Moorestown	Burlington county.	15 years (incomplete).
Haddonfield	Camden county.	7 years (incomplete).
Atco	Camden county.	9 years (incomplete).
Elwood	Atlantic county.	9 months.
Newfield	Gloucester county.	4 years (incomplete).
Vineland	Cumberland county.	13 years (incomplete).
Florence	Burlington county.	1 month.
Burlington	Burlington county.	10 years (incomplete).
Progress	Burlington county.	3 years (incomplete).
Camden	Camden county.	1 year (incomplete).
Philadelphia	*Pennsylvania.*	48 years.
Woodstown	Salem county.	3 months.
Salem	Salem county.	2 years (incomplete).
Fort Delaware	*Delaware.*	18 years, 10 months.
Allowaystown	Salem county.	3 years (incomplete).
Dover	*Delaware.*	9 years (incomplete).
Milford	*Delaware.*	9 years (incomplete).
Greenwich	Cumberland county.	10 years (incomplete).
Seaville	Cape May county.	4 years (incomplete).
Rio Grande	Cape May county.	7 years (incomplete).
Cape May	Cape May county.	5 years, 3 months.

After classifying these stations in groups, or climatic districts, it was found that the valley of the upper Delaware, the Kittatinny valley, the Highlands, and the south-central part of the State, were not well represented, or by incomplete records only. To fill out these

gaps, and to ascertain the climatic features of all parts of the State, six new stations have been started by the Geological Survey, and observations are to be taken at these places during 1880. Thermometers and rain gauges have been put in charge of the following persons, who have consented to keep records of temperature and rain-fall:

Chas. F. Van Inwegen, Port Jervis, N. Y.; A. C. Noble, Deckertown, Sussex county; Wm. Allen Smith, Weldon Mine, Morris county; L. H. Hunt, Schooley's Mountain, Morris county; Joseph C. Kent, Phillipsburg, Warren county; Eayre Oliphant, New Lisbon, Burlington county. The careful comparison of the records at these selected points for the same year (1880) with those of stations of long periods, will show the characteristic differences, and enable us at the end of another year, and in the next annual report, to publish the climatology of the State.

11. STATISTICS.

IRON ORE.

The product of the iron mines of the State for the year 1879, as derived from the ore tonnage of the Morris canal, the New Jersey Midland railway, the Delaware, Lackawanna, and Western railroad, the Central railroad, the Easton and Amboy railroad, and the Ogden Mine railroad, and the returns from Oxford furnace and from Franklin, was 488,028 tons. The returns for 1878 amounted to 409,674 tons. The increase for the last year is 78,354 tons, or 19 per cent. A small part of this aggregate tonnage of the transportation companies was mined in 1878, as the brisk demand for ore at the close of 1879 occasioned the removal of stocks which had accumulated at a few of the mines. The statistics of individual mines as they have been received will be found under their respective heads on pages 41–63.

ANTHRACITE BLAST FURNACES IN NEW JERSEY.

NAME OF WORKS AND LOCATION.	PROPRIETORS.	No. OF FURNACES.	REMARKS.
Franklin, Franklin, Sussex Co.	Franklin Iron Co.	1	Put in blast in July, 1879.
Musconetcong Iron Works, Stanhope, Sussex Co.	A. Pardee & Co.	2	In blast; large furnace was lighted Nov., 1879.
Warren, Hackettstown, Warren Co.	Joseph Wharton	1	Preparing to go in blast.
Pequest, Oxford, Warren Co.	Cooper, Hewitt & Co.	1	In blast (lighted February, 1880.)
Oxford Furnace, Warren Co.	Oxford Iron Co.	2	One in blast and one preparing to go in blast.
Phillipsburg, Warren Co.	Andover Iron Co.	3	In blast.
Chester, Morris Co.	Jersey Spiegel and Iron Co. / W. J. Taylor & Co., lessees.	1	In blast.
Port Oram, Morris Co	Port Oram Furnace Co.	1	Lighted January, 1880.
Boonton Iron Works, Boonton, Morris Co.	Executors of J. Cooper Lord.	2	One at work. One preparing to go in blast.
Ringwood Iron Works, Ringwood, Passaic Co.	Cooper, Hewitt & Co.	2	One in blast. One about to be rebuilt.
Secaucus Iron Works, Secaucus, Hudson Co.	Secaucus Iron Co., A. Pardee, President.	1	In blast.
		17	

Of the 17 stacks, 13 are now in blast and 3 more will be lighted within a month, and all of them will probably be in operation during the year 1880. The yearly capacity of the 17 furnaces is estimated to be, at least, 200,000 tons of iron.*

In addition to the above-mentioned furnaces, there is a charcoal furnace at Splitrock, at work, in which wrought iron is made, using the Wilson patent. And near Drakesville, Morris county, is Möller's furnace—not in operation.

The following list of furnaces and forges which have been in operation at some former time, is of much historic interest, and may be of some practical information. Further information in regard to many of them is desirable:

* According to a table in a recent number of the *Iron Age*, showing the "Condition of the Blast Furnaces of the United States, January 1st, 1880," 11 furnaces in the State are in blast, and their capacity per week is 3210 tons, equivalent to 166,920 tons a year. There are 4 spiegel furnaces, 3 of which are in blast, making 132 tons a week.

CHARCOAL BLAST FURNACES.

NAME.	LOCATION.	REMARKS.
Wawayanda	Vernon twp., Sussex Co.	Built in 1845; out of blast since 1856.
Hamburgh	Hamburgh, " "	
Franklin	Franklin, " "	Built in 1770; last repaired in 1854.
Ogden's	Odgensburg, " "	In existence before 1759.
Andover	Andover, " "	Built in 1763.
Clinton	West Milford twp., Passaic Co.	Stopped in 1849; in ruins.
Long Pond	Ringwood Works, " "	Built, 1764–7; rebuilt as an anthracite furnace.
Ringwood	Ringwood, " "	Built, 1764–7; a ruin.
Freedom	Wynokie Valley, " "	1838; out of blast 1855, and down.
Pompton	Pompton, " "	1837.
Ryerson's	Bloomingdale, " "	In ruins.
Charlottenburg	Charlottenburg, " "	1767; was abandoned 1772.
Mount Hope	Mount Hope, Morris Co.	1772.
Splitrock	Splitrock, " "	
Hibernia	Hibernia, " "	Built before 1764.
	Old Boonton, " "	
	Changewater, Warren Co.	
Oxford	Oxford, " "	Built in 1742–3; rebuilt, and in blast.
Union	Near High Bridge, Hunterdon Co.,	In existence in 1759; abandoned in 1778, and a ruin.
Amesbury	" " " " "	1755(?) in ruins.
Morris Iron W'ks	Tinton Falls, Monmouth Co.	At work in 1682.
Howell	Manasquan river, " "	
Bergen Iron W'ks	Bricksburg, Ocean Co.	
Dover	Manchester, " "	
Phœnix	1 mile east of Manchester, Ocean Co.	In ruins, (Gordon's map.)
Hanover	Hanover, Burlington Co.	Idle since 1854.
Mount Holly	Mount Holly, " "	Mentioned by Acrelius in 1759.
Mary Ann	Pemberton twp., " "	
Union Works	Woodland twp., " "	
Speedwell	" " " "	
Hampton	Shamong twp., " "	
Atsion	" " " "	
Batsto	Washington twp., Burlington Co.	Built in 1766; ran until 1855.
Martha	" " " "	
Taunton	Medford twp., " "	
Gloucester	Mullica twp., Atlantic Co.	
Weymouth	Hamilton twp., " "	Idle since 1854.
Etna	Weymouth twp., " "	
Cumberland	Manumuskin, Cumberland Co.	Out of blast since 1844.
Millville	Millville, " "	Built 1815; out of blast since 1855.
Bridgeton	Bridgeton, " "	
Tuckahoe	Tuckahoe, Cape May Co.	

All of these were charcoal furnaces. None of them have been in operation since 1856, and all in the southern part of the State are abandoned. Atsion was at work last. Oxford, Franklin, and Ringwood have been rebuilt as anthracite furnaces.

FORGES.

NAME.	LOCATION.	REMARKS.
	Canistear, Vernon township, Sussex Co.	1796.
	Franklin, Hardiston " "	
	Windham, " " "	Built about 1790.
	Sparta, "	Two forges, 1821-3.
Morris Anchor w'ks	Norman's Pond, Sparta twp., "	" "
Hopewell	Hopewell, " " "	1780.
Columbia	Byram township, "	1800.
Roseville	" " "	1828.
Lockwood	" " "	1857.
Andover	" " "	1804.
Stanhope	" " "	
Clinton	West Milford township, Passaic Co.	
Stockholm	" " " "	At and near Stockholm there are 4 forges.
Charlotteburg	Charlotteburg, West Milford township, Passaic county	Built in 1840.
	Pequannock Valley, West Milford twp., Passaic county.	There were 2 forges between Charlotteburg and Smith's, in the time of the London Co.
Smith's	Smith Mills, West Milford township, Passaic county.	
Vreeland's	1 mile w. of Bloomingdale, Passaic Co.	
Ryerson's	Bloomingdale, Passaic county	Built about 1800.
Long Pond	Ringwood Works, Passaic county	Built by Hasenclever, 1764-1767.
	Ringwood Works, " "	Three forges were built by Hasenclever in 1764.
	Boardville, " "	
	Wynokie, " "	
	Schraalenberg, Bergen county	According to Gordon's map.
	Russia, Jefferson township, Morris Co.	1775.
	Weldon " " " "	
	Hurdtown " " " "	
Swedeland	Milton " " " "	1801.
	Petersburg, " " " "	Two forges according to Gordon's map, at Petersburg.
	Woodstock " " " "	1790.
	Upper Longwood, Jefferson township, Morris county.	

NAME.	LOCATION.	REMARKS.
	Lower Longwood, Jefferson township, Morris county	There have been 2 forges at Lower Longwood and in the Berkshire and Longwood valleys the map of Gordon has 6 in all.
	Berkshire Valley, Jefferson township, Morris county.	
Valley	Near Baker's Mills, Roxbury township, Morris county	1780.
Washington	On Rockaway river, Rockaway township, Morris county	1850.
Mount Pleasant	Mount Pleasant, Rockaway township, Morris county	In ruins.
Ætna	Near Middle Forge, Rockaway township, Morris county	Built about Revolution.
Middle	Middle Forge, Rockaway township, Morris county	1810.
Denmark	Denmark, Rockaway township, Morris county	1800.
Timber Brook	Southwest of Charlotteburg, Rockaway township, Morris county.	
Durham	Southwest of Charlotteburg, Rockaway township, Morris county	1811–1856.
Earle's	Stony Brook, Pequannock township, Morris county	1822–1856.
Decker's	Rockaway valley, Pequannock township, Morris county	1846.
Dixon's	Rockaway valley, Rockaway township, Morris county	1827.
Splitrock	Splitrock, Rockaway twp., Morris Co.	About 1837.
Stickel's	Meriden, " " " "	1790.
Righter's	Meriden, " " " "	1820.
Beach Glen	Beach Glen, " " " "	Built in 1760.
Hibernia	Hibernia, " " " "	Gordon's map has two forges here.
Muir's	On White Meadow Brook, Rockaway township, Morris county.	
	Rockaway, Rockaway twp., Morris Co.	There are 2 forges here, 1790–1805; and Gordon's map has 2 additional on Horse Pond branch.
	Powerville, Morris county	Built 1853.
	Boonton, " "	Gordon's map has two forges here.
Righter's	Old Boonton, Hanover twp., Morris Co.	Built 1853.
Troy	Troy, " " " "	1745–1859.
Whippany	Whippany " " " "	Built in 1710.
	Speedwell, Morris township, Morris Co.	Gordon's map has two forges, w. & n. w. of Speedwell's works.
	Morristown, " " " "	According to Gordon's map.
	Shongum, Randolph " " "	On Den Brook, below Shongum, Gordon has 2 forges.

NAME.	LOCATION.	REMARKS.
	N. branch of Raritan, Mendham township, Morris county	Two forges, according to Gordon's map.
Budd's	Hacklebarney, Chester twp., Morris Co.	1850.
Budd's	Black River, " " " "	
Welsh's	1 mile below Bartleyville, Mount Olive township, Morris county.	
Bartleyville	Bartleyville, Mount Olive township, Morris county	1790.
Mount Olive, or Stephen's	1 mile above Bartleyville, Mount Olive ship, Morris county	
Shippenport	Shippenport, Morris county	1843.
Solitude	Near High Bridge, Hunterdon county.	
	Spottswood, Middlesex county.	
	Imlaystown, Upper Freehold, Monmouth county	Built in 1716.
Jackson's	Near Squankum, Monmouth county.	
Three Partners	Near Bricksburg, Ocean county	According to Gordon.
Butcher's Works	Near Burrsville, "	
	Dover, Ocean county	In operation 1866-7.
	Ferrago, Ocean county	Stopped in 1851.
	Westecunk (West Creek), Ocean Co.	
	Hampton, Shamong township, Burlington county	
	Monroe, Weymouth twp., Atlantic Co.	
	Manumuskin, Cumberland county.	

There was probably a forge at Tinton Falls as early as 1682, according to the statements of the East Jersey proprietaries, belonging to Lewis Morris' iron works.

The forges on the Pequannock, below Charlotteburg, those about Ringwood, that at Russia, Ætna forge, Hibernia, Troy, Whippany, Solitude, and Imlaystown, also antedate the Revolution. According to a census in 1784, the State had 8 blast furnaces and 79 forges. Gordon, in his statistical table published in 1834, has 12 blast furnaces and 108 *forge fires*. There were 14 forges in south Jersey at that date. The forge at Dover, in Ocean county, was at work in 1866–7. In the northern part of the State, Shippenport, Russia, Stockholm, Ryersons, at Bloomingdale, Powerville, Splitrock, and Middle forges, have been at work for short periods, at intervals, up to the present time.

ZINC ORE.

The zinc mines in the State have been worked steadily throughout the year, and they have produced 21,937 tons of ore.*

At Stirling Hill, near Ogdensburg, Sussex county, there are three mines, worked by three distinct companies: the Manganese Iron Company, at the southwest; the mine of the Passaic Zinc Company has been in operation throughout the year; the mine of the New Jersey Zinc Company is still idle.

At Franklin, three parties are at work on Mine Hill. The Franklin Iron Company is mining in the opening known as the "Buckwheat." To the northeast of the Buckwheat opening, a shaft has been sunk over 100 feet, in search of the *Buckwheat vein*, but thus far without success. The old Greer opening is now worked by Chas. W. Trotter, on a lease. But a small quantity of ore is mined.

The New Jersey Zinc Company has the northern end of the vein, and is working on both sides of the Hamburg road. The vein at their northernmost drifts is large.

CLAYS AND BRICK.

The clay deposits of the State were described at length in a special report published two years ago. In the Annual Report for 1878 there was a supplementary notice of the clays of the southern part of the State. The demand for these reports has been steady and large, indicating the interest manifested in the development of that part of our mineral resources. The general improvement in business began to show itself in the autumn, in larger and in an increasing number of orders for clays and brick. The needed repairs at so many of the iron works created a brisk demand for fire-bricks and for the refractory materials used in their manufacture. The fire-brick works, for a few months, have had as much as they could do to fill orders, and the clay miners have found a good market and fair prices. The superior quality of our fire-clays, and their adaptation to so varied uses, are gradually being found out by a continually widening circle of manufacturers, and they are more and more appreciated by them.

The statistics of the clay district of Middlesex county, according to the three principal groups of pits, are as follows:

* This estimate includes 15,937 tons of ore carried on the Morris canal, and 6000 tons of ore mined, but not shipped, by the Passaic Zinc Company, at Stirling Hill.

1. Woodbridge.* Fire-clay, fire-sand, *kaolin* and fire-brick shipped...	115,060	tons.
2. Clay banks north shore of Raritan river.† Fire-clay and fire-sand and *kaolin*	90,000	"
3. Clay banks on south side of Raritan river.‡ Fire-clay and fire-sand and *kaolin*	60,000	"
Total refractory materials	265,000	"

This aggregate is not quite equal to the tonnage of clay mined, as, in the estimate for Woodbridge, the fire-brick shipped do not weigh as much as the clay and sand which are used in them. It is equal to that of 1873, which was a prosperous year.

The product of the mines and pits of stoneware clay in Middlesex county is estimated for the year to be 10,000 tons,§ or about half of that of the best previous annual output.

The clay banks on the Delaware side of the State, excepting that of John D. Hylton, on Pensauken creek, in Camden county, are not extensive, and their aggregate product is small. The shipments from Hylton's banks‖ during the year 1879 consisted of—

Fire-clay	9,777	gross tons.
Fire-sand	3,220	"
Kaolin	4,350	"
Spar	1,000	"
Sharp sand	5,000	"
Moulding-sand for fire-brick	1,500	"
Total of refractory materials	31,847	"

In the business of making red brick, the revival came so late in the season that the brickmakers were not prepared to take advantage of the market. Along the Raritan and South rivers, the principal seat of this business, many of the yards were not worked to their full capacity until September. Mr. Higbie estimates the product of the yards on the Raritan and the South rivers, during the year 1879, at 87,000,000. According to the present outlook, and at the present capacity, the same authority puts the estimates for next year at 110,000,000.

The importance of the clay industry on the eastern side of the State is shown in the valuation of the product. At an average of

* Reported by Wm. H. Berry, of Woodbridge.

† Reported by Chas. A. Campbell, of Woodbridge.

‡ Reported by M. S. Higbie (of Sayre & Fisher), Newark, and George Such, of South Amboy.

§ Reported by Otto Ernst, of South Amboy.

‖ Reported by John D. Hylton, of Palmyra.

$2 per ton, the amount of sales would be at least half a million of dollars. The greater part of this raw material is manufactured into fire-brick, retorts, drain-pipe, terra-cotta, and wares, at works in the neighborhood of the pits. A considerable amount is shipped to the furnaces along the Lehigh, in Pennsylvania, and elsewhere. The location of this clay district—with such a length of water-front, with its lines of railroad in direct connection with the coal and iron regions, and its nearness to the large markets of the Atlantic seaboard—gives it advantages which must hasten its development.

The Raritan river, along which the clay beds are so largely developed, opens most convenient and cheap transportation to all parts of our coast. It is already the fourth river in the United States in tonnage, and the general government has begun an improvement in deepening the channel so as to provide still greater facilities for the immense business which is to be done upon it. The work has been in progress less than two years, and already manufacturers and shippers have felt the benefit of the great improvement which is being prosecuted in deepening the channel, and they are now enabled to load direct on vessels of deep draught of water, and thus secure cheap transportation to all points on the coast, which, added to the inexhaustible supply of raw material and improved facilities in working the same, enables them to compete with local works at distant points, and they are no longer dependent upon the demand in New York and vicinity. Should the improvement in regard to the Raritan river, as contemplated by the general government, be completed, the number of red brick made on this river will soon exceed 200,000,000 per annum, with a corresponding increase in all other branches of the clay business.

The adaptation of these clays for fire-brick and stone-ware are so well known that it is unnecessary to refer to these uses.

The employment of the dense clay of the Raritan fire-clay stratum for glass-pots has been suggested, and some experiments with it have been tried. This clay differs but little in composition from the best Woodbridge and South Amboy fire-clays; but it burns very solid and free from checks, resembling in this respect the best of the foreign clays which are imported for making crucibles and glass-pots and strong fire-brick. There is an abundance of this clay of the best quality, and it can be afforded at half the cost of that imported. It only needs

proper care on the part of owners and consumers to bring it into general use. It has been dug by William B. Dixon at Woodbridge, and by B. Ellison and Augustine Campbell on their farms near Bonhamtown. These localities are shown on the map accompanying the report on clays. The following extract from one of the reports made to the U. S. Potters' Association, at their recent annual meeting, in regard to the sale of reliable and uniform grades of clay, states the case for this as well as for all our varieties of clay in the proper form:

"Clays must be graded and sold according to grade, and each miner will be compelled, sooner or later, to establish their brand and make their clays entirely reliable, so they can be purchased by their brands, as has been done for many years in Europe.

"But before a brand of clay can be made reliable, the clay must be made uniform, which cannot be done by working clay beds in small sections. To this point your committee would call especial attention.

"All beds of clay vary more or less, even in the best strata the variation is perceptible every few feet; consequently a mine worked in small sections, or pockets, as our American clays are, and always have been worked, and sent to market as fast as they are washed, do not properly represent the clays of that mine, but, on the contrary, represent each time one small spot in the mine, the result being that every invoice of clay from our American mines is different, consequently our mixtures made from these clays are always changing and unreliable, causing losses that we have been entirely unable to account for."

The finer grades of white clay which are dug in the vicinity of Woodbridge and Amboy are extensively used in the manufacture of cream-colored and white-granite wares. Their superior plasticity is useful in mixing with the kaolin-clays of Delaware, which are not plastic. On account of the oxide of iron they do not burn white, as the kaolin-clays. A practical method of removing this constituent would be a valuable discovery, as it would permit of their use in place of the more costly and less plastic clays which are employed. For saggars there is a large amount of New Jersey clay used.

The employment of our clays for making terra-cotta has been enlarged greatly by the starting of the manufacture by Mr. A. Hall, at Perth Amboy. The works are known as the "Perth Amboy Terra-cotta Works." They are doing a large business, and furnish orna-

mental material of a high character. Terra-cotta is made at the Pea-Shore Fire-brick and Terra-cotta Works, near Camden.

At South Amboy a pottery has been recently built by the Juliano Ware Co., which will use clays from the neighborhood in the manufacture of their wares.

At Eagleswood a buff clay, suitable for modeling, has lately been opened on the Eagleswood estate; and it is used by the owner, Edward A. Spring, in his art pottery.

Statistics of Potteries making White Ware at Trenton, Elizabeth, and Jersey City.—From J. H. Brewer, Etruria Pottery Co., Trenton, and President of the United States Potters' Association.

Number of kilns 101
Average capacity (each) $30,000
Amount produced, if fully employed $3,030 000
Amount actually produced, about $2.500,000
Amount produced in United States $4,000,000
Amount imported, about $4,000,000
Production of New Jersey (clays, flint and spar,) 50,000 tons.
Coal used, 50,000 tons.
Wages paid, yearly, $1,250,000.
Hands employed, 3,000.

GLASS WORKS IN NEW JERSEY.

LOCATION.	PROPRIETORS.	NO. OF FACTORIES.	REMARKS.
Jersey City		2	Not in operation.
Medford			"
Jackson			"
Waterford			"
Winslow	A. K. Hay & Co.	3	In operation.
Tansboro	Bodine & Sons	1	"
New Brooklyn			Not in operation.
Williamstown	Bodine & Thomas	2	In operation.
Glassboro	Whitney Bros.	4	"
"	Warrick & Stanger	2	"
Clayton	Moore Bros.	4	"
Malaga	Malaga Glass Manufacturing Co.	2	"
Salem	John V. Craven	3	"
Quinton	Hires & Plummer	2	"
Bridgeton	Cohansey Glass Co.	5	"
Millville	Whitall, Tatum & Co.	10	"
Estellville			Not in operation.
Crowleytown			"
Green Bank			"
Total in operation		38	

The following statement from R. M. Atwater, of Whitall, Tatum & Co., Millville, gives the condition of this industry in our State at the present time:

"These factories vary in size. I should say that on an average they melted 2 to 2½ tons of sand each day, and turned out a product of full 3 tons each, of packed glass daily. The glass is in all cases a 'lime-glass,' composed chiefly of sand fluxed with sodā and lime. The sand is generally mined in the State. In some of the factories making finer qualities of glass, the sand from quartz is used, which is obtained from the Alleghany Mountains. The lime is generally obtained from oyster shells, or from the limestone deposits of New Jersey and Pennsylvania. The soda ash is imported. Some use is made of salt-cake (sulphate of soda.) Each hollow-ware factory employs about 100 hands. The work is piece-work, and the glass-blowers can earn from $2.50 to $4 per day. Their work consists of the general class of bottles. There are no factories running on table glass-ware, lamps or pressed ware, to any extent in the State. I extract the following note from the *Crockery Journal:*

"'Of the 106 window-glass factories in the United States, 34 are in New Jersey. Each factory employs about 50 to 75 persons.'"

In addition to the supply of the glass works in the State, the glass-sand pits along the Maurice river sell from 10,000 to 15,000 tons annually to works in adjoining States. The localities where glass-sand is dug were described in last year's report.

GREENSAND MARLS.

The importance of this natural fertilizer to the farming interests of the southern part of the State is so great that some account of the condition of the marl trade is necessary and desirable. In the last Annual Report the belts of oak-lands southeast of the marl district were described, and represented on the map accompanying that Report. The clearing and settling of these lands must create a demand for fertilizers. And along the whole length of the southern half of the State, from the Atlantic to the Delaware river, there is, bordering these oak-lands, the marl-belt. The supply of good marl is practically inexhaustible. The railroad communication between the marl district and the country to the southeast of it is shown on the map

with this Report. The state of the marl trade is much better than it was last year, and the outlook for the ensuing year is very promising. The prices have been reduced. This reduction in cost, and better prices for farm produce, enable the farmers to buy largely again. One of the agents writes: "We have reduced our prices to the lowest possible point, and hope for larger sales this season." Another says: "Our company * * * made a deduction of price of marl from 10 to 30 cents per ton, according to the distance carried." There seems to be an earnest endeavor, on the part of the companies selling marl, to increase sales and to extend their business by the inducements of low rates. The co-operation of the railroad lines with the marl companies, in the reduction of rates, is very desirable. Hitherto they have in many places been exclusive, as the farmers could not afford to buy at the schedule prices. The subject is again referred to, as it is of importance to both carriers and buyers. In order to get the statistics of the marl sold and carried on the railroads, letters were sent to officials of the companies. These are here printed. It is hoped that the publication of these statistics will tend to increase the business of the companies, and call the attention of our farmers and those engaged in the improvement of land to the great extent of the marl belt, its richness and fertility—due to the generous use of this natural fertilizer—and the capabilities of southeastern New Jersey under like treatment.

FREEHOLD AND NEW YORK RAILWAY.

J. E. Ralph, Secretary, Treasurer, and Superintendent, writes: The F. and N. Y. railway, for the 12 months ending December 31st, 1879, hauled 324 car-loads, of 250 bushels each, = 81,000 bushels..... 4,050 tons.

SQUANKUM MARL COMPANY.

W. E. Barrett, Superintendent, writes: Our sales, ending with the 1st of March, 1879, were about 150,000 bushels; equivalent to..... 7,500 "

SQUANKUM AND FREEHOLD MARL COMPANY.

A. A. Yard, Superintendent, says: We have sold and delivered the past year .....10,000 "

CREAM RIDGE MARL COMPANY.

Gen. G. Mott, Treasurer, writes that the company has sent out..... 4,710 "

PEMBERTON MARL COMPANY.

J. C. Gaskill, Superintendent, writes: Our sales for the year 1879 amount to.....10,000 "

VINCENTOWN MARL COMPANY.

Henry J. Irick writes: We shipped during 1879..... 3,010 tons.

FOSTERTOWN MARL COMPANY.

R. S. Reeve, lessee, writes: Our sales of marl last year amounted to about..... 5,500 "

KIRKWOOD MARL AND FERTILIZER COMPANY.

George M. Rogers, Superintendent, writes: The Kirkwood Marl and Fertilizer Company was organized late in the season of 1879. The sales for the balance of the year amounted to..... 5,300 "

WEST JERSEY MARL AND TRANSPORTATION COMPANY.

I. C. Voorhies, Superintendent, says in letter, December 24th: We have delivered since January 1st, 1879, to present time.....11,000 "

WOODSTOWN, SALEM COUNTY.

John W. Dickinson writes: The sales at the Dickinson marl beds this year will be about..... 3,000 "

Total.....64,070 "

The marl which is carried on the railroads is but a small part of the whole quantity dug in the State. The greater part of it is carted by teams directly from the pits to the farms whereon it is to be applied. Besides this, the aggregate of what is dug and used on the farms where it occurs is very large. To show how much is distributed by teams from a single locality, the following statistics of three farms at Marlborough, in Monmouth county, are here given. These pits are all within a half a mile of one another. The figures are exclusive of the amounts used at home. They are as follows:

O. C. Herbert's sales amounted to..... 9,814 tons.
Uriah Smock's " " ..... 8,000 "
C. H. Conover's " " ..... 1,750 "

Total..... 19,564 "

In the above figures, the amounts sold from these pits and sent away on cars is not included.

LIME.

No attempt has been made to collect the statistics of lime burned in the State. The blue, magnesian limestone is quarried extensively at several points along the Delaware, Lackawanna and Western, the Central, the Belvidere Delaware, and the Easton and Amboy railroads,

in Sussex, Warren, and Hunterdon counties, for kilns which supply lime to the country to the east and south of the limestone outcrops. A large amount of lime is delivered by teams in the neighborhood of kilns. Very nearly all of it is used for agricultural purposes.

The white, crystalline limestone has not been used to any such extent for lime, except in the vicinity of Hamburgh and McAfee valley, in Sussex county. A large amount of lime was formerly made on the Edsall farm, and sold in Paterson, Newark, and other towns in the State. Two years ago Sayre & Vanderhoof started the manufacture of lime near Hamburgh, and on the N. J. Midland railroad. They have two perpetual kilns. These are constructed with separate fire chambers, two on the sides of each kiln, and in such a manner that the flame only is in contact with the limestone. Wood is used as fuel. The stone is brought from the quarry on the Rude farm, which is two miles north of the kilns, in cars on a tramroad. It is very white and coarse crystalline, and, according to an analysis made for the "Geology of New Jersey," published in 1868, contains 99.5 per cent. of carbonate of lime. The lime is liked on account of its whiteness, and because it does not air-slake readily. It is shipped in lime cars to points on railroad lines in New Jersey. A large amount is sold in the southern part of the state. The fine lime is sold for agricultural uses. In 1879 the sales amounted to 30,000 barrels.

The use of this white limestone for making lime has been referred to in previous reports of the Survey, and its employment has been recommended. The success at Hamburgh confirms these statements, and suggests further trials and a more extended use. There is no reason why we should not supply New York as well as our own State.

The white limestone is quarried to a large extent in the valley of the Wallkill, at Stirling Hill, and near Franklin, for fluxing material in iron-making. Silsby & Martin sell the manganiferous limestone from their iron mine to Cooper, Hewitt & Co. It goes to the Ringwood furnace.

The Franklin Iron Co. gets its supply of limestone from the ledges at the side of the N. J. Midland railroad, and a few rods from the furnace. It is coarse, crystalline and white. The same range of limestone is quarried a short distance south of Franklin, for the supply of other furnaces.

12. PUBLICATIONS OF THE SURVEY.

The Annual Reports of the progress of the State Geological Survey are printed among the documents of the State, and they are very generally distributed by the members of the Legislature among their constituents. A liberal number of copies is also placed at the disposal of the members of the Board of Managers and the Geologist. The demand for them, however, is large, and those of 1876, 1874, 1873 and 1872 are all distributed, so that for those years no copies can be furnished.

The "Geology of New Jersey," an octavo volume, with a portfolio of maps, published in 1868, can still be supplied, though the number of copies left is not large.

The "Report on the Fire and Potters' Clays of New Jersey," with a map of the clay district, which was completed two years ago, has been widely distributed both at home and in foreign countries. The edition is probably sufficient for the present demand.

The large Geological Map of the State is mostly distributed, only a few copies being left.

The Geological Map of Northern New Jersey, which was printed in colors, and first distributed with the Annual Report of 1873, is out of print. A very large number of copies have been distributed.

The Centennial Map of New Jersey, on a scale of six miles to an inch, and showing geographical features only, was prepared by the survey, and has been distributed.

The proper method of making public the results of our Geological, Topographical and Economical Survey, is a question which has not been satisfactorily settled with us, and is equally unsettled in most other countries. At first the board resolved to sell the reports and maps at the cost of paper, printing and binding, and a considerable number of copies of the Geology of New Jersey and some of the maps were sold in that way, but there were always some copies at the disposal of

the members of the board and of other State officers, and the chance of getting from these without paying for them, led those who really wanted them to delay buying. From the way the printing is done the amount of free distribution has increased, and the sales have ceased. As the object of the Survey is to make known our natural products and resources, it may be said that we must do it by advertising—that is, by free publication and liberal distribution, just as in private business, and that the waste or misappropriation of a considerable part of the publication should not discredit the method so long as we continue to thrive in using it.

The Pennsylvania Reports are sold at the cost of printing and paper, but in fact most of them are given away.

The results of the Geological Survey of Great Britain are prepared and printed with great care and at heavy cost, and the price put on them is so high that few buy them.

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

The Board of Managers of the Geological Survey are constituted a board of publication of the results of the work, and they have authority to publish and distribute the reports as in their judgment is best for the interest of our citizens. It is specially desirable that the reports and maps should go into all public libraries, and into the hands of those whose pursuits render the information contained in these publications of value. It is probable that no better way will be devised for the distribution than to leave it in charge of the members of the board; and applications to them for such reports as may be desired, or to the State Geologist, with their approval, will be answered as far as possible.

The names and post-office addresses of the members of the board are on page 3.

13. EXPENSES.

The expenses of the Survey have been kept strictly within the appropriation. There is now standing to our credit on the Comptroller's books a small unexpended balance.

14. ASSISTANTS.

The Assistants to the State Geologist, who have been engaged in the work of the Survey in the course of the year are:

PROF. JOHN C. SMOCK, Assistant Geologist. He has been steadily at geological work as required, in different parts of the State, and in addition has given particular attention to the collection of details of the geology of red sandstone regions, &c.

EDWIN H. BOGARDUS, Chemist of the Survey, has been occupied with laboratory work through the year. In addition to the analyses which appear in this report, much time has been given to making chemical tests, in answer to inquiries in regard to specimens, which are sent in from all parts of the State.

C. C. VERMEULE, B. S., Topographical Engineer and Surveyor, has been engaged during most of the year in the work connected with the topographical maps—measuring angles to determine geographical positions, surveying and leveling for the topography and drawing the map.

GEO. W. HOWELL, C. E., Surveyor and Civil Engineer, has been engaged, as far as other professional duties would allow, in making levels and surveys for the topographical map.

PROF. EDWARD A. BOWSER, has spent some time in computing the latitudes and longitudes of points in the triangulation of north-eastern New Jersey.

My own time has been directed to the general progress of the work in its scientific and economical branches, and giving it such direction as may be most useful to the State in developing its natural resources.

It is proper also to mention the very great assistance rendered to the Survey by the numerous gentlemen who have contributed information and personal attention to further its objects. As the work gets to be better understood, information is more freely given to, as well as more generally sought from, the Survey. It would be an agreeable task to mention the names of those who have thus favored the work, but it would be difficult to tell where to end the list, and it is probably better to refer back to the body of the report, where the names are mentioned. Such assistance, however, is always gratefully received, and the thanks of the Board of Managers, and of the geologists, are hereby tendered to those gentlemen.

15. MUSEUM OF THE GEOLOGICAL SURVEY.

The museum of the Survey occupies the front rooms of the third story in the State House at Trenton. It is designed to be an exhibition of some of the results of the work of the Survey. There are in it collections of representative specimens from the mines of iron, zinc, and copper ores; from the fire-clay banks; from the glass-sand pits; from the greensand marl diggings; from the quarries of limestone, slate, flagging stone and building stone; and soils from the different agricultural districts of the State. Suites of rocks and fossils, characteristic of the geological formations, illustrate the geology of the State. There is a small collection of the more common minerals, and a few choice specimens of rarer species. The woods of the State are represented by about 100 varieties. In addition to these natural products,

there are fire-brick, pottery and glass wares, zinc oxide, spelter and irons from works in the State.

All the maps, both geological and geographical, of the State, so far as are known, are here.

Additions to the collections are made from time to time by the survey and through the kindly assistance of our citizens. Among these, recently placed on exhibition, are fossil fish in shale, from near Boonton, secured through the generous aid of H. Wilson Crane, of Boonton; and footprints in the red standstone from the quarry of John H. Vreeland, Hook Mountain. (See pages 27 and 28 of this report.)

There is need of much more material, both for the better illustration of our natural resources, and to make the museum more attractive to the many who visit it.* And attention is here asked to it as a safe repository and a proper place for the public exhibition of valuable and interesting specimens.

The museum is open daily, except Sundays.

New Jersey has pursued a liberal course with the Geological Survey thus far, and its prosperity during all the time it has been going on has been of the most marked character. The State has unequaled advantages in its location, its climate, and its natural resources. While it is of the 38 States in the Union only the 33d in size, it is the 17th in population, the 8th in the value of its real and personal property, the 20th in the value of its agricultural products, the 7th in the value of its manufactured products, and the 8th or 9th in the value of the products of its mines. In zinc ores it is the largest producer, and in the great staple, iron ore, it is the 3d or 4th.

Its increase in population and wealth for the last 30 years has been more rapid than that of any other of the older-settled States, and more rapid, too, than the average of the whole United States.

These results, so creditable to our State, are due, in addition to our natural advantages, to the liberal course with our schools; to ascertaining, developing, and publishing our natural resources; and to the strict, safe, and economical management of our finances.

The plan which we think best for the State is to continue the survey as at present until its triangulation by the United States

* No continuous record of the number of visitors has been kept, but it is estimated to be, on the average, 50 a day, or 15,000 in the course of the year.

Coast and Geodetic Survey shall be completed. Also, to have such topographical surveys and maps made of the mining districts of the State as cannot well be done by private enterprise; and to carry on such other topographical surveys as shall be necessary to make the State map on a scale of 2 miles to an inch, full and reliable for the public use. While this work is in progress, the detailed geology can be worked out and arranged so as to be put accurately on the maps, and published in three or four volumes, like that on the clays. There should also be prepared for publication a volume on the cretaceous fossils of New Jersey, with figures of the different species. This formation is more fully developed, and has been more studied, in this State than it has anywhere else in our country; and it is due to geological science that we should publish the typical and representative forms of the fossils which characterize it. To do this work will require the services of one specially devoted to the subject, and will involve an expense of perhaps $2000. The fossils in the older formations have been well studied and described in New York, Pennsylvania, and other States where these formations are more extensively developed than they are in this, and study and expense upon them need not be incurred by us.

All this work can be done fully in five years, and possibly in four or three years. When it is done the Survey can be closed, or reduced in expense to a bureau for recording progress in our material development and furnishing information in regard to our resources. A moderate annual expense for this purpose would undoubtedly be useful to the State for a long time to come.

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GEOLOGICAL SURVEY OF NEW JERSEY.

GEORGE H. COOK, STATE GEOLOGIST

JOHN C. SMOCK, ASS'T GEOLOGIST.

THE STATE OF NEW JERSEY

ECONOMIC GEOLOGY.

1880.

Scale: 6 Miles to 1 Inch.
Statute Miles.

JULIUS BIEN LITH.

Longitude West 75°00' from Greenwich.

75°40' 75°20' 74°20' 74°00'

41°00' 40°40' 40°20' 40°00' 39°40' 39°20' 39°00'

GEOLOGICAL SECTION,

SHOWING THE

FORMATIONS OF NEW JERSEY IN ORDER AND THEIR EQUIVALENT SOILS.

SOILS.	COLORS.	SECTION.	FORMATIONS.	
Alluvial Soils.			Alluvium	POST TERTIARY
			Glacial Drift	
Oak Land Soils.			Gravelly Earth	
Pine Land Soils.			Glass Sand and Sandy Clays	TERTIARY
Upper Marl Bed.			Upper Marl Bed.	
Middle Marl Bed.			Middle Marl Bed.	CRETACEOUS.
			Red Sand Bed.	
Lower Marl Bed.			Lower Marl Bed.	
Clay Marl.			Laminated Sand and Clay Marls.	
Clay and Sand Soils.			Potters and Fire Clays, and Sands.	
Red Sandstone, Shale and Trap Soils.			Conglomerates, Shales, Trap Red Sandstone and Trap Rocks.	TRIASSIC.
Limestone Soils.			Marcellus Shale Cherty Limestone.	DEVONIAN.
Slaty Soils.			Cauda-Galli Grit.	
			Oriskany Sandstone.	
Limestone.			Lr. Helderberg Limestone and Wal. Lime.	
Sandstone.			Red Slates and Sandstone.	SILURIAN.
Conglomerate Soils.			Sandstone and Cong. of Kittatinny Mt.	
Slate.			Shales, Roofing Slates, and Slaty Sandstones.	
Limestone.			Fossiliferous Limestone.	
			Magnesian Limestone.	
Sandstone Soils.			Sandstone, Slaty Grit and Green Pond Mt. Conglomerates.	
			Serpentine.	AZOIC.
Limestone and Granitic Soils.			Gneiss Crystalline Limestone Granite.	

NOTE.

Iron Mines are shown in red.