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Return to

GEOLOGICAL SURVEY
OF
NEW JERSEY.

THIRD ANNUAL REPORT

ON THE

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OF THE

STATE OF NEW JERSEY,

FOR THE YEAR 1856.

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TRENTON:
PRINTED AT THE "TRUE AMERICAN" OFFICE.
1857.

D. 1879.
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NEW JERSEY GEOLOGICAL SURVEY

To His Excellency,

RODMAN M. PRICE,

Governor of New Jersey:

Sir:

I have the honor herewith to submit to you the Third Annual Report on the Progress of the State Geological Survey, for the year 1856.

Very respectfully, your obedient servant,

WILLIAM KITCHELL,

Superintendent of N. J. State Geological Survey.

Newark, N. J., January 2d, 1857.

NEW JERSEY GEOLOGICAL SURVEY

REPORT

OF THE

SUPERINTENDENT AND STATE GEOLOGIST,

FOR THE YEAR 1856.

NEW JERSEY GEOLOGICAL SURVEY

REPORT.

At the commencement of the past year, the survey was in a condition to be actively prosecuted. The parties that had been previously organised and engaged in the field, had become sufficiently well acquainted with the nature of the researches required, to secure a rapid advancement of the work. Reconnoisances had been made, the preliminary arrangements attendant upon a work of this kind and extent were completed, and a large quantity of material had been collected and was in a condition to be systematized and employed in the preparation of the final County Reports.

Under these favorable circumstances, an appropriation of twenty-five thousand dollars was asked, for the purpose of advancing the survey, in accordance with the law, in the most expeditious and economic manner.

The appropriation having been made, the work in the office and laboratory was continued. The parties were prepared to enter the field as early as the season would allow.

Such was the condition of the survey when I received your instructions to close up its business, as it would be necessary to suspend operations on the first of May—the State Treasury not being in a condition to provide for the appropriation.

It was a matter of deep regret to myself, as well as to those who, appreciating the importance of this work, had labored to sustain it thus far, hoping to see it completed at an early day, in accordance with the plan that had been adopted.

It was evident that merely a temporary suspension of the

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survey would be a great loss to the State, inasmuch as the parties which had been organised with considerable difficulty, and had just become acquainted with the nature of their work, must be discharged, and researches but partially completed must be abandoned, and the various materials collected laid aside in a confused and disarranged state.

With a view, therefore, to preventing this, we were led to proffer the continuation of our services in the prosecution of the survey, believing that the next legislature would provide for the appropriation made at the last session.

Under these contingencies, the survey has been prosecuted during the past year, and although there has not been as much accomplished as was anticipated at the commencement of the year, nevertheless the work has actively progressed, and an additional stock of material has been collected, together with that which has been arranged for the preparation of the Final Reports.

TOPOGRAPHICAL DEPARTMENT.

This department of the survey has been prosecuted under the direction of Mr. E. L. Viele. A reference to his report will show the progress made.

CHEMICAL DEPARTMENT.

After the active operations of the survey were temporarily suspended on the first of May, Mr. Wurtz did not resume this department, consequently the series of quantitative analyses that he had commenced were not completed.

Mr. Kock, who had been previously engaged in Professor Cook's laboratory, has continued his services during the year, in researches connected with the geological department of the Southern Division of the State.

Dr. Ritschel has been engaged in my laboratory, in Newark, in the analysis of the iron ores and limestones of Sussex and Morris counties, and of the rocks of Essex and Hudson counties. In all, forty quantitative analyses have been

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completed, which will be reserved for the Final County Reports.

PALÆONTOLOGICAL DEPARTMENT.

Owing to the illness of Professor Hall, no progress has been made in this department, except in the collection of specimens, of which large additions have been made to the stock already on hand. Some of them have been sent to Professor Hall, at Albany, and they will be described and arranged as early as possible.

GEOLOGICAL DEPARTMENT.

In the Southern Division of the State, this department has been actively prosecuted, as a reference to the annexed report of Professor Cook will show. The Final Report on the County of Cape May has been prepared, and is now in the hands of the printer. It will be printed and ready for delivery, per contract, on the eighth instant. Researches have been made in other counties, of which the field work of Monmouth is nearly completed.

In the Northern Division, I have been personally engaged. Messrs. E. Haeusser and E. F. Baldwin have assisted me during a part of the year; the former in the counties of Sussex and Morris—the latter in the counties of Essex and Hudson.

In Sussex County, the different geological formations have been traced out and are located; sections showing their relative position and elevation have been made, and many of the minerals have been described. The metalliferous deposits have been examined and described, and a great part of the final report has been prepared. The whole county is in a condition to be reported on finally, as soon as the map is engraved and characteristic fossils of its formations described.

In Morris County, nearly the whole of the field work has been completed—at least as much as could be done until the map, which is nearly finished, shall have been placed in my

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hands. The formations have been examined, sections made, analyses of the iron ores, limestones, and serpentines completed, fossils collected, &c., &c., &c.

In Essex County, a detailed examination of the townships of Belleville, Bloomfield, Orange, Newark, Clinton, and Union has been made.

A detailed examination of the elevated portions of Hudson County, together with a more general one of the salt marshes along the Hackensack and Passaic Rivers, has also been made. The field-work of this county can be completed in two weeks, and the final report thereon prepared as soon as the map is finished.

In my last annual report, upwards of eighty iron mines were enumerated and described, all of which are situated in the counties of Sussex, Passaic, Morris, and Warren, and within an area of three hundred and sixty square miles.

Although some of them have been worked for a century and a half, and in early days furnished a very large proportion of the ore manufactured into iron in this country, yet they have been excavated to a very limited extent, many of them containing immense bodies of ore above water-level which may be economically extracted without the employment of expensive machinery.

It is estimated that they could be made to yield, advantageously, no less than one million tons of ore annually for many years to come, which would be sufficient to supply half of the present annual consumption of iron in the United States.

With a view to demonstrating the general character of these ores, together with their great economic importance, they will be considered briefly in this report, under the two following heads:

I. Geological occurrence and properties of the magnetic iron ores.

II. Metallurgy of the iron ores.

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I.—GEOLOGICAL OCCURRENCE AND PROPERTIES OF THE IRON ORES.

The different forms in which magnetic iron ore occurs in this district, are as follows:

First, in granules disseminated through the gneissoid rock as one of its necessary constituent minerals. The granules vary in size from particles so small that they cannot be seen with the naked eye, to grains corresponding in size with the other constituent minerals of the rock.

Second, in masses or bunches of very limited extent. This form generally occurs in those rocks that are the most highly metamorphosed—as the quartzo-feldspathic and syenitic rocks. These rocks, when considered with respect to their constituent minerals, do not exhibit a distinct lamination, nor when considered *en masse* do they exhibit distinct lines of stratification, as in gneiss or in mica and hornblendic schists; nevertheless, they generally pass into these latter rocks so insensibly that no line of demarcation can be drawn between them.

Third, in seams or strata, varying from the fraction of an inch to thirty feet in thickness. They alternate with strata of rock and coincide with them in strike and dip.

The ore seams, as well as the rocky strata, pitch downward beneath the surface towards the northeast at variable angles, and on this account the ore is exposed on the surface but to a very limited extent.

The seams or deposits of ore are generally remarkably pure, but they frequently contain in admixture the constituent minerals of their accompanying rocks. Apatite (phosphate of lime), hornblende, quartz, feldspar, and mica, are most common. In some portions, as in the Dickerson and Byram ores, apatite, in the form of granules, uniformly disseminated through the ore seam, constitutes as much as ten per cent. of it. This per centage may be considered as the maximum, and confined to few mines, and even to very limited spaces in those mines.

Hornblende frequently enters largely into its composition,

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as in the Sweeds mine, and many others. Mica, feldspar and hornblende are very frequently found entering largely into the composition of the ore seam, sometimes in granules irregularly disseminated through it, as in the Hibernia mines, and sometimes in laminæ alternating with laminæ of ore, as in the Beachglenn mine. Iron pyrites (sulphuret of iron) is also a common constituent of many of the deposits, among which may be mentioned the Silver, Haggerty and Stanhope mines. Quartz in small proportion, in the form of granules, disseminated throughout the ore, is not uncommon.

Generally, when the ore contains a considerable quantity of the above mentioned minerals in admixture, it is laminated, the planes of the lamination depending on one or more of the minerals. When, however, it is entirely or nearly free from impurities, it possesses a columnar structure, the general direction of the planes of the joints being at right angles to the inclination or dip of the ore seam.

Large wedge-shaped masses of rock, composed of quartz, hornblende, feldspar, mica and magnetite, called by miners "horses," frequently occur imbedded in the ore seams. Generally a line of demarcation can be drawn between the "horse rock" and ore, but so insensibly do they sometimes pass into each other that it is difficult to tell where the one begins and the other ends. They vary in extent, from regular seams or strata of rock alternating with the ore, to small irregular wedge-shaped masses, the longer axis corresponding with the strike of the strata, and its lamination, which is generally perceptible, corresponding with the lamination of the adjoining rocks.

Origin

Having described the geological occurrence of magnetic iron ore in this district, we are led to consider its origin, and to refer it to the particular class of metalliferous deposits to which it belongs; whether it is of aqueous or igneous origin; whether it occurs in the form of stratified or unstratified deposits.

That they cannot be referred to the unstratified deposits, appears evident from the facts stated in describing the different forms in which the ore occurs; nevertheless, it has

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been maintained by some that they are true veins of igneous origin, which implies that they extend to an indefinite length and breadth, that they differ in character from the rock in which they are situated, and have been formed subsequent to it. Such deposits do not usually coincide with the strike and dip of the strata in which they are enclosed, but generally cross the line of stratification and frequently send off branches of greater or lesser dimension, at different angles from the main vein. The body of the vein is in most cases separated from the walls on either side by decomposed rock called selvage.

It will be observed that none of these phenomena can be applied to the magnetic ore deposits of this district. Nor can they be veins of segregation, which implies that the material of which they are composed has been eliminated or collected together from the surrounding rock by some chemical action. Such deposits are composed of a gangue or materials different from the surrounding rock, and are very irregular in their form.

Stratified deposits imply that they are included within sedimentary rocks, that they are of aqueous origin, and that they coincide in geological position and in the mode of formation with the rocks in which they are situated. From the facts that have already been stated, they must be referred to this class of metalliferous deposits. Note!!

That the rocky formation of this district, including the gneiss, the hornblende and mica schists, the magnetic iron ore, and the quartzo-feldspathic rocks, are of metamorphic origin, there can be but little doubt; consequently, it is conceived that they were originally deposited by water in a horizontal position, that they are composed of materials derived from pre-existing rocks, and that they were subsequently disturbed in their position, and altered by metamorphic agencies, which have caused them to assume their present form and position. The origin, therefore, of these deposits of magnetic iron ore, is identical and cotemporaneous with the rocky strata in which they are enclosed.

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MAGNETIC PROPERTIES.

Whether we consider this ore-bearing district with respect to the deflection of the magnetic needle in different localities on its surface, or with respect to the magnetic polarity of the different seams of ore, or even of hand specimens, it presents a most interesting field for scientific research, which, undoubtedly, would lead to important economic applications.

To such an extent is magnetic iron ore disseminated through the rocky formation, that deflection of the magnetic needle is of frequent occurrence; so much so, that great difficulty is often experienced in surveying with this instrument. The amount of deflection and the distance at which it is produced, depend on the quantity of magnetic ore disseminated in the rock, and its position with respect to the surface; and as these are variable, no rule can be established by which the amount of deflection and the distance at which it is produced can be calculated. A very small mass of magnetic ore near the surface is frequently sufficient to reverse the needle, even when it is placed several feet above the ore, as in the case of a surveyor's compass when supported, on the tripod; and on the other hand, a large body of ore a few feet beneath the surface would produce but a slight deflection.

The ore, whether in seams or small masses, generally possesses magnetic polarity and a magnetic axis. There is, however, a great difference in the amount of influence exerted on the needle in different localities; in some the action being much more powerful and at a greater distance than at others. Seams of ore five feet in thickness, have been observed to deflect the needle at a distance of thirty feet; the intensity of its influence increasing as the magnetic axis of the ore is approached. Some deposits of ore possess more than one magnetic axis. On placing the needle on the out crop of such a deposit, so that the axis of the needle will correspond with the magnetic axis of the ore, and then gradually moving the needle in the direction of the ore

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seam, it will be reversed as many times as there are magnetic axes in the deposit. This is probably due to the difference in intensity of the magnetic properties of the ore in different parts of the same deposit. When a seam of ore is capped with rock even to the extent of a few feet, its influence on the magnetic needle when placed directly over it on the surface, is very variable; in some localities producing a great deflection, and in others but very little. So variable have been the results of the observations, with respect to this, that no rule can be established that would determine the greatest depth at which the needle would be affected, nor that would determine the quantity of ore from a given deflection of the needle at the surface.

The smallest fragments of ore frequently possess magnetic polarity and a magnetic axis; the extent of their magnetic qualities depending on their position with respect to the surface; the nearer to the surface, the greater will be their magnetic properties. This appears to depend on the action of surface water and atmospheric agents; for it as been frequently observed that ore when first taken out of a mine at a considerable depth, possessed but slight magnetic properties, but on being exposed to the atmosphere for a few months or years, it would increase so much that excellent hand specimens of loadstone for experimental purposes could be selected therefrom. Seams of ore that contain numerous joints and fissures, through which water and atmospheric agents pass, possess more decided magnetic properties than those which are more compact and less free from crevices and fissures.

Whether the mountain ridges of this district possess magnetic polarity, independent of the deposits of ore therein, I am unable to say, as our observations have not been sufficient to determine.

It is maintained by some that mountain ridges and cones possess magnetic polarity, independent of the presence of magnetic iron ore, while others attribute it invariably to the presence of this mineral, even if it be in quantities so small that they cannot be detected by the naked eye.

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Reich remarks, "that it is very desirable that numerous observations should be made in districts where considerable variations in the deviation are noticed, and at places not far distant, so as to ascertain whether these variations are not limited to peculiar localities. That this is the case, would appear from Sabine's observations of the inclination and intensity, at different parts of Scotland, which do not at all indicate disturbances effected by large mountains at considerable distances."

On the other hand, Hansteen "states that large mountain ranges exercise a sensible influence upon the mean direction of the magnetic needle. This result is obtained from an extended series of observations, made by himself, as to the deviation and dip of the magnetic needle, and the magnetic force, during a journey through Sweden, and especially through the mountainous western part of Norway."*

Bischof, after citing numerous observations that have been made in various parts of the world by different observers, in regard to the influence of mountains on the magnetic needle, concludes as follows: "Assuming that it is magnetic iron ore alone, either as masses or disseminated through rocks, to which the magnetic influences are to be ascribed, and in my opinion this is quite unquestionable, it would seem, that magnetic observations, instituted with the same degree of care as those made by Reich, would be well adapted for the discovery of hidden beds of magnetic iron ore. Such observations might, therefore, prove eminently serviceable to the iron industry. Certainly, it would be requisite first to ascertain whether mountain masses, containing only disseminated magnetic iron ore, but extending over a considerable surface, would not produce as great an effect as beds of magnetic iron ore. Sabine's observations do not appear to favor this. But, however this may be, the magnetic needle indicates the presence of magnetic iron ore, where it cannot be recog-

* Chemical and Physical Geology of Gustav Bischof, translated by Benjamin H. Paul, ii. 500.

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nized mineralogically, and demonstrates the very general distribution of this mineral."

These remarks have a particular application to this district. That the beds or seams of magnetic iron ore produce a much greater effect on the magnetic needle than mountain masses containing only disseminated ore, there can be no doubt. Numerous observations made over this whole district have satisfactorily demonstrated this; for the greater number of the seams of ore in which the mines are situated, have been discovered by indications of the magnetic needle. These facts, therefore, have a very important economic application. The use of the magnetic needle in revealing hidden beds of ore, of sufficient extent to be of economic value, requires considerable experience, together with a knowledge of the magnetic laws, which the different varieties of ore, when considered with respect to their form and extent, possess; even then the indications of the needle are very deceptive.

In order to distinguish between a small body or mass of ore and a continuous seam or large deposit, the distance at which the needle is deflected, together with the extent of the attraction in the direction of the magnetic axis of the ore deposit, should be considered. If it be but a small body of ore, its magnetic force will be confined to a very narrow space; if a continuous seam, it will be proportionably greater.

METALLURGY OF THE ORES.

Of the various forms of apparatus that have been used for the reduction of iron ores in different parts of the world, the three following have been chiefly employed in this State.

1. THE CATALAN FORGE.
2. THE CHARCOAL BLAST FURNACE.
3. THE ANTHRACITE BLAST FURNACE.

To these may be added Renton's Furnace, which was first erected and put into operation in this State.

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The Catalan Forge and Renton's Furnace are adapted to the manufacture of wrought iron directly from the ore; the Charcoal and Anthracite Blast Furnaces to the manufacture of pig iron.

CATALAN FORGE.

This kind of forge is said to have been used by the ancient Romans, and to have been in operation from that time to the present day. It was introduced into this State as early as the beginning of the eighteenth century, and has been in constant use ever since.

It is generally designated as the "bloomery fire." The form of its construction is very simple and nearly uniform everywhere. With the exception of the hot blast, but little improvement has been made in it from its introduction into the State to the present time.

The common bloomery fire consists of a hearth of stone-work, from six to ten feet square, in which there is a fire-place from twenty to thirty-six inches square, and from fifteen to thirty inches deep, lined with cast-iron plates. It is arranged with hot blast and driven by water power.

The richest magnetic ores alone are used. When there is considerable extraneous material mixed with the ore, it is separated therefrom, either by means of washing, or by the magnetic separating machine.

The deoxydizement or reduction of the ore is accomplished by means of charcoal.

The average quantities of ore and coal required in the production of one ton of malleable iron in the form of blooms, is as follows:

Ore, - - - - -	2 tons.
Coal, - - - - -	300 bushels.

The ore, after having been mechanically reduced by means of stamps to a condition resembling coarse sand, and if required, separated from the impurities by the magnetic machine or by washing, is introduced into the forge, in alternating charges with coal; each charge consisting of about

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two hundred and fifty pounds of ore and twenty-five bushels of coal.

As the process of deoxydizement and reduction progresses, the melted iron collects in the bottom of the fire-place, from whence it is removed in a semi-fluid or pasty mass, and placed upon an anvil, where it is either fashioned into a bloom, or drawn out into bar-iron, by a heavy hammer worked by water-power. When it is made into bar-iron, it requires a succession of heats and hammerings, whereby a larger quantity of materials is consumed in producing a ton of bar-iron; two and a half tons of ore, and five hundred bushels of coal, being the standard quantities allowed.

At many of the forges the iron is manufactured into anchors, which find a ready sale in New York, on account of their superior strength.

RENTON'S FURNACE.

Various attempts have been made from time to time to invent apparatus by which wrought iron could be manufactured directly from the ore, more economically than by processes at present used. Of these, Renton's Furnace has been introduced into this State. It is situated in Newark, and was erected about five years ago, under the direction of the patentee, James Renton, for the American Iron Company, of that city.

It consists of two principal parts: first, a brick stack, sixteen feet high and thirteen feet square, enclosing a chamber, in which are placed a series of vertical fire-brick tubes, each twelve feet in length and five by eighteen inches in section; second, a puddling and welding furnace, with which the fire-brick tubes are connected.

The ore is introduced into the tubes at the top of the stack, after having been reduced to a state of great mechanical subdivision, resembling fine powder, and mixed with about twenty per cent. of charcoal dust as a deoxydizing or reducing agent.

The tubes, being filled, are left open at the top, and closed

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at the bottom by a contrivance which enables the furnace-man to let the charge down into the puddling furnace at his pleasure.

The heat from the puddling furnace passes around the tubes in which the ore is inclosed, and raises them to a high red heat, by which the ore is exposed to a temperature sufficient to produce deoxydizement. After the ore has been exposed to the heat for about eighteen hours, it is let down into the puddling furnace, where it is welded or collected into a ball, and from thence taken to the trip-hammer or squeezer to be fashioned into a bloom, or prepared for the rollers.

The gases formed in the reduction of the ore make their escape at the open end of the tubes.

About two tons of iron are manufactured with one furnace, in twenty-four hours, when the ore is of good quality.

From the above description, it will be seen that the ore undergoes two successive changes: first, it is deoxydized by means of the carbon, and thereby reduced to a metallic state; and second, it is collected together in a ball suitable to be brought under the hammer.

It is evident that only ores in the form of oxides, and those in a pure state, are adapted to this process. Among the ores that have been most successfully reduced in this furnace, is the magnetic ore of the Dickerson mine. Ores of equal purity, from other mines in this district, would unquestionably work equally as well, but I am not aware that they have been tried.

The obstacles to the success of this furnace, in an economic production of iron, appear to be:

1st. The uniform purity and minute subdivision of the ore, required.

2d. The time and labor required in producing a ton of iron.

It is claimed, however, by its proprietors, that " the distinctive peculiarity and superiority of the furnace over all others is, that by its mechanical arrangement, the chemical change which is commenced and carried on in the tubes is

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not interrupted until the ball is ready for the hammer, thereby reducing the manufacture of wrought iron into a practical, economical, scientific, and uniform system," and that the advantages of this method over the old modes, are as follows, to wit:

"The ores yield a greater per centage:

"The iron is more uniform, and of a better quality:

"It is made cheaper, and does not require such a heavy outlay of capital."

As I am not in possession of facts respecting the outlay in erecting this furnace, and the cost of producing a ton of iron, I am unable to judge of its merits.

CHARCOAL BLAST FURNACE.

Formerly, this kind of furnace was extensively used in the reduction of these ores; but since the introduction of anthracite coal in the manufacture of iron, and the great scarcity of charcoal, it has been almost entirely abandoned.

In eighteen hundred and thirty-two there were in the State twelve in blast; and at the present time I know of only two, viz: the Oxford and Wawayanda furnaces. The Oxford furnace is situated in Warren County, and is owned by Charles Scranton. The ore used in the furnace is derived from mines in the vicinity. The iron is manufactured into car wheels.

The Wawayanda furnace is situated on the Wawayanda Mountain, near the New York state line. It is of large size, and arranged with hot and cold blast. At the time it was visited the cold blast alone was used, because a superior article of iron was thus produced.

The ore is obtained from the mines bearing the same name, in the vicinity.

The following materials are consumed in producing a ton of pig iron:

Charcoal, - - - - -	160 to 200 bushels.
Magnetic iron ore, - -	2 tons.
Limestone, - - -	0.25 tons.

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They are introduced into the furnace at the tunnel-head, in charges; each charge consisting of eleven baskets of coal, (twenty-two bushels,) five hundred and twenty-five pounds of ore, reduced to a state of mechanical subdivision, about the size of hickory nuts, and from thirty to fifty pounds of limestone, the quantity depending on the quality.

From fifty to sixty charges are introduced in a day of twenty-four hours, yielding from seven to eight tons of iron.

The casting is done twice a day—at noon and at midnight.

The iron is considered peculiarly adapted to the manufacture of car wheels, and is chiefly consumed by Whitney & Son, of Philadelphia, for this purpose.

The ores of the principal mines throughout this district, in former days, have been extensively reduced in these furnaces. The iron manufactured therefrom has been of excellent quality, as the various uses to which it has been applied will testify.

ANTHRACITE BLAST FURNACE.

The introduction of anthracite coal in the manufacture of iron, has done much for the advancement of the iron industry in this country, and must ere long place it beyond foreign competition.

The application of this coal for the reduction of rich magnetic ores, was first made by Mr. Edwin Post, who erected a furnace at Stanhope and commenced the manufacture of iron from the Irondale ores.

This experiment soon led to the erection of anthracite furnaces in the vicinity of the coal-fields of Pennsylvania, which, to this day, have obtained a large proportion of their ores from New Jersey—the idea being entertained that the iron manufacture could be more economically prosecuted by transporting the New Jersey magnetic ores to the coal-fields, and there smelting them, than by the transportation of the coal into the iron region. The prevalence of this idea has been the means of delaying the erection of anthracite furnaces in this State; but under the influence of increased and

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still increasing facilities for transportation, the time has arrived when the manufacture of iron may be as economically prosecuted in the iron region of this State as in the coal districts of Pennsylvania.

The principal anthracite furnaces of this State in which the magnetic and specular ores of this district have been worked, are four—three of which are situated at Phillipsburgh, on the Delaware River, in Warren County, and one at Boonton, in Morris County.

The furnaces at Phillipsburgh are of very large size—two of them fifty-five feet high, hearth seven feet, tunnel-head ten feet, and bosh twenty and twenty-two feet. The smallest one is forty-two feet high, hearth seven feet, tunnel head eight feet, and bosh eighteen feet.

The largest furnace, viz.: fifty-five feet high and twenty-two feet bosh, works much better than those of lesser dimensions; it requires less fuel and labor in producing an equal quantity of iron.

To the present time the three furnaces have produced ninety-six thousand tons of pig-iron. Their average weekly yield is five hundred tons. The maximum weekly yield of one furnace is two hundred and fifty-one and a half tons. In the smallest furnace, two hundred and thirty tons have been made per week, for six weeks in succession, with one and a half tons of coal per ton of iron.

The ores consumed in these furnaces have been obtained chiefly from the Andover mine, nearly two hundred thousand tons having already been consumed. The ores of the Roseville, Dickerson, Allen, Hibernia, Irondale and Ringwood mines have also been used alone, as well as mixed with Andover ores.

At first, under the impression that Andover ore would not work well alone, it was mixed with hematite ore, in different proportions; but it was soon ascertained that the Andover ore worked better and made a superior iron to the mixture, and the hematite was consequently abandoned.

The coal is that variety of anthracite known as Lehigh coal, and was obtained from Mauch Chunk.

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The flux is a magnesian limestone obtained from the quarry within a few hundred yards of the furnaces.

The pig iron produced at the furnaces is puddled with anthracite coal, at the rolling mill of the company, at Trenton, and the blooms thus made have been manufactured into the various kinds of bar iron, railroad iron, wrought iron beams for fire-proof buildings, wire of different sizes and of the finest quality, shafts of great strength and toughness for large class steamers, and steel of superior quality.

The following materials are consumed in producing a ton of iron, in the use of the above ores, respectively:

ANDOVER MINE.

Andover ores, (specular,) - - -	2.25 tons.
Coal, - - - - - - -	1.75 "
Limestone, - - - - - -	0.25 "

The iron is similar to that produced from the franklinite ore, being highly crystalline, and in its fracture having a bright metallic lustre, resembling that of antimony. A large proportion has a foliated structure, being crystalized in laminæ; another variety has a fibrous structure, the fibres radiating from the centre to the outside of the pig; and another variety has a granular structure, the grains being coarse and crystalline.

It is considered, for many purposes, superior to iron manufactured from magnetic ores, on account of its crystalline structure, caused by the presence of manganese and a more intimate union of the carbon and iron.

ROSEVILLE MINE.

Magnetic ore, - - - - - -	3 tons.
Coal, - - - - - - -	2.5 "
Limestone, - - - - - -	0.3 "

The small proportion of limestone required is owing to the prensence of carbonate of lime mixed with the ore.

The iron is red-short, but it is soft and very fine grained, and is well adapted to foundry purposes.

It has been advantageously used in the manufacture of

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kettles for trying out whale oil, and for this purpose has gained considerable notoriety.

RINGWOOD MINES.

Magnetic ore, (assorted,) - -	1.75	tons.
Coal, - - - - - -	1.75	"
Limestone, - - - - -	0.65	"

DICKERSON MINE.

Magnetic ore, - - - -	2	tons.
Coal, - - - - - -	2	"
Limestone, - - - - -	0.8	"

The iron is cold-short, even when mixed with one-fourth Andover ore, but makes a good foundry iron.

ALLEN MINE.

Magnetic ore, - - - -	2.25	tons.
Coal, - - - - - -	2	"
Limestone, - - - - -	0.5	"

The iron is slightly inclined to red-short, but makes a good forge iron, and when mixed with one-fourth Andover ore, produces a superior article, equal to the Andover iron.

HIBERNIA MINES.

Magnetic ore, - - - -	2	tons.
Coal, - - - - - -	2	"
Limestone, - - - - -	0.4	"

This iron is similar to that produced from the Allen ore.

In the use of the above ores, the following results have been obtained:

1. Ores containing apatite, (phosphate of lime,) produce a cold short iron.

2. Ores containing iron pyrites, (sulphuret of iron,) produce a red short iron, but suitable for foundry purposes.

3. Ores containing manganese produce a hard crystalline iron, which is neither cold nor red-short, but of great tenacity.

4. Ores 1 and 2, or 1 and 3, or 2 and 3, mixed in suitable

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proportions, produce a neutral iron, suitable for forge purposes.

THE BOONTON FURNACE.

This furnace is forty feet high, fourteen feet bosh, five feet tunnel-head and hearth, and has six tuyeres.

Its average annual production is 6,000 tons of pig iron. In 1855 it produced 6,179 tons.

The ores used are exclusively the magnetic ores of Morris County, chiefly from the Sweeds and Mount Pleasant mines.

The flux is magnesian limestone, obtained chiefly from Hackettstown, in Warren County, and Montville, in Morris County.

The coal is anthracite, and of the Lehigh variety.

The following quantities are consumed in producing a ton of pig iron :

Magnetic ore, - - - - - -	2	tons.
Coal, - - - - - - -	1.87	"
Limestone, - - - - - -	.06	"

The Sweeds ore produces a red-short iron, and the Mount Pleasant ore a cold-short; but when mixed as they are here used, they produce a neutral iron of excellent quality, and admirably adapted to the purpose for which it is applied.

The pig-iron is puddled at the works adjoining the furnace, and the blooms thus made are rolled into nail-plates and rods, which constantly employ one hundred and nine machines in manufacturing nails and spikes; of which, during the year 1855, 146,445 casks, of 100 pounds each, were produced.

ANTHRACITE FURNACE FOR REDUCING FRANKLINITE ORE.

In connection with the metallurgy of the magnetic and specular varieties of iron ore, may be included the franklinite ore, which, until Mr. Edwin Post reduced the ore with anthracite coal, at Stanhope, and thereby demonstrated the application of that fuel to its reduction, has resisted all attempts to its introduction in the manufacture of iron.

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I regret that I am not in possession of details respecting the "modus operandi," and the results of this experiment, in order to give a minute account of it, and thus render to Mr. Post the credit to which he is entitled for this valuable contribution to metallurgical science.

Since Mr. Post's experiment, two furnaces have been erected for the reduction of this ore, one at Newark, at the zinc works of the New Jersey Zinc Company, and the other at Franklin, in the vicinity of the deposit of ore. The former was erected for the purpose of reducing the residuum (chiefly franklinite) of the zinc furnaces; the latter, for reducing the ore as it occurs in its native bed at Franklin, Sussex County.

THE NEWARK FURNAC.

This furnace was erected under the superintendence of Mr. C. E. Detmold, (late President of the New Jersey Zinc Company,) during the autumn of 1855. It is a small anthracite blast furnace, twenty feet high, eight feet bosh, and four and a half feet tunnel head.

It has three tuyeres, and is arranged with hot blast. It is made of fire-brick, enclosed by a sheet iron mantle and strengthened by wrought iron bands.

The furnace is surmounted by a chimney, ten feet high and four feet six inches square, with three doors for charging the furnace. Near the top of the chimney is an opening four feet in diameter, through which the zinc passes into a sheet-iron pipe leading to the fan. The mouth of the chimney is closed by four dampers, which may be raised whenever the zinc and gases do not pass freely into the pipe.

The ore from which the residuum is derived, is a mixture of franklinite and red oxide of zinc. The zinc is extracted in the form of the white oxide, by a process of sublimation; the ore having been crushed and mixed with a portion of fine coal as a reducing or deoxydizing agent, and then subjected to a high temperature in closely muffled furnaces, which causes the vapor of zinc to be evolved and consequently re-oxydized, in which state it is used as a paint.

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The residuum obtained by this process, is composed chiefly of franklinite and carbon, in the form of a fine powder, resembling fine sand.

The fuel employed is anthracite, and the flux oyster shells.

The following quantities were consumed in producing a ton of pig iron:

Residuum,		2.90 tons.
Coal for furnace,	2.10 tons.	
" " boilers,	1.10 "	
" " hot blast,	0.16 "	—3.36 "
Oyster shells,		0.43 "

For every ton of pig iron produced, one hundred and thirty-six pounds of the oxide of zinc were collected; and as the arrangement for allowing the escape of the zinc and gas was not sufficient to carry them off, it was found necessary to keep open one or two of the dampers at the mouth of the chimney, through which a large proportion of the zinc escaped and was lost.

When the furnace was in good order, the production of pig iron was from thirty to forty tons per week; the residuum yielding from thirty-three to thirty-seven per cent. of iron, and the coal consumed *in the furnace* from one and a half to two tons per ton of iron. After the furnace had been in blast twenty-one weeks, one of the boilers failed, which rendered it necessary to "blow out" the furnace.

During the twenty-one weeks it was in blast, it consumed:

Residuum,	1631 tons.
Coal for the furnace,	1165 "
" " heating boilers,	607 "
" " hot blast,	88 "

Its production was:

Pig iron,	552½ tons.
Oxide of zinc,	77,255 lbs.

THE FRANKLIN FURNACE.

This furnace was erected by the New Jersey Franklinite

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Company, and put in blast in the winter of 1854. It was in operation only a few weeks, owing to some imperfection in its construction and the inexperience of the workmen "in the combined operation of smelting iron and collecting zinc oxide."

It is a small blast furnace with hot blast, and arranged with a chimney at the tunnel-head, with which a pipe is connected for conveying the zinc oxide to a condensing chamber.

Although the furnace was in blast but a short time, yet sufficient data were obtained to satisfy the company that the franklinite ore can be economically smelted, yielding two products, viz: a superior article of pig iron and the oxide of zinc.

The ore used was taken from the great metalliferous deposit in Mine Hill, and considered of a mixture of franklinite, red oxide of zinc and willemite, (sillicate of zinc.)

The following is an account of the working of the furnace for two weeks, ending March 25, 1855. During a part of this time the zinc oxide was not collected, on account of a deficiency of power to work the fan:

Ore used, - - - - -	102.50 tons.
Coal, - - - - - -	137 "
Limestone, - - - - -	25.20 "
Iron made, - - - - -	22.90 "
Oxide of zinc made, - - - -	22,084 lbs.

The iron produced from the franklinite ore is of a very peculiar quality and excellency. It is particularly adapted to the manufacture of steel and malleable iron, and hence commands a higher price than pig iron manufactured from other ores of iron. Dr. A. A. Hayes, of Boston, has analyzed a specimen of iron produced at the Franklin furnace. The following extract is taken from his report thereon to the company:

"In general physical characters, the sample resembled 'white pig iron,' but a closer inspection shows a different molecular arrangement, by which the crystals are affected

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in form and distinctness by chemical dissection. The mass of iron exhibits *two* distinct crystalline aggregations; the broad folia of one of these being separated by thin lamina of a different color, hardness and composition, in this respect resembling meteoric iron. The color of the specimens is nearly that of the finer samples of metallic antimony; the masses divide easily, but the angles and edges of the imperfect crystals are harder than the hardest cast-steel, and in the attempts to obtain a powder, they became embedded in its surface; a mean specific gravity is at 60 F. 7.665. Electrically, it presents a positive part, closely invested by a relatively highly negative body. Chemically, its characters are of an imperfect steel; its carbon constituent is in the state of that which has been deposited from carburetted gases by a high temperature, and has no properties in common with graphite.

"No trace of sulphur was found. A trace of phosphuret of calcium could be detected, but neither zinc, chromium, vanadium, or copper could be found. Associated with the carbon in an accidentally earthy manner, derived doubtless from the slag, and in this is a minute quantity of unreduced franklinite. This occurrence of ore in iron I have often noticed in samples which *do not* present graphite. There was no evidence of the existence of the metallic bases of the earth's either.

ANALYSIS.

"In the following statement the iron is presented as a simple alloy, consisting in one hundred parts of

Pure iron,		93.364
" manganese,		3.204
" carbon,		2.250
Slag, silica,	.640	
Ore and alumina,	.240	
Lime,	.170—	1.050
		99.868

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"The mechanical and chemical constitution of this iron point to great ease in working it into malleable iron. Both the manganese and carbon are readily oxidized by the puddling, while the pure iron will take the form of tough or malleable iron very readily. It is also the kind of metal required for manufacturing steel, by fusion with oxide of manganese, losing in the operation a portion of carbon and all its metallic manganese."

An essay of a bar of franklinite iron, manufactured at Stanhope, by Mr. Edwin Post, was made at the French National Establishment, for the manufacture of chains and anchors for the navy, by Mr. Theophile Bornet, chief of the works, and author of the "Tables of the Strength of Metals."

"REPUBLIQUE FRANÇAISE."

ADMINISTRATION DE LA MARINE."

FORGES NATIONALES DE LA CHASSANDRE.

Essay of a bar of iron from a new ore, THE FRANKLINITE, *from New Jersey, United States:*

The bar, obtained by direct treatment of the ore in a catalan forge, is 25 millimetres by 24.5 millimetres square, and presents a section in square millimetres of - - -	612.50 *m.*
Charge under which the bar began to stretch,	15,000 *k.*
Elastic force, per millimetre, - - -	24.5 *k.*
Charge under which the bar broke, - -	25,000 *k.*
Absolute tenacity, per millimetre, - -	40.8 *k.*
Elongation of the bar at the moment of fracture, per millimetre, - - - -	5 *m.*

Aspect of the fracture—all nerve. The bar was imperfectly welded, and contained fissures which diminished the real surface exposed to traction; in consequence, the *absolute tenacity,* had the bar been sound, would have been greater. At the moment of rupture, but little heat was disengaged.

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Observations.—The tensions of the hydraulic press of the national forges, are given by means of an excellent apparatus, which indicates the results with the greatest precision. An immense number of experiments have been made with this press, not only upon all the irons of France, but upon the best irons of England, Sweden, Spain and Siberia; never, until the present essay, has any bar been tried the *absolute tenacity* of which surpassed 40. killogrammes per millimetre.

(Signed,) TH. BORNET,

Chef des Travaux aux Forges Nationales de la Chassande.

GUERIGNY, 12th July, 1850.

P. S.—The franklinite iron tried at the forges, works and welds to perfection.

(Signed,) T. BORNET."

The following summary of the progress and present state of the iron manufacture in this country, together with the remarks upon its future prospects, is taken from a masterly paper on the "Statistics and Geography of the Production of Iron," by Abram S. Hewitt, Esq., of Trenton. It furnishes an admirable sequel to the details of the supplies and manufacture of iron which have been given in the preceding pages :

"In 1740, when the English iron trade began its wonderful career, this country was a comparative wilderness. A hardy population, scattered along the seaboard, barely succeeded in conquering for themselves the means of livelihood. The resources of the country were unknown, and no roads existed into the interior, nor was there any capital to be spared for the erection of works, from the resources of a community struggling for existence. Skilled labor was not to be found among a race who had quitted their ancient homes from a stern sense of duty at a time when operatives were proverbially ignorant and brutish. Notwithstanding these difficulties, the manufacture of iron took root; and as factories for the working of iron in the colonies were strictly forbidden by the mother country, the pig iron was chiefly

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exported to England, so that for the year 1771, the amount reached seven thousand five hundred and twenty-five tons. When the revolution broke out, the country was in a condition to supply the iron required for the great work of freedom; but so little capital existed that the Continental Congress were forced to take up the business of iron-masters, and made in New Jersey, chiefly, the iron and steel required for the army.

"By the close of the war, England had entered upon the full tide of success in the manufacture of iron, by the use of mineral coal. Capital, skill, and labor abounded, while here all was distress; the currency deranged by the unmanageable flood of continental money, and exchanges made by the rude process of barter. The advance of the nation from a condition of bankruptcy, with its resources all undeveloped, was painfully slow; while in England, each year added to its resources, its skill, and its ability to withstand and crush competition. But the United States could be no competitor, using charcoal against mineral coal. It was not even known at the beginning of this century that we had any coal that could be rendered available for this purpose; and when our great resources in this respect began to be understood, there were no avenues to market from the coal fields. These avenues have since been constructed; but at what an enormous outlay of energy, capital, skill and dogged resistance to obstacles of every kind, those who are familiar with the history of the Schuylkill canal, the Reading railroad, the Lehigh canal, the Delaware and Raritan, the Chesapeake and Ohio, the Delaware and Hudson, the great state works of Pennsylvania and New York, will alone be able to comprehend. The outlay for this purpose, which had to be made before the iron business could be said to have a chance of existence in this country, probably exceeded one hundred millions of dollars; and it was not until 1840, that the first furnace was successfully started and worked with anthracite coal, which in England was regarded as entirely inapplicable, until 1837, when Mr. Crane first demonstrated that it could be used.

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"After Crane's success, new efforts were made; and it is to be recorded to the honor of Nicholas Biddle, that he was among the first to contribute his money and his influence to the successful prosecution of the business. To another of our New York citizens, Edwin Post, Esq., who brought great intelligence, capital, and indomitable perseverance to the task, is due the honor of having first smelted successfully our rich magnetic ores with anthracite coal, at Stanhope, N. J., as he has since succeeded in reducing the franklinite heretofore believed to be entirely refractory.

"From the time of the application of anthracite coal, the historian will date the birth of the American iron business. Its great density and purity fit it peculiarly to our rich ores; so that while in England, with three years the start of us, the product of anthracite iron had reached only one hundred and forty thousand tons in 1855, in this country it amounted to at least three hundred and sixty thousand tons; showing that, where an approach to an equality of the elementary conditions can be realized, there are lacking in this country neither energy nor skill to take advantage of the opportunity to achieve a successful result.

"The increase of capital in this country, and especially in the hands of the iron-masters, will overcome one of the artificial advantages which the English have heretofore possessed over us. At present, capital is unusually dear in England, and the course of trade, and the better knowledge abroad of our resources, are doing much to equalize the value of capital, and to remove one of the most serious difficulties in the way of the progressive growth of our domestic manufactures.

"But at the periods of low prices, the English maker does not require so much capital, because his labor is cheaper, and his iron therefore costs less.

"It is certain, however, that within the last ten years the disparity in the wages of labor in the two countries, has been greatly reduced, not by any fall in the price here, but in the increase of the price in England. And it would seem reasonable to anticipate that, with the present rapid and cheap

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intercourse between the two continents, an equalization in the rewards of human industry would inevitably take place, and every step towards such an equality is in favor of our production of iron on terms of equality in every respect.

"It is apparent, then, that the only reason why iron *now* costs more to make in this country, is the greater value of capital and labor, and that there are natural laws at work, slowly but surely sapping at the roots of these obstacles. But it may be alleged that it will require too long a time to equalize these conditions, and that it is better to abandon the business now, and wait till these desirable changes have actually been realized. To say nothing of the ruin which this course would entail upon those who are now engaged in the business, and who have nursed it to a condition where it no longer requires the aid of any duties beyond what the revenue of the general government demands; to say nothing of the loss of skill and machinery, which twenty years of sacrifice would not replace; I think that another natural law is at work, which will soon place us beyond the aid of tariffs or the fear of competition—a law which, overcoming the extra cost of labor and capital, insures to us that iron will be produced here at an early day as cheaply as it can possibly be got from Great Britain, even if entire free trade be allowed. If such be the fact, to discriminate against the iron trade, to deny to it the revenue duties which are imposed upon other articles of import, would be the height of folly; for the business would be ruined, and the country would save no money and vindicate no principle by such consolation.

"Let us see what this law is. I have been at great pains to trace the increase of the consumption of iron by the world, and to form an accurate idea of its future demands. I have called your attention to the fact that, even now, the resources of Great Britain have been so taxed to meet the existing demand, as to increase *the cost* of iron, (I do not mean the price,) because the miners are driven to less favorable localities to procure adequate supplies of raw material. If the production of three and a half millions of

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tons per annum has made each ton cost more than it did when the production was only two millions, the addition of another million must have a corresponding effect. But the world will want and must have the other million, and two of them, and three of them, and, unless other countries aid in the supply, the price will rise far above our present cost of production. It seems to be the inevitable conclusion of the facts I have stated, that this day is not far distant. Even now, we can make iron at the *average price* of English iron, and if we make none, that average price would be higher; so that there is no reason to believe that iron would be sold for less than it now is, if it all came from England. But let it be noted that the American iron-master now asks for no special legislation in his behalf; but he objects to any legislation, and very properly, which excepts him from whatever incidental advantage there may be in the fair imposition of duties for revenue. Heretofore, in times of great depression, long continued, he has felt the want of financial or legislative corks to float him over these 'sloughs of despond,' and it is at such times, and such times only, that you have heard him, a drowning man, conscious that he has many years of life in him, if he could only touch a buoy for a short period, calling on Congress for temporary relief, or entreating that the slight prop between him and ruin might not be knocked away. Now, however, he feels that the steadily increasing demand of the world for iron, and the fact that England cannot supply the whole of it without a decid increase in cost, insures to him that soon, aside from question of capital and labor, these periods of extrem pression will either cease to occur, or if recurring at all continue for such short intervals that he can sustain him till the improvement takes place.

"I have been thus careful to show that this day the p session of adequate skill, of extensive and properly c structed works, of a large body of intelligent workmen great natural resources in the way of raw materials channels of communication, and of equally great ones in th canals and railways which the genius of our age and people

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have constructed, makes legislation for the purposes of protection no longer necessary, because I regard the days of protection, for the sake of protection, as passed away. I have been equally careful to show that the artificial elements of dearer labor and capital do not make us independent of a fair share of those duties which are necessarily imposed for the raising of national revenue, but that there are causes at work which promise soon to make us independent even to this aid, to which we have a fair claim in the balance of national interests; because, under this state of fact, intelligent and influential men, identified with our great railway interests, have combined together in the short-sighted policy of demanding a remission of the duties on railroad iron at a time when it has been demonstrated, and is admitted by all experienced engineers, that our American rails are more durable than the foreign rails, and consequently worth more by the whole amount of duty paid. They have made this movement at the very time when the facts and probabilities all favor the conviction that the steady approach to the equalization of the elementary conditions of cost in the two countries, will soon place us on a par with our only competitors.

"We can point with pride to the fact that we have passed the half-way point; and if the business is not struck down by legislation expressly leveled at its destruction, in less than two years we shall be able to supply the whole wants of the country.

"Having thus traced the progress of the trade in this country, and shown that its difficulties are only artificial and temporary, it only remains for me to investigate the geographical elements of our present make of iron, and to show in what parts of this great country are, and will be, the seats of production.

"The Delaware, with its main branch, the Lehigh, reaches into the coal region. The secondary ores abound along its shores, while the Morris Canal has made the great primitive ore resources of New Jersey easily accessible. Hence the earliest successful efforts to make iron with anthracite coal

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on a large scale occurred in this region, and from the cheapness of the raw materials, it must be the leading seat of the iron trade on the Atlantic slope. New York is the natural outlet for this region, and our far-seeing capitalists have already made provisions for it by the construction of direct lines of canal and railway. The product of this region in 1855, was about one hundred and forty thousand tons, including, as I always do, the make of wrought iron direct from the ore."

Mr. Hewitt, in his valuable paper, above quoted, has demonstrated that the increasing iron consumption of the world will soon overtask the national resources of Great Britain, and that no other country but the United States can make up the surplus in the main. This, together with the rapidly increasing consumption of the United States alone, will ere long place this branch of industry the foremost in our country, in which New Jersey must take a very active part, not only in furnishing the raw material, but in the manufacture of the iron therefrom.

WILLIAM KITCHELL.

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REPORT ON THE PROGRESS

OF THE

GEOLOGICAL SURVEY,

OF THE

SOUTHERN DIVISION OF THE STATE,

DURING THE YEAR 1856.

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To Dr. Wm. Kitchell, *Superintendent of the Geological Survey of New Jersey:*

Sir:

I herewith submit my report on the progress of the Geological Survey in the Southern Division of the State, for the year 1856.

Your obedient servant,

GEO. H. COOK,

Assistant State Geologist.

Rutgers College, New Brunswick, Dec. 26, 1856.

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REPORT.

The Geological Survey of the Southern Division of the State has been continued, either in the field or in the laboratory, during the entire year.

The final report on the geology of the county of Cape May has been finished, and is now in the printer's hands. It is expected that it will be published in the early part of January.

In regard to this county, it may be stated, that although there is but little variety in its geological formations, and though it has no mineral wealth, it has in its soil and climate peculiar advantages for agricultural improvement. The price of land is low and a large portion of the best soil in the county is still unimproved. Considerable space has been occupied in describing the different fertilizers which are found, and in detailing the methods by which they may be made useful. The agricultural resources of Cape May, when properly developed, will add largely to the wealth of the state; and it is hoped that the geological and agricultural report, with the topographical map of the county, by Lieutenant Viele, will render important service towards this object.

Several contributions have been made to the Cape May Report, which add materially to its interest and value. Thos. Beesley, Esq., of Dennisville, has furnished a List of the larger Wild Animals of the county, and a very full Catalogue of its Birds. He has also commenced collecting birds for preservation in the State Cabinet. Professer Spencer F. Baird, of the Smithsonian Institution, Washington, has fur-

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nished a Catalogue of the Fishes of the New Jersey shores. Samuel Ashmead, Esq., of Philadelphia, has contributed a set of beautifully preserved specimens of the Marine Algæ of our sea-shore, with a Catalogue; also a List of Flowering Plants collected about Beesley's Point, together with specimens of a part of them. Dr. Maurice Beesley, of Dennisville, has written for the volume an interesting and carefully authenticated "Sketch of the Early History of the County of Cape May." I take pleasure in calling attention to the valuable and generous assistance which these gentlemen have rendered to the survey.

Neither can I, in justice, omit to acknowledge the useful assistance and the hospitality which I everywhere received.

§ The survey of Monmouth County is nearly completed. A large number of marls have been analysed for the final report, and levels have been taken for the proper construction of geological sections. Much material in relation to its agriculture has also been collected; and the principal work remaining, is to delineate the geological formations upon the map of the county, and to write the final report. These can be accomplished in a short time after the map is received. From the report of the topographical engineer, Lieutenant Viele, it will be seen that his field operations in Monmouth are completed, and the map may be expected soon.

§ In Cumberland County, all the townships have been partially examined; specimens of soils have been collected, also of marls and other fertilizers, and full notes of the agricultural practice and capabilities of the county have been made. The laboratory work is commenced and every preparation is made to carry the survey of the county forward with dispatch.

§ All the remaining counties in the Southern Geological Division of the state, have been visited; examinations of the geological formations have been continued; collections of fossils, soils and fertilizers have been made to some extent from each of the counties. Especial attention has been given to agriculture, and it is hoped that a beginning has

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been made towards collecting and embodying, in available form, the successful practice of our best farmers.

§ The Southern Division of New Jersey, on account of some of its mineral deposits, as well as from the numerous and enormously large fossil bones and shells found in them, has long attracted the attention of geologists. Up to the year 1827, it had generally been spoken of as an alluvial formation. Some had designated it as tertiary. In that year Mr. Vanuxem and Dr. Morton, from facts which they had collected, came to the conclusion that the *marl* or *greensand* of this state was of the same geological age with the cretaceous formation of Europe. Subsequent investigations have confirmed the opinions of these gentlemen.

As the principal representative in our country of the cretaceous formation, various localities in the marl region have been much resorted to by geologists for the purpose of collecting its peculiar fossils. The inhabitants have also been in the habit of preserving some of the fossils, to give to persons who might esteem them as curiosities. In this manner the fossils have been very extensively scattered; and while some of them have found their way into cabinets of geology, the majority of the specimens, including among them many that were rare, have been lost to science. Of the specimens which have been preserved in cabinets, many are without any localities, being only labeled as coming from New Jersey.

With the discovery of the cretaceous formation in other parts of the United States and territories, renewed attention has been drawn to our own deposits of this formation, and it is felt to be a matter of much importance to know as many as possible of the fossils found here, in what subdivision of the marl stratum they are found, and their precise localities, so as to trace out, by comparison, the equivalents to these subdivisions, in other and remote places.

All the fossil shells and corals which have been collected in the course of the survey, have been placed in the hands of Professor James Hall, the distinguished palaeontologist,

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of New York, for description. Professor Joseph Leidy, of the University of Pennsylvania, and eminent as a comparative anatomist, has the fossil bones and teeth for description. These gentlemen have found many new species among the specimens, and of those which are known, they find many better specimens than have been seen before. Much interest is felt by them to have the collections made as complete as possible before the descriptions are published.

I have made exertions to secure all the specimens I could for the state cabinet, and where this was not possible, to borrow them for description. Many gentlemen have lent their aid in furtherance of this object. Dr. Knieskern has been indefatigable in making collections at Shark river. Valuable collections of bones and shells have been given to the state by John S. Cooke, of Tinton Falls, by Rev. G. C. Schenck of Marlboro, Thomas B. Jobes of New Egypt, M. T. Rue near Perrinesville, Henry Aregood of Kincora, J. J. Hummell of Shiloh, and others. Interesting specimens have been lent to the state by Professor O. R. Willis of Freehold, Mr. Hopper of the same place, Rev. Mr. Finch of Shrewsbury, Rev. Mr. Lockwood of Keyport, Mr. Elnathan Davis of Jericho, and others. Not having the fossils here, I am not able to give the names of all who have favored the survey, by the gift or loan of specimens, but it is intended that due acknowledgement shall be made to all in the published descriptions.

The fossils are obtained in digging the marl, and of course can only be got through the favor of those who own or work the pits. A little effort on the part of those located in the marl districts, in preserving specimens, might greatly enrich our state cabinet, and add materially to the stores of science. Every year valuable fossils which are dug out, are destroyed or given away as curiosities, to those who attach no scientific value to them; and they are, for all useful purposes, lost. I would earnestly appeal to that feeling of state pride which every true Jerseyman should possess, to enlist citizens in collecting and saving specimens to form a

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cabinet, which shall properly represent the fossils of the state.

§ Accompanying this report, is "A Catalogue of Plants growing without cultivation in the Counties of Monmouth and Ocean, by P. D. Knieskern, M. D." This catalogue gives the names of seven hundred and eighty-one species, and a number of varieties, all "plants found and examined by" Dr. Knieskern, "within the last ten or twelve years." He says, "There are doubtless many plants that may still be detected within our limits, not included in this catalogue, especially in the portion farthest from the coast, which has not been examined as thoroughly as the pine barrens and the region bordering on the ocean."

It is desirable to publish in the final reports, as complete a list as possible, of plants growing in the state. By circulating this catalogue among botanists, so that our present deficiencies may be known, additions can be obtained from different parts of the state, and in this way it will be put in condition for final publication.

It is requested that this catalogue be printed in pamphlet form, separate from the report, for the use of Dr. Knieskern and the officers of the survey.

PRESENT CONDITION OF AGRICULTURE IN NEW JERSEY.

In prosecuting the survey of Cape May County, it was found that the advancement of its agriculture had been so great since the United States census of 1850, that the statistics of the Census Report gave a very inadequate idea of the amount of its agricultural productions, at this time. By the favor of the Assessors in the different townships, I was enabled to get accurate statistics, for the present year. The result is truly gratifying; it shows an advance in the agricultural products of about fifty per cent. since 1850, and the price of land has nearly doubled.

No statistics have been collected in the other counties; but from observations in the southern half of the State, I am well satisfied that the spirit of agricultural improvement is

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more active in almost any of the other counties, than in Cape May; and that the progress which is making is quite as rapid as it was between 1840 and 1850. (See tables A and B in the Appendix.)

The advancement made in New Jersey during that period, when viewed in comparison with that of the neighboring States; Connecticut, New York, Pennsylvania, and Delaware, was very flattering. In the staple crops, of wheat and Indian corn, we show an increase of more than one hundred per cent. which is more than double that shown in either of the other States, and in potatoes a gain is shown of seventy-nine per cent. against a gain of fifty-two per cent. in Delaware, and losses of twenty-two, forty-nine, and thirty-seven per cent. in the States of Connecticut, New York and Pennsylvania. Other crops show a fair advancement in the comparison, the particulars of which may be seen by a reference to the tables.

In the aggregate crops of wheat, rye, oats, Indian corn, potatoes, barley, and buckwheat, if the amount for each State is taken, and averaged among the whole number of acres in each State, it gives for New Jersey, four and twenty-one hundredths bushels per acre; Connecticut, two and twenty-four one hundredths bushels per acre; New York, two and seventy-eight one hundredths bushels per acre; Pennsylvania, two and forty-one hundredths bushels per acre; and for Delaware, three and thirty-six one hundredth bushels per acre. There is also a very large balance in favor of New Jersey in products of orchards and market gardens. In the products of the dairy the balance is against us in the article of cheese. In live stock there is no great difference in the several States. It is remarkable that there is a diminution in the amount of stock kept in all the States above mentioned.

The comparison furnishes a most satisfactory vindication of our State, in its soil and productions, from the aspersions which it is so fashionable for some of our neighbors to cast upon it.

New Jersey occupies a location for markets, unequalled by any other State in the Union. Lying between the great commercial centres of our country, New York and

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Philadelphia, and having within her own borders much mechanical and manufacturing industry, a ready market for all her products is ever open; almost surrounded by navigable waters, penetrated at numerous points by rivers and creeks, and crossed by several railroads and canals, she possesses great facilities for quick and cheap transportation; so that for bulky, heavy or perishable articles she might have almost a monopoly of the markets.

Her soil, it has been well said by one of our citizens, in comparing it with that of a neighboring state "is easier tilled, equally productive, less liable to suffer from sudden changes of wet and dry, imbibes more freely the sun and dew, to favor the growth of early fruits and vegetables, and ripens them sooner for market."

With marls, limestones, and other fertilizers in great profusion within the State; with fish, crabs, and other matters, the spoils of the sea, upon her borders, and with contiguity to large cities and cheap means of transport for their waste manure and offal, New Jersey possesses unequalled resources for cheap and abundant fertilizers.

The success which attends good farming is perhaps the best evidence that can be adduced for our agricultural advantages. It has been shown from the census tables, that our product per acre, where the whole area of the State is taken into account, considerably greater than in any of the adjoining States. If the separate crops are taken, the average for corn, oats, and potatoes is higher than in the States adjacent; our wheat and rye are put down as yielding a smaller crop per acre, which, as an average, is undoubtedly correct. The premium crops of wheat, in all the counties where there are agricultural exhibitions, have been above thirty bushels an acre, in some of the counties they have been above forty bushels an acre for several years in succession, and there are instances in which crops of fifty bushels, or upwards, per acre have been harvested. The practice is much more common in this State than in others, of sowing wheat and rye in corn, or after corn or potatoes. A diminished crop of grain is the necessary consequence of

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this mode of cultivation; though the produce of the field and the profits for the year are increased thereby. Wherever there is thorough cultivation the crops of grain are not inferior to those raised in other states. But it is in fruits, and in market-garden produce that our greatest advantages are found.

The returns for an acre of strawberries are from one hundred dollars upwards. The Burlington County Agricultural Society, in 1855, awarded the premium for the most profitably cultivated crop in the county, to one of strawberries. It yielded at the rate of twelve hundred and twenty-two dollars an acre, clear profit. Cranberry fields are known which annually yield to their owners three hundred dollars an acre. Large profits are also obtained from the cultivation of other small fruits. The state is noted for the production of apples and peaches, and fortunes have been made in their cultivation. Market-gardening pays well to those who engage in it. Early potatoes, which yield one hundred dollars an acre, are common, and those yielding three times that sum are not unknown. Equal profits can be obtained from the cultivation of sweet potatoes.

And yet with all these advantages and the examples of the large profits mentioned, to be found in all parts of the state, there are still two million acres, or nearly one half of the state uncultivated. Not entirely waste, it is true, but only yielding crops of wood, every fifteen to thirty years, which in growth may average a cord, a year, for each acre, but which on account of fires, late frosts, &c., probably produce to the owners, not half that amount.

In view of the facts presented above it is astonishing that so little attention has been paid to these unoccupied lands. The greater portion of them are not lighter or poorer than other soils from which persevering and skilful husbandry is now drawing the largest and most certain returns. And they offer the great advantages of healthy locations, and contiguity to the older settled portions of our country.

The large body of uncleard land, which occupies the central portion of southern New Jersey, is narrowed on all

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its borders, every year by the inroads of the farmer, and many large and productive farms are now found, where but a few years ago there was only unbroken forest.

Could the productiveness of these lands be generally known, and were they properly opened to markets, by means of roads and railroads, it would be the means of saving to the state every year, hundreds of useful citizens who now leave us to seek new homes in the west.

In regard to one of our staple crops, the potato, the Census Reports furnish some important facts. The general result of a large increase in the yearly product of New Jersey, of an increase in the product of Delaware and a diminution in that of Connecticut, New York, and Pennsylvania has been mentioned. On comparing the product of our state by counties, it appears that the increase was mostly in Monmouth, Burlington, Camden, Gloucester, Salem, and Cumberland, the counties in which marl is found, while in the remaining southern and middle counties of the state the increase is small, and in several of the northern counties there is a material diminution of the crop. (See table C in the Appendix.) So too, in the state of Delaware, the largest crop, and I presume, the largest increase of Irish potatoes, is in New Castle county, in which marl is found. In the state of New York there was an increase in only three counties, and these were the three constituting Long Island; and of these three the largest increase was in those, which there is some reason to believe, lie in the same geological formation, with those counties in New Jersey, in which there was the largest increase. In Connecticut there was an increase in Middlesex county, which lies in the valley of the Connecticut river, and at its mouth. In Pennsylvania there was a small increase in eight counties, located in the eastern part of the state, and mostly on the Delaware river, and its branches. Of the states in which there was no greatly increased population from immigration, New Jersey and Delaware were the only ones in which there was not a diminution of the crop of Irish potatoes between 1840 and 1850. By a reference to table C, it will be perceived that there has been a moderate increase of the crop

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in the sandy and light soils where marl has not been used; but the large increase is confined to the counties in which marl exists as a constituent of the soil, or is used as a manure.

The fact of this remarkable difference, in favor of our marl districts, is that which mainly concerns the practical farmer, but the cause of it cannot but be interesting to reflecting minds. Whether its special action is due to some component of the marl, or whether its usefulness is partly owing to the mingling of new earth, taken from beneath the surface, with the soil, is a question not easily answered. There is no effect produced on the appearance of the potato top. The crop, of choice varieties, is from seventy-five to one hundred and fifty bushels an acre. The potatoes are of good size, smooth and smoth-skinned, of superior quality for the table,* and not subject to the potato rot. The marls which are least esteemed for permanent improvement of the land, produce quite as good effects upon a single crop of potatoes as those which have the highest reputation. The Cumberland marls, which are not green sands, are deemed almost indispensible to this crop, and they produce potatoes of an excellent quality; though I think the average crop per acre is somewhat less than where green sand marl is used.

The value of this crop makes a large item in the whole agricultural product of the state. In an article in the New Jersey Farmer, for December, the potato crop of Monmouth county for the present year, is estimated at thirty-three per cent. more than that of 1850; or, in round numbers, at one million and fifty thousand bushels, and the average price as over seventy-five cents a bushel. At that price the whole crop would be worth seven hundred and eighty-seven thousand, five hundred dollars. The crop of the state may be safely estimated at four times this quantity, which in value would be three million, one hundred and fifty thousand dollars.

FERTILIZERS.

The abundant supplies of fertilizers found in our state

* Potatoes from the marl region will bring fifty cents a barrel more than others, in the New York market, and then have the preference.

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are attracting more and more of public attention. The green sand marls are getting to be used over larger districts of country, and they are gradually finding their way to more remote markets.

There has been sent over the Freehold and Jamesburg Agricultural Railroad, during the past year, 270,982* bushels of marl, all of which has found a market out of the marl district, and some of it out of the state. The high state of agricultural improvement along the lines of railroad, where this marl is distributed, is sufficient evidence of its value. An association called the New Jersey Fertilizer Company, has opened marl pits on the shore of Sandy Hook Bay, near Riceville, and have built a wharf for the purpose of shipping the marl of that locality. From this point marl can be very easily obtained by farmers along the shores of our own and the neighboring states. Marl is also dug extensively at White Horse, in Camden county, on the line of the Absecom Railroad, and the marl is delivered at places along the road throughout its whole length, greatly to the advantage of the country through which the road passes and to the state. The Delaware and Raritan Bay Railroad, which is now in process of construction, passes through the rich marl regions of Monmouth county, and when completed will open a large district of our state to the benefits of this valuable fertilizer, and will furnish a convenient outlet for it to the sea shore. There are other localities where the marl is situated, so that it can be readily shipped on board vessels, and numerous places situated in the interior, from which the best of marls could be cheaply procured if there were convenient means of transport.

The diminution in the cost of this article by the substitution of railroad transportation, for the conveyance by teams, will be understood when it is mentioned that formerly when marl was hauled from Squankum to Jamesburg, the cost at the latter place was thirteen cents a bushel. Now, parties interested propose if the railroad is extended from

*For these returns I am indebted to I. S. Buckalew, Esq., Superintendent of the Jamesburg and Freehold Agricultural Railroad.

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Freehold to Squankum to deliver the marl in Belvidere at that price.

Inquiries are being made in reference to the price of marl and its probable amount, by enterprising persons in other states and in Europe. In regard to its price, it may be mentioned that the Squankum marl sells at Freehold for eight cents a bushel,* and that the New Jersey Fertilizer Company deliver their marl on board vessels at their wharf for seven cents a bushel. The White Horse marl is delivered on the line of the railroad at any point within ten miles of the pits, at ninety cents a ton. At pits in different parts of the marl region, the marl is sold at prices varying with the labor of excavating, without much regard to its real worth. From twenty-five to seventy-five cents a ton, includes the general range of prices.

The absolute worth of the marl to farmers, it is difficult to estimate. The region of country in which it is found has been almost made by it. Before its use the soil was exhausted, and much of the land had so lessened in value that its price was but little, if any, more than that of government lands at the west; while now, by the use of the marl, these worn out soils have been brought to more than their native fertility, and the value of the land increased from fifty to a hundred fold. In these districts, as a general fact, the marl has been obtained at little more than the cost of digging and hauling but a short distance. There are instances, however, in which large districts, of worn out land, have been entirely renovated by the use of this substance, though situated from five to fifteen miles from the marl beds, and when, if a fair allowance is made for labor, the cost per bushel could not have been less than from twelve to sixteen cents. Instances are known where it has been thought remunerative at twenty-five cents a bushel.

The chemical composition of the marls may aid in estimating their value, as fertilizers; though it must be confessed that agriculturists are by no means agreed upon the

*A bushel weighs about 100 pounds when first dug, and about 80 pounds when dry.

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specific values which should be allowed for the different proximate elements found in manures.

The following are analyses of green sand marls, from different parts of the formation, and are selected as representatives of the principal varieties.*

	(1.)	(2.)	(3.)
Water	12.200	10.260	10.600
Silica	38.700	46.660	51.162
Prot-oxid of iron and alumina	27.690	24.921	22.300
Potash	4.167	6.818	4.274
Lime	....	2.865	3.478
Carbonate of lime	13.910	....	....
Magnesia	1.213	3.039	2.037
Phosphoric acid	1.140	3.509	4.549
Sulphuric acid	0.309	0.922	0.429
	99.629	99.194	98.820

These specimens are taken from the three principal marl beds; one from the first, two from the second, and three from the third. (1) is the marl which has been most largely used upon potatoes in Monmouth. (2) is the variety of marl which is most generally used in Burlington, Camden, Gloucester and Salem counties. (3) is the marl which is found in Deal, Poplar, Shark river, and Squankum, in Monmouth county.

In regard to the several constituents of the marl, it has been common to consider the phosphoric acid, and the potash, as the only substances of sufficient value to be taken into the account. Professor S. W. Johnson, of Yale College, in an article in the American Agriculturist for July, 1856, estimated the value of potash for agricultural purposes at four cents a pound, which is probably as close an approximation to its value as can be assigned, in the varying circumstances under which it is used in agriculture. Phosphoric acid he estimates at two different values, according as it is in a soluble or insoluble state. In its soluble form it is found in superphosphate of lime; in its insoluble form, in bones; to some extent, in superphosphate of lime and in guano. Soluble phosphoric acid he estimates at five

*For a description of the several beds of green sand, and their geological and geographical positions, see Geological Reports of New Jersey for 1854 and 1855.

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cents a pound, and insoluble at two cents. Professor Way, Chemist of the Royal Agricultural Society of England, has estimated the worth of soluble phosphoric acid at eight and a half cents a pound, and insoluble at three cents. The prices of bones and of superphosphate are not very different in the two countries, and yet one of the results arrived at is more than fifty per cent. higher than the other. Such discordant results show the difficulties attending the subject for the authorities are, both men distinguished for care and accuracy in their investigations. If the estimate is to be made from the selling price of bone dust and superphosphate of lime, the prices assigned by Professor Way are not too high. There has been hardly time, since the first introduction of superphosphate of lime into our country, to ascertain the estimation in which it will be held by farmers. From the best information I have been able to procure, the amount of superphosphate annually manufactured is increasing. The price has diminished slightly within two or three years past, but it is still as high as the English. Bones, bone dust and bone turnings are increasing in price, and are more highly valued by the farmer every year. A reason for the differences in the value attached to phosphoric acid may probably be found, in the fact that its effects as a fertilizer, are much more perceptible upon some crops than upon others. Wheat, rye, and oats are known to be but little benefitted by it; while, on the contrary, its effects upon pastures, root crops, and garden vegetables, are entirely satisfactory. According, then, as one or other of these crops is the leading one with the farmer, will the phosphoric acid be esteemed. From the peculiar location of our state in relation to markets, and the nature of our leading products, I am led to the opinion that the prices fixed by Prof. Way are the nearest correct, for our uses. In the case of marl, however, even this is too low an estimate for the phosphoric acid. The acid is in its insoluble form; but it is disseminated through the marl in small particles, which are in a pulverulent state,—just as the superphosphate must be, as soon as it is washed into the soil,—which is a form much more availa-

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ble for growing vegetation, than the hard and slow-decaying fragments of bones which have been crushed in a mill.

It is a safe estimate, at least, to rate the phosphoric acid in the marls at five cents a pound, the price assigned by Prof. Johnson for the soluble acid, and in relation to the potash, I think it should be put still higher.

As the analyses may be considered to give the absolute weights of each of the different constituents in one hundred pounds of marl,—its value will be easily calculated, by multiplying the numbers in the table by twenty, and then by the price mentioned above. Thus in (1) the potash, 4.467 × 20 = 89.34 and 4 × 89.34 = $3.57: the phosphoric acid 1.14 × 20 = 22.8 and 22.8 × 5 = $1.14: and the sum of the two is $4.71; the value of one ton of the marl, according to the above prices. In the same way (2) is worth $9.05, and (3) $7.96 a ton.

There are, however, other constituents which are of importance. Ammonia, which is acknowledged to be the most costly of all the fertilizing substances applied to soils, and which is indispensible to thrifty vegetation, is found, in small quantity, in all the marls.

The sulphuric acid, set down in the analysis, is usually combined with lime, and is in the form of sulphate of lime or plaster, a valuable fertilizer. In some of the marls there is a considerable quantity of carbonate of lime, in fine powder. This is also an excellent manure.

The oxid of iron and alumina, in their action, are not well understood. It has been asserted by some chemists that the protoxid of iron, in the marl, is changed to a peroxid by the action of air and moisture, and in the change ammonia is generated. That oxid of iron is an absorbent of ammonia is generally believed. In my report of last year I called attention to the fact that in the products of a given measure of land, a very much larger quantity of oxid of iron was taken up by potatoes than by any other commonly cultivated crop; and that this fact taken in connection with that of the large quantity of oxid of iron in marl, which is specially

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adapted to the growth of this crop, appeared to have some significance. I hope to investigate the subject further.

Soluble silica which is liberated in large quantity, in the decomposition of these marls, has been rated very highly by some agricultural chemists.

The substances above mentioned are certainly found in large quantity, in common earths and soils, but they are not usually found in a condition to be easily made available to vegetation. The marls are soft so as to be readily penetrated by water, and though not soluble in pure water, they are readily decomposed by water containing acids, and are then soluble. Even carbonic acid, one of the weakest of acids, and which is found in water in the soil, is sufficient to decompose them, and to bring the various constituents into the condition necessary that they may act upon growing plants. It is believed that the other constituents of the marl which have not at all entered into the estimate of its value, increase its fertilizing power, both by direct action, and by their agency in absorbing and retaining other important elements of vegetable nutrition; but the precise value which is to be attached to them is not well understood.

The amount of the green sand marl which can be obtained for use is very great. It underlies the whole country in a strip which extends from Sandy Hook Bay and the Atlantic ocean, on the shore of Monmouth county, to Delaware river and bay, at Salem, in Salem county, a distance of ninety miles, and which has a breadth varying from fourteen miles at its northeastern extremity to six miles at its southwestern extremity. The area included in the strip is nine hundred square miles. On account of the marl being found in earth and not in rock, it cannot be worked under the surface like a mine; and excavations are profitably made in it only where the covering of top earth is but a few feet in thickness. In the greater portion of the area mentioned, the marl lies too deep under the surface to be profitably worked at present. But wherever streams have cut down below the general level of the country, some one of the different beds of marl is exposed, and on the sloping sides of the valleys, the deposit

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lying nearly level, can be worked back for a considerable distance before the covering of earth becomes so thick as to render further progress unprofitable. Precise estimates have not yet been made of the amount of surface under which marl can be profitably worked, but there are certainly many square miles, even of those varieties which are generally considered the best.

In many cases a ton or more of marl is dug from underneath each square foot of surface; but, if we allow even half of this, for the amount obtained from each square foot, a square mile will yield (13,939,200) nearly fourteen million tons; an amount sufficient to supply any probable demand for years to come.

The calcareous marl which constitutes the upper part of the second marl bed, and which has been vairously designated, as yellow limestone, yellow marl, gray marl, lime, sand, etc., is extensively developed through the length of the marl district. It consists mainly of carbonate of lime. Some portions of it are pulverulent and can be worked with a shovel, while other portions are stony and can be used for burning into lime. Its value as a fertilizer is too well known to need description here.

The tertiary marls of Cumberland county are valuable as a source of manure for the district of country in which they lie. They are found on the western borders of the county and are principally dug in the valleys of several streams, which, when united form Stoe creek. The whole of the workings are comprised within a strip which extends about four miles in a northeast and southwest direction, and which is perhaps a half mile wide.

These marls are not green sand. Some of them have a large per centage of shells which are in a broken and decayed condition; others are entirely destitute of shells or of carbonate of lime. The two analyses which follow, are sufficient to exhibit their composition.

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TABLE.

Silica and quartz sand, -	79.160	83.328
Peroxid of iron, - -	3.562	4.770
Alumina, - - - -	.442	5.412
Lime, - - - - -	7.500	0.211
Magnesia, - - - -	0.884	0.668
Potash, - - - -	1.227	0.829
Phosphoric acid, - -	0.420	0.854
Sulphuric acid, - - -	0.166	0.283
Carbonic acid, - - -	4.030	
Nitric acid, - - -		a trace
Ammonia, - - - -		0.067
Organic matter, - - -		1.967
Water, - - - - -	2.400	2.193
	99.791	100.582

The first of these marls is like most of those containing shells, in some however fifty per cent. Some have attributed their value to the carbonate of lime in the shells; but those who use them do not consider this to be the cause of their fertilizing action, and make no difference in the price of those which contain shells and those in which there are none. There is a tract of country about Shiloh, upon which lime has never been observed to produce any beneficial effect; but which has been brought to a high degree of fertility by the use of these marls. They are carted to distances of five miles, and are thought to pay well for the expense of transportation, and the first cost, which is from fifty to seventy-five cents a wagon load.

The second analysis is that of a rather remarkable substance. It is called marl by the inhabitants, and is dug in the same tract of country with the other. To an ordinary observer it would seem to be a yellow loam or subsoil, and there is nothing by which a closer inspection would be able to distinguish any difference. It is extensively used as a manure, and is particularly valued for spreading upon grass

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lands. Farmers purchase it at the pits for twenty-five cents a load, and haul it four or five miles for use, and think it well repays its cost.

The king-crabs or horse-feet, were mentioned in the Annual Report of last year, as abounding on some of our shores; and it was also mentioned that an establishment for making a concentrated manure, from them, had been erected at Goshen, in Cape May county, by Messrs. Ingham & Beesley. Several hundred tons of this substance were made last year and sold under the name of *Cancerine*. It is a powerful fertilizer, and in its composition as well as in its effects, has considearble resemblance to guano. The fertilizing properties of guano are generally conceded to be due to the amounts of ammonia and phosphoric acid which it contains. The per centages of ammonia and phosphoric acid contained in guano and in the cancerine, are here given.

	Ammonia.	Phosphoric Acid.
1. Peruvian Guano, - -	15.00	14.75
2. Peruvian Guano, - -	14.79	10.15
3. Cancerine, - - -	10.75	2·71
4. Cancerine, - - -	9.92	4.05

No. 1. is from an analysis of No. 1 Peruvian Guano, by Prof. S. W. Johnson, of Yale College; published in the American Agriculturist, for December, 1856.

No. 2. is from an analysis made in my laboratory. The specimen was obtained from a respectable dealer, in New Brunswick.

No. 3. is the result of an analysis of what I thought to be an average sample of Cancerine.

No. 4. is the average of three analyses of Cancerine, made here at different times.

In the article of Professor Johnson, which was just referred to, he estimates the value of ammonia at sixteen cents a pound, and phosphoric acid in guano, at two cents a pound; this would give the prices of

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1. Guano,	$53.90	per ton.
2. Guano,	51.39	"
3. Cancerine,	35.48	"
4. Cancerine,	31.16	"

In this estimate phosphoric acid is set down at a lower price than I have assigned to it in calculating the value of green sand, but as the two prices bring the guano up to its selling price, and the only object is a comparison, this variation will not materially influence the relative values of the two.

There is a difference in the state in which the ammonia exists in the two substances. In guano much of it is ready formed, and is easily dissolved by water, or volatilized by heat; while in cancerine, though the elements are present, the ammonia is not yet formed, and it is not soluble nor volatile; and so not liable to deteriorate in strength, until the process of decay commences in it. But for the same reasons the guano is quicker in its action.

The result of trials with it, during the year, have fully sustained its value as determined by the analysis. The wheat crop of southern New Jersey, last year, was from five to ten bushels an acre less than common, probably on account of the severe winter. The effects of neither guano nor cancerine were very decided upon this crop. Some very good crops of wheat were harvested where cancerine was the only manure used. Upon summer crops, Indian corn, potatoes, &c., it has succeeded in all cases.

From the results obtained, I consider this pioneer establishment to have demonstrated that we have both the material and the means for manufacturing a concentrated manure which in its quality and price is a substitute for Peruvian guano. Several thousand tons of the cancerine could be produced in a year.

The fish, particularly the mossbonkers which abound near our shores, have been much used as a manure. Applied in the raw state, they are powerful fertilizers. An examina-

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tion and analysis of the mossbonker has been made here, the present fall, for the purpose of ascertaining the value of this fish, when dried, for manure.

ANALYSIS OF THE FRESH FISH.

Water,	77.17	per cent.
Oil,	3.90	"
Dry substance,	19.93	"
	100.00	

Analysis of the dry Fish.

Lime,	8.670
Magnesia,	.670
Potash,	1.545
Soda,	1.019
Phosphoric acid,	7.784
Chlorine,	.678
Silica,	1.333
Organic matter,	78.301
	100.000
Ammonia,	9.282

There were five fishes in the lot examined, and they weighed four pounds, four and one-eighth ounces, which is a little more than the average weight of such fish during the spring and summer. They were taken in the latter part of October, and were quite fat.* The yield of oil from them is probably above that of other seasons of the year. The amounts of ammonia and phosphoric acid contained in the dry fish are sufficient to make it a valuable concentrated manure.

The amount of material for such manure which could be obtained upon our shores, has not been accurately estimated,

* The specimens were procured for me by Charles Sears, Esq., of Riceville, Monmouth county.

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but it is enormous. A friend who has been at some pains in making inquiries upon the subject, estimates the amount which could be obtained at a single point on the shore, during one season, at one hundred thousand barrels. Sixty wagon loads were taken at a single haul, on the shore of Raritan Bay, the last summer. In different seasons the prices vary, between five and eight cents a bushel. The price on the shore of Monmouth county has not been below eight cents a bushel during the past season.

It would be a public benefit to have these supplies of fertilizing materials, which fairly bring themselves to our shores, put in a form to be more extensively used; and the oil and the fish manure offer fair opportunities for profit to a well conducted manufactory of these articles.

The following analyses of green sand marl were made from specimens taken from different parts of the marl formation for the purpose of comparing the composition of the green mineral. (1 and 2) are from the first marl bed, (1) from Mannington township, Salem county; (2) from Middletown, Monmouth county; (3 and 4) are from the second marl bed, (3) from Mannington, Salem county, and (4) from Shrewsbury, Monmouth, (5 and 6) are from the third or upper marl bed, (5) from Gloucester township, Camden county, and (6) from Ocean township, Monmouth county.

Analyses of Green Sand as taken from the Marl Beds.

	(1.)	(2.)	(3.)	(4.)	(5.)	(6.)
Prot-oxid of iron	8.320	16.816	21.712	21.204	14.020	17.388
Alumina	6.095	6.658	7.992	8.230	6.000	6.048
Lime	2.364	12.524	1.050	0.496	1.985	4.066
Magnesia	0.423	2.544	2.034	2.024	4.615	2.963
Potash	2.464	4.880	7.064	7.088	4.296	3.680
Soluble silica	20.200	31.200	45.912	46.936	32.960	35.356
Insoluble silica	49.929	5.610	4.008	4.220	23.680	9.328
Sulphuric acid	0.872	0.632	0.408	.411	0.878	3.124
Phosphoric acid	1.392	1.064	1.272	0.192	2.640	6.864
Carbonic acid	0.200	9.320	.000	.000	.000	.000
Nitrogen	0.047	0.043	Trace.	0.017	0.038	0.024
Water	7.080	8.920	8.000	8.600	10.640	10.210
	99.378	100.261	99.092	99.418	100.662	99.051

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The per centage of matter soluble in water was ascertained to be as follows:

	(1.)	(2.)	(3.)	(4.)	(5.)	(6.)
Alumina	0.105	0.135	0.075	0.065	0.075	0.055
Lime	0.546	0.455	0.349	0.156	0.382	1.225
Magnesia	0.097	0.079	0.093	0.093	0.079	0.041
Potash	0.238	0.278	0.186	0.362	0.134	0.097
Sulphuric acid	0.876	0.415	0.398	0.406	0.813	2.876
Prot-oxid of iron	Trace.	Trace.	0.031	0.031	0.103	0.201
Phosphoric acid	....	....	....	....	0.355	0.194
	1.362	1.362	1.132	1.143	1.941	4.693

It should be observed in relation to these specimens of green sand, that they were not selected for the purpose of getting specimens of the average value as fertilizers, numbers 3 and 4 are much below the average, and number 6 is above, containing a larger per centage of phosphoric acid than any othhr specimen that I have examined.

The following analyses are of clean grains of green sand. The specimens were prepared by first washing out all clay and muddy substances that could be kept suspended in water; then drying the remaining matter at about a summer heat; and afterwards carefully picking out the grains of green sand from the particles of quartz, phosphate of lime and other substances with which they were mixed. After all the trouble taken, however, it will be perceived that there was a small quantity of sand and phosphate of lime left with the grains. The phosphate of lime is evidently not a constituent of the grains of green sand; it can be plainly distinguished from them in the mass, by the color of its particles, which are of a very light green or greenish white; but some of it adheres so closely to the green sand grains, as not to be separated by washing.

Of the three specimens here given; (1) is from the first marl bed, and was obtained at Cream Ridge, Monmouth county: (2) is from the second marl bed, and was procured at White Horse, Camden county; (3) is from the third marl bed, and was taken from a pile of Squankum marl, at Freehold.

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Analyses of Grains of Green Sand.

	(1.)	(2.)	(3.)
Soluble silica	45.510	50.010	41.729
Prot-oxid of iron	21.134	21.120	16.627
Alumina	7.960	7.368	5.929
Magnesia	2.460	2.866	2.938
Potash	6.748	7.370	6.066
Lime	3.842	0.312	8.026
Phosphoric acid	0.993	0.628	7.356
Sulphuric acid	1.129	0.430?	1.005
Carbonic acid	0.553	0.000	1.353
Insoluble silica (sand,)	0.850	0.402	0.909
Water	9.110	9.474	7.688
	100.299	99.980	99.656

An examination of the preceding analyses will show that the soluble silica, prot-oxid of iron, alumina, magnesia, potash and water, are nearly the same, in quantity, in all the specimens, while the other constituents are extremely variable. It seems a legitimate conclusion from this examination, that the grains of green sand are made up of the constituents mentioned above, as being constant; and that the remainder compose the material which is found mixed in with the grains, and, in some cases, adhering to them. If we assume this conclusion to be correct and sum up, in each column, the six substances mentioned, as constituting the green sand, we may by an easy calculation ascertain the amount of each of these substances in one hundred parts of the pure green sand. The following are the results of such a calculation upon each of the three analyses given last.

Composition of Green Sand, as Calculated from the preceding Analyses.

	(1.)	(2.)	(3.)
Silica	48.977	50.923	51.532
Prot-oxid of iron	22.744	21.504	20.533
Alumina	8.566	7.503	7.322
Magnesia	2.647	2.918	3.628
Potash	7.262	7.505	7.491
Water	9.804	9.647	9.494
	100.000	100.000	100.000

The close resemblance shown between the three specimens, when compared in this way, gives satisfactory evidence that the green sand is a definite chemical compound. The inference, too, seems a fair one, that the variation which is observed in the fertilizing properties of the marl or green

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sand, is due to the foreign matter mixed in with the grains, and which varies with the localities.

A re-examination of the white clay of South Amboy shows it to contain zirconia. Qulitative analyses of the white clays of Woodbridge and Trenton detect the same substance in them also, and it is probably a constituent of all the clays of this formation. There is reason to believe that the white clay at Trenton is produced by the decomposition of the gneiss rock, which occurs there. Crystals of zircou are not uncommon in the rock at that place.

Analysis of a fire-clay from Whitehead's clay-bank, on Burt's Creek, near South Amboy, Middlesex county.

Soluble Silica, - - -	43.937
Insoluble Silica, - -	1.703
Alumina, - - - -	38.008
Zirconia, - - -	1.403
Peroxid of iron, - -	0.747
Magnesia, - - -	0.077
Lime, - - - -	0.413
Potash, - - -	0.368
Water, - - -	13.863
	100.519

In closing the report it should be remarked that those scientific details which must give to the survey its accuracy and value, have been mostly omitted, not from under-estimating their importance, but because it is judged they will find their more appropriate place in the final reports.

The practical and economical relations of the survey are the main objects for which it was instituted, and to these this report has been chiefly confined. If I have succeeded in exhibiting the important relations they hold to the mate-

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rial wealth of the state, I shall have done no more than justice to the enlightened policy which originated and has sustained the work.

GEO. H. COOK,
Asst. State Geologist.

NEW JERSEY GEOLOGICAL SURVEY

[A.]

Table showing the areas of the states of Connecticut, New York, New Jersey, Pennsylvania and Delaware, in 1850; also, the Live Stock and Principal Agricultural Productions of those states in 1840 and 1850.

	Connecticut.		New York.		New Jersey.		Pennsylvania.		Delaware.	
Areas of the States in acres	3,001,360		30,080,000		4,676,370		29,440,000		1,356,800	
Acres of improved land	1,768,178		12,408,964		1,767,991		8,628,619		580,862	
Acres of land in farms, unimproved	615,701		6,710,120		984,955		6,294,278		375,282	
Per centage of whole area in farms	79		63		59		51		70	
Value of farms per acre	$30 50		$29 00		$43 67		$27 33		$19 75	
	1840.	1850.	1840.	1850.	1840.	1850.	1840.	1850.	1840.	1850.
Horses and mules ... Number.	34,650	26,923	474,543	447,977	70,502	63,044	365,129	352,657	14,421	14,643
Neat cattle	238,650	212,675	1,911,244	1,877,639	220,202	211,255	1,172,665	1,153,915	53,883	53,211
Sheep	403,462	174,181	5,118,777	3,453,241	219,285	160,488	1,767,620	1,822,357	39,247	27,503
Swine	131,961	76,472	1,900,065	1,018,252	261,443	250,370	1,503,964	1,040,366	74,228	56,261
Wheat ... Bushels.	87,009	41,762	12,286,418	13,121,498	774,203	1,601,190	13,213,077	15,367,691	315,165	482,511
Rye	737,424	600,893	2,979,323	4,148,182	1,665,820	1,255,578	6,613,373	4,805,160	33,546	8,066
Oats	1,453,262	1,258,738	20,675,847	26,552,814	3,083,524	3,378,063	20,641,819	21,538,156	927,405	604,518
Indian corn	1,500,441	1,935,043	10,972,286	17,858,400	4,361,975	8,759,704	14,240,022	19,835,214	2,099,359	3,145,542
Irish and sweet potatoes	3,414,238	2,689,805	30,123,614	15,403,997	2,072,069	3,715,251	9,535,663	6,032,904	200,712	305,985
Barley	33,759	19,099	2,520,068	3,585,059	12,501	6,492	209,893	165,584	5,260	56
Buckwheat	303,043	229,297	2,287,885	3,183,955	856,117	878,934	2,113,742	2,193,692	11,299	8,615
Hay ... Tons.	426,704	516,131	3,127,047	3,728,797	334,861	435,950	1,311,643	1,842,970	22,483	30,159
Value of orchard products ... Dollars.	$296,232	$175,118	$1,701,935	$1,761,950	$464,006	$607,268	$618,179	$723,389	$28,211	$46,574
Value of market garden produce	....	196,874	....	912,047	....	475,242	....	688,714	....	12,714
Tobacco ... Pounds.	....	1,267,624	....	83,189	....	310	....	912,651	....	....
Butter	....	6,498,119	....	79,766,094	....	9,487,210	....	39,878,418	....	1,055,308
Cheese	....	5,363,277	....	49,741,413	....	365,756	....	2,505,034	....	3,178

NEW JERSEY GEOLOGICAL SURVEY

[B.]

Table showing the per centage of *Loss* or *Gain*, in several staple agricultural products, in the states of Connecticut, New York, New Jersey, Pennsylvania and Delaware, from 1840 to 1850; also, the *Product* per acre in each state, when its whole crop of 1850 is divided among the whole number of acres in the state. (The product of wheat, rye, oats, Indian corn, potatoes, barley and buckwheat, is given in bushels; that of hay in tons; and of orchard products in dollars.)

	Conn.			N. York.			N. Jersey.			Pennsyl'a.			Delaware.		
	Loss.	Gain.	Product.	Loss.	Gain.	Product.	Loss.	Gain.	Product.	Loss.	Gain.	Product.	Loss.	Gain.	Product.
Wheat	52	...	.014	...	7	.436	...	107	.344	...	16	.529	...	53	.356
Rye	19	...	.200	...	39	.137	21	....	.269	30	...	.165	76	...	.006
Oats	13	...	.402	...	29	.852	...	9	.725	...	4	.742	35	...	.410
Indian corn	...	29	.644	...	63	.593	...	101	1.881	...	59	.683	...	49	2.318
Potatoes	22	...	.806	49	...	.512	...	79	.502	37	...	.308	...	52	.225
Barley	41	...	.006	...	42	.118	48	....	.001	21	...	.006	93	...	......
Buckwheat	23	...	.076	...	39	.106	...	3	.189	...	4	.075	24	...	.006
			2.238			2.784			4.211			2.498			3.357
Hay	...	21	.170	...	19	.124	...	30	.093	...	40	.063	...	34	.022
Orchard products	41	...	.053	...	4	.958	...	31	.130	...	17	.025	...	65	.034

[C.]

Table showing the number of bushels of potatoes raised in the several counties of New Jersey and Delaware, in 1840 and 1850.

NEW JERSEY.

COUNTIES.	1840.	1850.
Sussex	201,090	110,020
Warren	142 662	92,278
Passaic	78 886	79,160
Bergen	127,043	165,363
Hunterdon	121,569	73,731
Somerset	76 854	63 573
Morris	219,936	135,518
Essex	178,193	159,282
Hudson	14,478	32 885
Mercer	57,581	96,222
Middlesex	86,965	127 021
Cape May	14 394	18 546
Cumberland	31,851	137 312
Atlantic	15,932	21,645
Ocean, (formed from Monmouth, in 1850)	....	40,371
Monmouth	273 280	812,849
Burlington	195,126	412 143
Camden, (formed from Gloucester, in 1844.)	....	373 039
Gloucester	167,525	508 834
Salem	70,044	248 315

DELAWARE.

COUNTIES.	1840.	1850.
New Castle	84 166	125 924
Kent	68,357	89 225
Sussex	48 189	90 806

NEW JERSEY GEOLOGICAL SURVEY

REPORT

ON THE

TOPOGRAPHICAL DEPARTMENT.

NEW JERSEY GEOLOGICAL SURVEY

December 31st, 1856.

SIR:

I herewith transmit the report of the operation under my direction, connected with the Topographical Department of the State Survey, from the first of January to the thirty-first of December, eighteen hundred and fifty-six.

Your Ob't Serv't,

EGBERT L. VIELE,

State Topographical Engineer.

WM. KITCHELL, *State Geologist and Sup't.*

NEW JERSEY GEOLOGICAL SURVEY

REPORT.

The close of the year 1855 found the Topographical Department of the State Survey in a condition of active progression. The survey of the county of Sussex had been completed, drawn, and an engraved copy was in process of execution. The survey of the county of Cape May had also been completed, drawn, and preparations made for engraving it. The survey of the counties of Warren, Morris, and Monmouth were nearly completed and good progress made in the surveys of Salem and Cumberland counties. The triangulation of a large part of the northern portion of the state had been accomplished.

All of the difficulties incident to the first stages of so important a public work had been surmounted, and a thorough organization of every department was completed on principles which insured a perfect degree of accuracy and efficiency.

Great unanimity prevailed throughout the state in favor of the survey. The press yielded its cordial support, and the Legislature endorsed it with an almost unanimous approval. Under circumstances so gratifying it was natural that those, to whose charge the work had been entrusted, should feel an increased enthusiasm in the prosecution of their labors and should endeavor to push them to a successful completion. Guided by these feelings, the organization of the Topograghical corps was maintained.

NEW JERSEY GEOLOGICAL SURVEY

A plane-table party was continued in the county of Cumberland and a revisory party in the county of Cape May.

The draughtsmen and engravers were continued and their work urged forward as rapidly as could be done consistently with the required accuracy.

Preparations were made for taking the field at an early day in the coming season, in short, every effort was made to keep up the vitality of the survey, but our designs were suddenly checked by the unfortunate circumstance, that the money was not in the Treasury to meet the applications made by the Legislature for the continuance of the survey, however, with the small sum obtained, arrangements were made to go on with the work by paying some of the employees a portion of their salary, others agreeing to wait for theirs until the money should be in the Treasury. Under this arrangement, parties were organized and took the field as follows:

Triangulation party, June 1st, 1856. This party continued in the field until the 11th day of October, occupying the following stations, of each at which twenty observations were taken with the theodolite.

1. Springfield, Essex county,
2. Boonton, Morris county,

} These two points are used as base lines for the work of the secondary triangulation.

3. Mt. Hope, Morris county,
4. Morris Plains, "
5. Horse Hill, "
6. Whippany, "
7. Parsippany, (Ch.) "
8. " (west,) "
9. " (south) "
10. Denville Depot, "
11. " (north,) "
12. " (south,) "
13. Hybernia, "
14. Split Rock "
15. Green Pond, "

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16. Kickout, Morris county.
17. Ball Hill I, " } Pompton Mts.
18. " II, " }
19. Bloomingdale, Passaic county.
20. Pompton Plains, Morris county.
21. Pompton, "
22. Pompton Hill, (Church,) Passaic county.
23. Beavertown, Morris County.
24. Hook Mt. I, "
25. Hook Mt. II, "
26. " III, or Pine Brook, Morris county.
27. Hanover Neck, "
28. Beeches' Hill, Passaic county.
29. Ramopo I, "
30. " II, "
31. Wind beam, "
32. Book Mt., "
33. Cnaus Mt., "
34. Bearfort, "
35. Makapin, "
36. Carpenters' Farm, Sussex county.
37. Paul's Corner, "
38. Wawayando Mt. I, "
39 " II, "
40. Twenty-eighth Mile stone, " } on state line.
41. Twenty-ninth " " }
42. Amity Pochuk, state of New York.
43. Mt. Eva, " "
44. Greenville, (Blue Mts.) "
45. Port Jarvis, "
46. Pennsylvania, (station in) Pennsylvania.
47. Carpenters' Point, Sussex county.
48. High Point, "
49. Caldwell, (Church,) Essex county.
50. " Mt., "
51. Fairfield, (Church,) "

The observations made on the above fifty-one stations were one thousand and twenty. Besides the work above

NEW JERSEY GEOLOGICAL SURVEY

mentioned, signals were erected at different stations on the Ramopa, Ringwood, and Greenwood Lake Mts., nineteen in number.

County of Morris.—A plane-table party took the field in in this county on the first day of June, and was withdrawn on the thirteenth of November. The party had gone into the field with the determination to finish the survey of the county during this season if it could possibly be done. The illness of its chief for fifteen days delayed the rest somewhat, yet it was within a few days of its completion when the party was withdrawn. They had been retained in the field after the small sum allowed to them had been exhausted, with the hope that the means to pay them could be obtained until the county was finished, but the party was withdrawn, with deep reluctance, and not until they had become embarrassed for want of funds.

Monmouth County.—The plane-table party was organised and sent into the field on the eleventh day of June, and continued actively engaged until the seventh of November, when, for want of funds, it was withdrawn, within a short time of its completion. A friend of the survey, not a resident of the state, supplied the necessary funds to organise a party to return to this county and complete the survey. This was done, and I am happy to say the survey is completed and the map drawn.

Cumberland County.—A party was organised and sent into the field on the first day of July, and was withdrawn on the tenth day of November without finishing the county. The party could work in this county all winter if the necessary means could have been allowed it.

The summary of the work thus far accomplished is as follows:

County of Cape May.—Survey completed, map drawn, engraved and published.

County of Sussex.—Survey completed, map drawn and partly engraved.

NEW JERSEY GEOLOGICAL SURVEY

County of Monmouth.—Survey completed and map drawn.

County of Morris.—Survey nearly completed, and map partly drawn, (could have been completed in about three weeks).

County of Warren.—More than half surveyed.

County of Salem.—Half surveyed.

County of Cumberland.—Half surveyed.

County of Hudson.—This county could have been completed in four weeks, with the aid (which had been offered) of the New York Harbor Commissioners' work.

The plane-table sheets of the field work which have been finished, are backed and bound, to be deposited in the office of the Secretary of State. Thus the matter stands, and it remains for the legislature to take such action as in their wisdom they shall think best. I can add nothing to what has been said in regard to the value of the survey to the state. Its importance is stamped upon its face. To myself it would be a source of inexpressible gratification to see the work completed, even at a personal sacrifice, and I trust that the work so well begun, may not be suffered to languish for want of the proper support.

EGBERT L. VIELE,
State Topographical Survey.

NEW JERSEY GEOLOGICAL SURVEY

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