FIRST ANNUAL REPORT

OF THE

GEOLOGICAL SURVEY

OF THE

STATE OF NEW JERSEY,

FOR THE YEAR 1854.

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VIEW FROM DINGMAN'S FERRY, LOOKING UP THE DELAWARE RIVER.

SUPERINTENDENT'S REPORT.

To his Excellency, Rodman M. Price, Governor of the State of New Jersey:

SIR:—Having been honored by you with the charge of superintending the geological survey of this State, I beg leave herewith to submit the following reports, for the consideration of the Legislature, of the progress of the survey for the past year.

These reports embrace, generally, an account of the plan which has been adopted in prosecuting the work, and some of the results which have an important economical application to agriculture, mining, &c., it being deemed advisable, at this early period, to abstain from any details or theoretical considerations, leaving them to their more appropriate place in the final minute and systematic report.

GENERAL REMARKS.

The object of the survey is to lay before the people of this State as much practical and available information as possible, respecting its natural resources and advantages.

The investigations necessary to the accomplishment of this object, are embraced under the following heads:

1. To determine the different varieties of rocks, and their relative position.

2. Their thickness and geographical range.
3. Their mineral and palæontological contents.
4. Their lithological and chemical character.
5. Their application to agriculture, mining, architecture, &c.
6. Their topographical features.

The discovery of valuable mineral substances; the establishment of principles which will serve as unerring guides to their discovery and extent; and the utter uselessness of searching for them, except in particular geological formations; the derivation, composition and character of soils; their means of improvement and adaptation to particular plants; the plotting and construction of public works, such as railroads, canals, &c.; architecture; great internal improvements; determining the availability of water courses; establishing the most economical plans for drainage—thus rendering unhealthy districts, healthy and unproductive lands fertile; mining; and almost every branch of the arts and manufactures are included in the above investigations.

In order to arrive at the most reliable and thorough results, demanded by such investigations, researches in the following departments of practical science are required:

Topographical Engineering.
Geology.
Palæontology.
Chemistry and Mineralogy.

TOPOGRAPHICAL ENGINEERING.

Topographical and Geographical Maps—Sections.

The topographical or physical features of a country depend on its geological formations. Wherever there is a change in the underlying rocks, there is a corresponding change on the surface, indicating the extent and limits of each formation, and serving as guides to the explorer. The varied aspect of a country, its mountain scenery, hills and dales, plains, water-falls and courses, all depend, to a greater or less extent, on the change from one formation of rock to another. In making a geological examination of a country, one of the first objects to be accomplished is to represent, on a topographical map, the precise locations and boundaries of the different formations of rocks; also to draw vertical and horizontal sections and profiles of the surface configurations, which will show the order of superposition of the strata and layers of rocks, and their thickness. Hence the importance, in all minute and detailed geological investigations, of an accurate representation of the topographical features of a country. Without this it is totally impossible to describe its orographical structure.

It is to be regretted that, of the many geological surveys of the different States of the Union, none have been preceded by an accurate topographical map. England, France, and some countries of the Continent, understanding its importance, have conducted their geological surveys on a proper basis, and thus furnished to the world that minuteness and accuracy of geological representation and description nowhere to be found in this country.

GEOLOGY.

The term rock, in geological language, not only applies to the hard, solid portion of the earth's crust, but also to the soft and loose materials, such as beds of sand, clay, peat, marl, and soil. They do not occur in a confused and irregular manner, but have a systematic order of arrangement, by which they may be classified into groups depending on their origin, relative age, and general characters.

The most general classification is that which refers to their origin, and which divides them into three principal classes—igneous, aqueous, and metamorphic.

IGNEOUS ROCKS.—The igneous rocks are those which have been formed by the action of heat in the central portion of the earth, and ejected to the surface in a molten state. On cooling, they assume a crystalline aspect, and are generally composed of one or more of the following simple minerals:—feldspar, quartz, hornblende, and mica. They occur in veins, dikes, great irregular masses traversed by joints and divisional planes, constituting mountains, ridges, &c.

AQUEOUS ROCKS.—The aqueous rocks are those which have been formed by the agency of water, from the disintegrated particles of other rocks transported by currents, and deposited as sediment, in the form of strata, beds, layers, laminæ, &c. They very often contain organic remains of plants and animals.

METAMORPHIC ROCKS.—The metamorphic rocks are those which have been formed by aqueous agencies, and subsequently so much altered in their texture by the action of heat, as to resemble igneous rocks. They contain no visible organic remains.

The above is a very general classification of rocks, derived from their origin. They are subdivided into groups called systems, according to their relative age. It is to be regretted that much confusion prevails in regard to their nomenclature.

Every country, and almost every geologist, has a particular system of names, derived either from characteristic fossils, localities, or some lithological peculiarity of the rocks. Those most generally used and understood in this country, are the nomenclature of the English geologists, and that proposed by the geologists of the New York survey. The former is chiefly derived from localities in Great Britain, the latter from localities in New York where particular groups of rocks are well developed. As this was the first attempt at a complete classification of the rocks of this country, it has been generally adopted in different States of the Union, and undoubtedly will remain as a standard of comparison. Geological investigation arranges and classifies the rocks, represents their extent, thickness, and order of arrangement, by means of sections, profiles, &c.; points out and describes the valuable mineral deposits of each formation, and the manner in which they may be worked and applied to various economical purposes. But in order to accomplish this most successfully, it must call to its aid palæontology, mineralogy, and chemistry.

It is by means of the minerals, and organic remains, that the geologist is enabled to determine the varieties of rocks, and their relative ages—one of the most important considerations in a practical or economical view, for it is only in particular formations, and of a particular relative age, that valuable mineral deposits occur. For example, in connection with the igneous and metamorphic rocks (azoic), as granite, trap, gneiss, chloritic, talcose, and hornblende slates, beds of quartz and saccharoidal marbles, or white crystalline limestone, occur the principal metalliferous deposits, as gold, silver, copper, iron, zinc, &c. It is in connection with the aqueous rocks of a certain relative age, that occur the great coal deposits, &c. The former are determined by their lithological character, the latter by their organic remains.

PALÆONTOLOGY.

(ORGANIC REMAINS OF ANIMALS AND PLANTS.)

Its Importance and Relation to Geology.

Palæontology is the science which treats of fossil remains. It has been satisfactorily proved by geological and palæontological research, that at different periods of time the crust of the earth has undergone numerous and various changes; that at one time it was inhabited by no living being; that the waters of the ocean covered its surface; that at a certain period animals and plants sprang into existence, and after living through a few generations died, leaving their remains entombed in the sedimentary deposits of the ocean's bed. Starting from this point, as we ascend in the scale of animal and vegetable existence, we find new tribes of animals and plants successively appearing and disappearing, generation ssucceeding generations, until finally man and his associates, the most perfect of them all, crown the era of animal existence. Some tribes and species have lived through long and successive periods of thousands of years, others for comparatively but a short period. It is often asked during what length of time have all of these successive changes taken place. But the geologist can compute time only by comparison. That it must have been inconceivably great, no one who studies the vast sedimentary deposits in which these remains are found before man appears upon the surface, and then compares the time which was necessarily required in forming these deposits with the time during which that portion of the earth's crust was deposited in which the remains and works of man are found, will fail to conclude that it is impossible to form an adequate idea of its long duration.

Having perfected and regulated, the order of succession in which these changes have taken place, the geologist, commencing with the oldest aqueous rocks, reads the condition of the earth at that period, the state of the atmosphere and its temperature, the changes which took place by aqueous and volcanic agencies, and then, coming as it were to a chapter of more modern history, he reads of another period; and thus, turning page after page, examines successively the changes which have marked the earth's history during a lapse of millions of years.

So regularly have these changes occurred over the whole surface of the earth, that the nature of the organic remains is sufficient to determine the general character of the rocks, and the period at which they were formed.

Perhaps it may not be out of place here to remark, for the information of many with whom I have conversed in different parts of the State during the past year, and who entertained an idea that the principal object in collecting fossils, or organic remains, was merely the formation of cabinets of curiosities at the State capitol, and at the various county seats, at a large expenditure of the public money, that the organic remains found in the rocks constitute the basis of economical geology. It is to them that many of the valuable discoveries in the aqueous rocks are due. The researches of Messrs. Conrad and Hall, have been the means of placing the geology of this country on its proper basis. Had it not been for the fossils, or remains of plants and animals that were found in the aqueous rocks of the State of New York, the geologists of the survey of that State would not have been able to determine the non-existence of coal in that region, which has been the means of preventing a useless expenditure of thousands of dollars, in searching for that material. It was by means of organic remains that the extent and boundaries of the salt-bearing rocks of that State have been ascertained and accurately defined. It is by means of the occurrence of particular fossils in the marl formations of this State, that the researches of the past year have proved the existence of three distinct beds, and determined accurately the extent and thickness of each of them—a matter of great importance to the land-holders of that section of the State. It is evident, then, that to attempt to describe the geological features of a country, and particularly their economical importance, without considering their organic remains, would be throwing aside the grand principles upon which the science is founded.

CHEMISTRY AND MINERALOGY.

In the preceding paragraphs we have referred to the different formations of rocks which compose the crust of the earth, and the various changes which from time to time they have undergone, as well as the great lapse of years during which these changes have taken place. It is one of the first principles of Natural Philosophy that no change can take place in nature, which cannot be referred to some cause, some active force, as the agency. This fact is satisfactorily demonstrated on every hand in the world around us. Whether we consider those mighty and wonderful changes in the earth, or the more insignificant changes which take place in the merest atom upon its surface, every where the same law holds good.

At this stage, then, of geological investigation, after having examined the varied results of a series of changes that have been going on for myriads of years, it becomes us to examine into the causes of these changes, and *chemistry* reveals to us the laws by which they are governed. It has been said by Bischof,* the celebrated chemical geologist, that our earth, as far as we know it, is a great chemical laboratory, in which since the period of its creation uninterrupted chemical processes have been in operation, and will continue so long as it describes its course around the sun. The soil, the atmosphere, animals, and plants, are constantly undergoing changes; and each performs its part in the great and uninterrupted circle of transmutations.

Rocks are composed of one or more distinct substances called simple minerals, such as quartz (silica), feldspar, mica, hornblende, carbonate of lime, talc, oxide of iron, &c. These simple minerals are composed of elementary substances, such as oxygen, hydrogen, carbon, silicium, aluminum, potassium, sodium, calcium, &c., which uniting together in twos form binary compounds; and it is in this latter state that they occur in minerals.

The most common binary compounds are silica, composed of oxygen and silicium; alumina, of oxygen and aluminum; lime, of oxygen and calcium; potash, of oxygen and potassium, &c.

Rocks are sometimes classified according to the predominance of some one of the above binary compounds—as a silicious or arenaceous rock, one in which quartz predominates; an argillaceous rock, one in which alumina or clay predominates; a calcareous rock, one of which lime is the principal constituent; and a carbonaceous rock, one in which carbon prevails.

Almost all the changes that take place in the rocks and materials, organic or inorganic, which constitute the crust of the earth, or grow upon its surface, have their origin in the transformations of the simple elementary bodies. Having a knowledge of the laws by which these transformations are governed, we are able to apply them to the various useful purposes of life.

* Bischof's Geologie—(Introduction.)

It is in consequence of such transformations that soils are formed of the *debris* of rocks, from which plants receive their sustenance; consequently the chemical character of soils partakes more or less of that of the rocks from which they are derived. There are other causes too, which tend to modify the composition of soils in particular localities, as the occurrence of drift, disintegration of bowlders, presence of organic matter, &c. When all of these circumstances are taken into consideration, the general properties of soils are known without subjecting them to minute chemical examinations. The decomposition and disintegration of rocks by chemical agencies is a subject of great importance in rural economy, and one which should receive careful investigation. It has an important practical application in a variety of ways. It teaches the distinctive properties of the soil, to what kind of vegetation it is adapted, and how it may be improved either by cultivation, or by the addition of foreign substances as fertilizers. It is by investigating the laws of nature in her varied chemical and mechanical changes, that we are enabled to imitate them in the practical pursuits of life, and make them subservient to our happiness and prosperity.

RESULTS OF SCIENTIFIC INVESTIGATION IN THE STATE AT THE COMMENCEMENT OF THE SURVEY.

Upon receiving my commission as superintendent of the survey, I proceeded immediately to ascertain what reliable information respecting the topography and geology of the State previous researches had already laid before the people. My principal object was to ascertain if there existed any correct maps, or reliable surveys, which might serve as a proper basis for delineating accurately the geological features of the State. The different editions of the State map, the county maps, and several local surveys were examined. None of them were found to be sufficiently correct, or to furnish the necessary data from which such a map could be compiled as the objects of the survey, in compliance with the law, demand. Some of the results of my researches were as follows:

The first complete map of the State was compiled by Thomas Gordon, from various local surveys, together with some original surveys procured by an act of the Legislature, passed November twenty-eighth, eighteen hundred and twenty-two, authorizing a loan to Thomas Gordon of one thousand dollars, to enable him to obtain additional surveys for the purpose of making a State map. This map, known as Gordon's map, was completed and published in the year eighteen hundred and twenty-eight. During the same year, upon the sixth of March, a resolution was passed by the Legislature, authorizing the Governor to subscribe for one hundred and twenty-five copies. On the fourteenth of February, eighteen hundred and thirty-one, the Legislature passed an act authorizing the treasurer to cancel Gordon's bond, and the Governor to take one hundred and twenty-five additional copies at one thousand dollars.

A second edition of the State map was revised, corrected, and improved, by Robert E. Horner, by a resolution of the Legislature, appropriating one thousand dollars, passed February twenty-fifth, eighteen hundred and forty-seven. This is the last and most reliable edition of the State map. Every other map, made since the publication of this edition, has been compiled therefrom; and the manner in which this was made was sufficient to satisfy me of its want of accuracy, and of its insufficiency as a basis for the geological purposes of the survey. Subsequent examinations and field researches have verified my suppositions, as will be seen by referring to the annexed report of Mr. Viele, the State Topographical engineer.

In the year eighteen hundred and thirty-five, the Legislature passed an act authorizing a geological and mineralogical survey of the State, with an appropriation of one thousand dollars. This survey was conducted under the superintendence of Professor Henry D. Rogers, and the first report of it was made during the following year. March tenth, of the same year, a further appropriation of two thousand dollars was made. March seventeenth, eighteen hundred and thirty-seven, two thousand dollars more were appropriated; and on the twenty-seventh of February, eighteen hundred and thirty-eight, two thousand copies of a final report were ordered to be published at eighty-seven cents each. This report, containing three hundred and one pages, together with a geological map, was published in eighteen hundred and forty, and embraces a general outline of the geological formations of the State, with analyses of some of the rocks, greensand, and fresh water marls and calcareous tufas, also some general observations on their application to agriculture and the arts.

The survey of Professor Rogers was as minute and detailed as the circumstances and the early day of geological science would allow; and when we take into consideration the meagre means placed at his disposal, and the short space of time allotted for the accomplishment of the work, we can do no less than say, that the outlines of the different formations were accurately defined, and a vast amount of useful information respecting the natural resources of the State presented, resulting in great public benefit. and had the people more generally availed themselves of it, would have been of still greater benefit to them in their agricultural, architectural, and many other pursuits of life.

Previous to the survey of Professor Rogers, local examinations to some extent had been made chiefly in the mineral regions of the northern part of the State, and in the marls of the southern section. Among those who took the most active part in the researches at that time, were Dr. Samuel Fowler, of Franklin, Sussex County, who published several articles in Silliman's Journal, on the mineralogy and geology of Sussex County; Prof. Nutall, Messrs. Vanuxem, Keating, and others, who, from time to time, contributed papers to Silliman's Journal, and the Journal of the Academy of Natural Sciences, of Philadelphia. Dr. Morton and Mr. T. A. Conrad, of Philadelphia, had very thoroughly examined and described the fossils of the southern section of the State. The published results of these labors are among the most valuable contributions to science that this country has afforded, and will stand as monuments to the high scientific attainments and indefatigable industry of their authors.

During the past three or four years, many detailed local examinations have been made in the mineral regions of the State by eminent scientific men, which have resulted in very valuable discoveries of new minerals and natural fertilizers. But as the investigations have been made solely for the advancement of private interests, the people at large have been but little benefited thereby, and indeed have frequently parted with valuable property in mineral districts for a trifling consideration; things which would not have occurred had they been possessed of such reliable information as a detailed geological survey would have afforded.

At the time of the last geological survey, very little attention was paid to the importance of the application of chemical and geological researches to agriculture. The State was comparatively thinly settled, and the average quantity of rich virgin lands being very great in proportion to the inhabitants, its necessity and value were not so apparent as at the present time, when a constant tide of immigration is densely populating its territory, and the once rich lands are becoming impoverished by an exhausting system of tillage.

MINERAL RODS, HAZEL WITCHES, FOOL'S GOLD, SEARCHING FOR GOLD.

The frequent applications that have been made to me for the loan of divining or mineral rods, either for the purpose of discovering the hidden treasures that lie concealed beneath the surface of the earth, or for reaching some vein of gold, silver, or copper, of which a traditionary account has been handed down from generation to generation, or for exploring the spot where a flash of light has been seen, or an explosion heard—which by many are believed to be infallible signs of the occurrence of minerals; and the experiments which I have witnessed of the use of the hazel witch, for the purpose of locating wells where the water runs nearest to the surface, suggest the propriety of making some remarks by way of caution to those who believe in the efficacy of such means.

In my travels through the State, hardly a day passes on which such applications are not made to me, together with the recital of wonderful discoveries which have been made through such instrumentalities. It is not indeed wonderful, that there is so much credulity among the great masses of the people, for they have but little knowledge of the properties of minerals, or of the elementary principles of natural science. It seems to them as reasonable to believe that the presence of gold, silver or copper may be indicated by some such instrumentality, as that a vein of magnetic iron ore may be discovered by means of the magnetic needle. In order that I may give a clearer idea of the manner in which many people of this State have been duped, I will briefly mention a few cases that have come under my own observation.

Two years ago, a very worthy and respectable man called upon me, stating that he supposed I had a mineral rod that would discover a vein of copper, its depth from the surface, its width, and the quality of the ore, and that he would like to borrow it for the purpose of finding a vein of copper in Morris County, which his grandfather had discovered some sixty years ago, and some of the ore from which he had smelted in a blacksmith's forge in the vicinity. He stated that his grandfather had moved to Missouri when his father was a boy, and had often told his son of this copper vein, giving to him before his death a map of the property, upon which was indicated the precise spot where the opening had been made into it. He felt so confident that by means of this map he could go directly to the concealed treasure, that he endeavored to purchase the property at a very high price. On arriving at the premises in question, he was unable to find the opening into the vein, on account of the changes which cultivation had wrought upon the fields. He immediately applied to a man in the vicinity who possessed a mineral rod of marvellous virtue, and who professed to be skilled in its use; told him his story, and, after receiving from the *mineralizer* assurances of the occurrence of a copper vein in that field which his mineral rod had discovered several years previous, offered to disclose it to him, together with its precise width, richness, &c., for the sum of twenty-five dollars. The stipulated amount having been paid, they proceeded to the field; the mineral rod pointed out the vein, the dimensions of which were duly defined with stakes. So well satisfied was he with the correctness of the revelations of the magic rod, that on the following day he offered to purchase the property at ten times its value. Its owner, however, catching the enthusiasm and dreaming of becoming suddenly rich, would not dispose of his property under any circumstances; but offered to lease it on very favorable terms. A lease was accordingly drawn, and our hero commenced operations by sinking a shaft over the supposed vein; and when he applied to me had already sunk the shaft twice the depth required by the revelation; and having expended several hundred dollars, was about returning to the West either to induce his father, an old, feeble man, to come and point out the spot, or to recruit himself with funds to prosecute the work.

During the last summer, I met with one of these philosophers in whose hands the divining rod possesses such wonderful powers, and who has acquired great reputation in the northern part of the State, not only from the pretended discoveries that he has made, but for his untiring efforts to unfold *hidden treasures.* After much difficulty, my curiosity was gratified by seeing the veritable rod with which, according to his own statement, he had located the principal gold mines of Virginia and North Carolina, had discovered sunken steamboats on the great lakes, had told how much silver there was in the Sussex Bank, had traced the franklinite and zinc ores of Stirling Hill for miles from their present location, had discovered the principal iron veins of New Jersey, and for which he had been offered two hundred thousand dollars by a company in California.

The instrument resembled an ordinary metallic syringe, about one inch in diameter, and five or six inches in length, having screws attached to the larger extremity, by which it could be fastened to the handle of a cane. He stated that it was made of silver, and that its virtue depended on a peculiar substance which he had discovered, and which he placed in the syringe, when he wished to search for silver ore. These instruments were made of different materials according to the metal sought; for example, if the object of his search was gold, he used one made of that metal, and charged in the same manner: if he sought iron, his instrument was of iron, &c. When on his exploring expeditions, he carried with him a number of them. He never allowed them to go out of his hands, as their magic influence would thus be at once destroyed. I was very much amused by his company during a short trip over the Sparta Mountain, when he promised to point out to me the precise locality of the franklinite and zinc veins crossing this region. He informed me, in different places, as to the precise number of feet and inches at which these veins lay from the surface; and after showing several small bowlders of zinc and franklinite ore lying on the surface of his vein, he observed: "a good many scientific geologists have been around here, who think they know every thing about minerals and so on, and they say that these are loose pieces that have travelled from the mine at Stirling Hill, but it ain't so; it's agin' nater for stones to swim or run up hill."

I would not have repeated so much of his jargon, had I not been informed that during the past three or four years he has received eight or ten thousand dollars for his professional services in that vicinity, and that a large amount of money has been expended in digging under his directions.

Water philosophers, or those who profess to be able, by means of the *witch hazel*, to discover springs and streams of water beneath the surface, are somewhat numerous throughout the State, and are often called from some distant place to decide upon locations for digging wells. I had an opportunity of witnessing the operations of one of them in locating a stream of water, and determining its depth, capacity, &c.; but in regard to the correctness of his statements I had no visible evidence.

One of the most common delusions, and one that has caused a great expenditure of money, is the flashing of lights and rumbling noises, concerning which many notions are entertained. During the past summer, I found men on the Blue Mountain digging for gold in the hard Shawangunk grit, where lights were said to have been seen; and numerous are the excavations that have been made there in search of gold, solely on account of some traditionary tale about the appearance of fire or smoke. Among the inhabitants of that mountain there is hardly a man who has not heard of lights and rumbling noises. In several of the excavations I found iron pyrites, which, by a rapid decomposition, sometimes produces a great deal of heat and even smoke; and if lights have ever been seen, their origin can be referred to the pyrites. For the information of those who are so credulous in such matters, I may be allowed to say that they are no indication of valuable mineral deposits.

The occurrence of iron pyrites, to a greater or less extent, in almost all the rocks of the northern part of the State, has been the cause of a useless expenditure of money. On account of its resemblance to gold in color, and the frequency of its being mistaken for that mineral, it has been called "fool's gold." Many have sought me with parcels of it carefully wrapped in paper, which they had obtained at an expenditure of much labor and money, and have asked its value, together with advice as to the best method of continuing their work. It may be readily distinguished from gold by holding it in the flame of a candle or throwing it in the fire, when it will lose its brilliant hue; while gold, under the same circumstances, will preserve its color. It may also be detected by its brittleness; for if the point of a knife be pressed against it, it will break readily, while gold is tenacious and difficult to be broken.

The frequent occurrence of dark-colored slates and shales along the Delaware River, and east of the Blue Mountain, has induced many to believe that coal must be associated with them; and many excavations have been vainly made in search of it. It often happens that coal miners, passing through the country, assert the presence of coal in these districts, on account of the similarity existing between the shales here and the slates of the coal mines in which they have worked. These men are not unfrequently employed to dig for coal. But so far as the geological researches have extended during the past year, it is ascertained that no coal exists there.

I think it may be safely said that the money expended in idle researches at the instigation of pretenders, or from a lack of information respecting the natural resources of the State, would be more than sufficient to complete the survey, and thus afford reliable information to every one of its inhabitants.

We are apt to wonder at the credulity of our forefathers in their belief in the magician's wand and the philosopher's stone, but nowhere in history have we accounts more absurd than those furnished in our very midst. In fact, there has always been a kind of superstitious feeling or credulity respecting the precious metals, and I know of no better way of dispelling it than by the promotion of education, and the dissemination of useful knowledge, in which New Jersey is now taking a very creditable stand, by the establishment of a liberal system of instruction, and by carrying on extensive internal improvements.

PLAN OF SURVEY.

The plan adopted for prosecuting the survey, and by which it has been conducted during the past year, divides it into four principal departments, viz.:

1. The Trigonometrical and Topographical.
2. The Geological.
3. The Palæontological.
4. The Chemical and Mineralogical.

TRIGONOMETRICAL AND TOPOGRAPHICAL DEPARTMENT.

On referring to the accompanying report of Mr. E. L. Viele, the State Topographical Engineer, it will be observed that this part of the survey has been vigorously prosecuted. When we take into consideration the limited means placed at his disposal for properly commencing the work, the many difficulties under which he labored at the outset, and the lateness of the season, it will be seen that much has been accomplished. It will be remembered that the object of this part of the survey is to furnish a detailed and accurate topographical map of the State, upon which its geological features may be correctly delineated, and from which sections may be made representing the thickness and superposition of each formation of rocks; and as this is the groundwork of the geological survey proper, the greater part of the funds placed at my disposal has been appropriated to its prosecution, in order that as much of the topography might be completed as possible by the opening of the next year, which being mapped out during the winter, would serve as a guide in the detailed geological examination for that year. Independent of the great importance of this survey, on account of its connection with geology, it will be of incalculable benefit in various respects. It will furnish a map upon which every mountain, hill, and valley, with their comparative dimensions, every boundary line, natural and artificial; every road, river, stream and canal; every farm and house, will be represented. By it, public works may be plotted, and systems of drainage established. It will be of great benefit in the opening of mines, quarries, and deposits of fertilizers.

GEOLOGICAL DEPARTMENT.

In the geological department two divisions of the State have been made: Northern and Southern. The line of division extends from Staten Island Sound near Elizabethport to the Delaware River, a little below Trenton, following the southeastern border of the red shales and sandstones which stretch across the central part of the State. This line has been selected on account of its being a natural division of the State into two nearly equal parts, in respect to area, while in respect to their physical, geological and agricultural features, they are entirely different. The adoption of this division will, in the final report, be the means of avoiding unnecessary repetition.

SOUTHERN DIVISION.

The southern division of the State has been assigned to Professor George H. Cook, assistant geologist of the survey. He entered upon his duties in Monmouth County on the 27th of July last, and from that time to the present has been engaged either in the field or in the laboratory. His attention has been chiefly directed to the marl beds of the greensand formation; and a perusal of his report will satisfy all of the great importance of a more minute examination than has hitherto been made. Allow me to call your attention especially to that part of his report which refers to the following facts, proved from examinations in the field:

1. "The clays and marls which constitute the basis of most of this part of the State are in regular and continuous layers."

2. "The layers are not level, but incline or dip towards the southeast."

3. "Since those layers were formed, the action of the water, or other causes, has worn away and changed the surface of the country."

Laying aside for the present, the importance of these facts in a scientific point of view, I will merely refer to their practical application.

Although the layers of marl, constituting this formation, are not level, yet they are deposited in a certain plane whose inclination is towards the southeast. The irregularities of the surface of the soil having been produced subsequently to the deposition of the marl layers, by the action of currents of water, winds, &c., it is evident that these irregularities are entirely independent of the surface of the marl layers. Knowing then the inclination of the layers of the latter, and adopting their surface as a base, we may, by measuring the inequalities of the surface across the formation, ascertain the precise depth of each bed of marl from the surface, and represent it by means of maps and sections; thus each landholder within the formation can determine the most accessible localities for opening marl pits. Hitherto the discovery of marl pits has been uncertain and accidental, on account of a want of that accurate information respecting their position, division into distinct layers characterized by particular fossils, and their position relative to the surface configuration. If, then, land upon which marl is accessible is worth from five to seven dollars per ten feet square upon the surface, and scientific investigation determines where such lands may be located within the five hundred and seventy-six thousand acres of this formation, it is superfluous to enlarge upon the great benefits to be derived from it.

NORTHERN DIVISION.

To the geological examination of the northern division of the State, I have given my own personal attention, and the results thereof will be seen in the sequel to this report.

PALÆONTOLOGICAL DEPARTMENT.

This being one of the most essential branches of the science of geology, I directed, at the commencement of the survey, each member of the corps to pay particular attention to searching for, gathering, and preserving organic remains. The result is, that quite a large collection of the fossils of Sussex and Monmouth counties has been made and forwarded to the State capital, as well as to the county seats of the counties in which they are found. The collection from each formation being still incomplete, and the time very limited, it is deemed inexpedient to make any description of the specimens already procured until a subsequent report. I would recommend a vigorous prosecution of this very important department of the survey, so that upon its completion, every species of organic remains found in the State may be accurately described and represented.

CHEMICAL AND MINERALOGICAL DEPARTMENT.

Mr. Henry Wurtz, the chemist and mineralogist of the survey, entered upon his duties on the first day of November last. In order that the chemical investigations of some of the most important minerals and fertilizers might be made at as early a day as possible, I directed him to rent a building suitable for a laboratory at Trenton, and to proceed at once to furnish it with the necessary apparatus and reagents. The amount of funds set apart for this purpose being wholly insufficient, Mr. Wurtz has, by adding his own apparatus and chemicals, formed a very complete and convenient laboratory, and already made some chemical investigations of the fresh-water marls and calcareous sinters of Sussex County, the results of which will be found in his accompanying report. Prof. Cook has also been engaged in his laboratory at Rutgers College, in making examinations of the greensand marls, and the results of his researches will be found to be of very considerable importance.

CABINET.

The law authorizing the survey provides for the collection of two complete suites of specimens of all the different minerals, rocks, fossils, marls, clays, sands, peats, &c.; one to be forwarded to Trenton, to be disposed of as the Legislature may hereafter direct; the other, consisting of the minerals,

&c., peculiar to each county, to be forwarded to the county seat, and there disposed of as the Board of Freeholders shall deem proper. As far as the researches have extended in detail, three suites have been made—two for Trenton and one for the county seat. I think it advisable that two suites should be made for the State, in order that the final arrangement of the cabinet may be divided into two parts, viz.: a geological and geographical arrangement. The former to exhibit the rocks in their order, together with their associate minerals, fossils, &c., corresponding with the geological maps, sections, &c.; the latter a local arrangement in townships or sections of townships, to correspond with the accompanying local descriptions. I propose to adopt the latter alone for the county cabinets.

During the year twenty-six boxes of rocks, minerals, and fossils have been forwarded to Trenton from Sussex County, and eight to Newton. Prof. Cook has made a complete collection of the marls of Monmouth, as far as his detailed examinations have extended. They have been properly prepared and labelled, and now await a suitable place for their reception. The very great variety of minerals and organic remains of this State, will necessarily form an extensive cabinet, and I would therefore call the attention of the Legislature to the importance of taking some steps towards obtaining suitable rooms for its permanent arrangement. I would also here state that several applications have been made to me by different educational institutions in this, as well as in other States, for complete collections of New Jersey minerals, rocks, &c. But as much expense attends the collection of specimens, and as the law does not authorize more than two suites, I could not comply with any of these requests. It is very desirable, however, that a knowledge of the resources of this State should be spread as widely and rapidly as possible, and there is no more effectual way than by distributing samples of its productions to every part of the country. The subject is worthy of the consideration of the Legislature.

EXPENSES OF THE SURVEY.

Upon organizing a competent corps, consisting of an engineer, assistant geologist, chemist, and mineralogist, and other aids sufficient to commence and carry on the survey in accordance with the adopted plan, a difficulty was encountered at the outset, on account of the smallness of the appropriation.

Reconnoissances were to be made, instruments, apparatus, and chemicals to be provided and transported, and a variety of preliminary arrangements required, as may readily be expected at the opening of a work of this kind. It was evident that to commence the survey on this plan, in all the departments, not only a rigid economy must be observed, but that the greater part of the necessary instruments must be obtained otherwise than by purchase. With this view, letters were addressed to Prof. Bache, superintendent of the United States Coast Survey, laying before him the embarrassing circumstances under which we labored, and soliciting the loan of certain instruments. Prof. Bache, convinced of the great importance of the undertaking, responded unhesitatingly to our solicitations, and forwarded all that we needed; the acknowledgment of which, together with the acknowledgment of the receipt of instruments from the New Jersey Franklinite Company, will be found in the accompanying report of the topographical engineer. Each member of the corps also loaned his instruments and apparatus, and thus a great expense was avoided at the outset.

As several applications had been received from young men desirous of becoming connected with the survey, for the purpose of acquiring practical knowledge in the several departments, it was thought advisable to receive all such as volunteers, who should be willing to bear their own expenses, and have assigned to them a particular duty, to which they should attend as assiduously as if they were compensated. At different times during the year, eight have been received upon these terms; and although an acknowledgment is due to some of them, yet, as a general rule, I do not think the plan is an economical one; for in every department of the survey, it is necessary that each member of it should know his duty, and attend to it zealously. The applicants or volunteers are chiefly young men, who have just completed their collegiate education, without any fixed business habits, and in some cases unsettled as to the choice of a profession. They enter upon the survey, and in a few weeks, becoming dissatisfied, desire to try some other department. The result is, that the party becomes disorganized, operations temporarily suspended, until a reorganization can be made; and thus, indirectly, a greater expense incurred than would compensate competent assistants. In making the above remarks, I do not wish to convey the idea that such has been the case with all the volunteers who have been engaged in the survey. Some of them have been of much service to the State, and I trust have received in return much useful and practical information. This statement I am induced to make on account of the numerous applications for such situations, as well as for the purpose of removing the impression received by many, that such services must diminish the expense of the survey.

The following is an abstract of the disbursements in prosecuting the survey for the year ending December 31, 1854:

For services,	$3,680 10	
" instruments and apparatus,	133 50	
" incidentals,	186 40	
Amount,	$4,000 00	
Appropriation for survey, made March 2d, 1854,		$4,000 00

ESTIMATE OF EXPENSES FOR THE YEAR EIGHTEEN HUNDRED AND FIFTY-FIVE.

The following is an abstract of the expenses for prosecuting the survey in an expeditious and economical manner, for the year eighteen hundred and fifty-five:

Trigonometrical and Topographical department,	$15,000
Geological Department—Southern Division,	2,000
" " Northern Division,	4,000
Chemical and Mineralogical department,	2,500
Palæontological department,	1,500
	$25,000

With this amount the topography can be extended over the greater part of the State; the geological researches made in detail as far as the topography extends, together with a general examination of the remaining portion, leaving the survey in such a condition that the entire field work of the State can be completed in eighteen hundred and fifty-six.

In the preceding pages, I have endeavored to present a general outline of the manner of prosecuting accurate geological surveys, and of the plan upon which the survey of this State has been commenced and carried on, the amount of time and means for completing it, and the benefits to be expected therefrom. I trust that the Legislature will take the matter fully into consideration, and that an ample appropriation will be made towards its rapid completion. The geographical position of the State, its varied physical aspect, geological formations, and soils, demand that every acre of its territory should be thoroughly examined. There was a time, in the infancy of the science of geology, when general investigations were deemed sufficient to answer all practical purposes. That time has passed away; economical geology has become an accurate science, and in order that the most beneficial results may be attained from its investigations, it must be pursued in an accurate manner.

SEQUEL TO NORTHERN DIVISION.

I have devoted the greater part of my time, from the middle of July to the first of December, to geological examinations of the northern division of the State. During this time I have made a reconnoissance of Sussex County, and a part of

Morris and Passaic counties; also detailed examinations of the townships of Sparta, Hardiston, Vernon, Wantage, Montague, and a part of Sandiston and Newton. Several geological sections have been made from actual measurements and levelling across the country from the Delaware River to the Highlands; also sections, on a greater scale, of important mineral localities and mines, representing the relative position, thickness and dip of each kind of rocks, and their associated ores. Twenty sketches, illustrating the physical features of the surface, and geological peculiarities of the rocks, have been taken, and will be submitted for the inspection of the Legislature. The sections, profiles, and sketches, are intended to accompany the final report.

Thirty-four boxes of minerals, fossils, marls, peats, &c., have been collected, and forwarded to Trenton for examination, labelling, &c. But since the close of the field labors, there has not been sufficient time to make such an examination as is necessary before an accurate and complete report can be rendered on any particular locality or formation. I shall therefore only give a synopsis of such results of the investigation as may be particularly useful, and shall confine myself to that part of Sussex County in which the more detailed researches have been made.

GENERAL REMARKS ON THE PHYSICAL GEOGRAPHY AND GEOLOGICAL FORMATION OF SUSSEX COUNTY.

The physical geography of Sussex County, indeed, that of the whole northern division of the State, presents a striking contrast to that of the southern division; for while the latter resembles an extended plain, offering but little to attract the attention of the traveller, except its fertile fields and evergreen forests, the former is diversified with mountains, hills and valleys, affording that beautiful and varied scenery so characteristic of mountain districts.

There are three principal ranges, or series of elevated lands, crossing the county in a northeasterly and southwesterly direction, viz.: the Blue or Kittatinny Mountain, extending along the northwestern boundary of the county, from the State of New York to Pennsylvania; the series of hills or ridges forming the Pochuck Mountain and Pimple Hill; and that part of the Highlands known as the Wawayanda, Wallkill and Andover Mountains, stretching along the southeastern border of the county.

Corresponding with the mountain ranges are three valleys, viz.: the valley of the Delaware, situated between the foot of the northwestern slope of the Blue Mountain and the Delaware River; the Kittatinny valley, ten miles in width, extending from the southeastern base of the Blue Mountain to the Pochuck and Pimple Hill range; and the valley of the Wallkill, situated between the latter and the Highlands. While the mountains are characterized by a rocky, meagre, and unproductive soil, and covered with trees of various species, and thickets of scrub oaks, the valleys are fertile, with a soil of alluvial and diluvial origin, easily cultivated, and bountifully rewarding industry.

The mountains, valleys and plains, are watered by numerous springs, lakes and rivers. The former are every where to be found on the elevated lands; and this, together with the peculiar adaptation of the soil to the growth of grass, renders the country admirably fitted to the rearing of fine stock, for which it is somewhat celebrated.

The numerous lakes, situated upon the highest lands, form a striking feature in the physical aspect of the country. They are sometimes one mile, sometimes several miles, in length and width; and they abound in the choicest varieties of fish. Among them may be mentioned the Wawayanda Lake, located upon the mountain of the same name, and which is a beautiful sheet of water about two miles in length, half a mile in width, and from ninety to one hundred feet in depth; the Machipaconk Lake, on the Blue Mountain, three quarters of a mile in length and half a mile in width; Cedar Swamp Lake, on the Blue Mountain, near the New York State line, and thirteen hundred feet above the level of the water in the Delaware; Culver's, Swartwout's, Long, Morris's, and numerous other lakes.

The streams take their origin chiefly in the central part of the county, and empty their waters into the Hudson and Delaware rivers. Among them may be mentioned the Little and Big Flatkill, Paulin's Kill and Pequest, whose waters are emptied into the Delaware; and the Wallkill, with its numerous tributaries, as the Wawayanda, Warwick, Black, and Papakating creeks, emptying into the Hudson.

Its geological formations are as varied as its physical features. From the earliest period of the earth's existence, the two great dynamic forces, the igneous and the aqueous, have here alternately exerted themselves in forming and modifying its surface. At one time the waters of the ocean, teeming with animal life, covered its whole extent, and deposited the materials which now constitute its sedimentary rocks. At another time igneous agencies upheaved them from their ocean beds, forming the mountains and the valleys, filling the sedimentary deposits with rich ores and minerals, and thus here bringing together the three principal classes of rocks: aqueous, metamorphic, and igneous.

The aqueous rocks consist of a series of blue limestones of various shades of color, texture and composition; argillaceous, silicious, and calcareous slates and shales, and red, white, and gray sandstones, grits and conglomerates. They are composed of those series of rocks, denominated by the geologists of the New York survey, the New York System; and correspond with the Devonian and Silurian Systems of the English geologists. The most recent, or uppermost of this series, is a black fissile slate, called Marcellus Slate, the oldest member of the Erie Division of the New York System. This rock has but a very limited range in this State, occupying a bend of the Delaware River, which extends only three quarters of a mile below Shabacong Island; it then disappears beneath the alluvial matter of the island, and of the valley of the Delaware. Its greatest width is three hundred yards. It may be examined on the farm of Peter Van Noy, about a quarter of a mile from the river, where a tunnel has been made in search of coal. Its color is very dark—almost a jet black; it is very fissile, and under the stroke of the hammer, it breaks into small pieces not greater than six or eight inches across. It contains iron pyrites, which on the exposed surface of the rock, having decomposed and covered it with an incrustation of the hydrous peroxide of iron, gives to it a brownish iron-rust color. A considerable quantity of this iron-rust, or hydrous peroxide of iron, has been carried down by streams of water and deposited along the banks of the river, and thus led many, erroneously, to believe that valuable deposits of iron ore are located in the vicinity.

The next series of rocks in the descending order; upon which the Marcellus Slate reposes conformably, is the Helderberg Series. This division embraces a series of limestones, varying in their lithological, chemical and fossil characters, by which they are subdivided into beds. Among the subdivisions occurring in this State which are well developed, and may be accurately defined by their characteristic fossils, may be mentioned (taking them in their order), the Corniferous, Onondaga, Encrinal, and Delthyris Shaly limestones, and Water Lime Group. They all abound in fossil remains; the most abundant being the encrinal, coralline, and testaceous remains; and each subdivision has some that are characteristic of it. They extend along the Delaware River from the New York State line to Walpack Bend, and vary from one mile to a mile and a half in width, composing that series of rolling hills and fertile ridges situated at the northwestern base of the Blue Mountain.

Directly under the Helderberg Series occurs the Ontario Division, of which the Medina Sandstone is well developed here (No. V. of Prof. Rogers), consisting of dark red sandstones and shales, occupying the northwestern slope of the Blue Mountain.

Next in the descending order occurs the Champlain Division, of which may be mentioned the following subdivisions:

1st. The Oneida, or Shawangunk Conglomerate, occupying the elevated portions of the Blue Mountain, and which is composed of a series of fine-grained silicious grits, coarse sandstones, and conglomerates made up of silicious matter from fine sand to pebbles of quartz three quarters of an inch in diameter; the Hudson River Group, composed of dark-colored slates, shales, thick-bedded and slaty calcareous grits, &c.; the Utica Slate, composed of dark-colored and argillaceous slates, furnishing in many places an excellent material for roofing; the Trenton and Black River Limestones; Calciferous Sand Rock, and Potsdam Sandstone. The above subdivisions of the Champlain Series, commencing with the Hudson River Group, occupy chiefly the Kittatinny and Wallkill valleys.

The metamorphic rocks are gneiss, hornblende slate, and white crystalline limestone. The latter occurs chiefly in the valley of the Wallkill, between the Wawayanda and Wallkill mountains, and the Pochuck and Pimple Hill range; the two former constitute the principal part of the rocks of the mountain ranges, as well as several parallel belts of the Wallkill valley.

The igneous rocks occur chiefly in the form of intrusive veins, dikes, and irregular masses of granite, syenite, and quartzose feldspathic rock, in the metamorphic, with the exception of a porphyritic granite which occurs protruding through the Hudson River Slate, and upheaving the Oneida or Shawangunk Conglomerate of the Blue Mountain near Beemersville, five miles northeast of Culver's Gap.

ECONOMIC GEOLOGY.

Among the various ores and materials of economical value occurring in the above formations are:

Magnetic iron ore;

Specular iron;

Limonite (hydrous peroxide of iron);

Iron pyrites;
Franklinite;
Red oxide of zinc;
Galena (argentiferous);
Sulphate of baryta;
Roofing slate;
Limestone for building and agricultural purposes;
Marble;
Calcareous sinter;
Shell marl;
Peat;
Kaolin (porcelain clay).

MAGNETIC IRON ORE—MAGNETITE—MAGNETIC OXIDE OF IRON—NATIVE MAGNET—LOADSTONE.

This ore, when pure, has an iron black color, and metallic lustre; is strongly magnetic; produces a black streak when rubbed on a surface of unglazed white porcelain, and gives a black powder when pulverized. Its composition is oxygen and iron—a combination of the protoxide and peroxide—72.4 of iron and 27.6 of oxygen. It may be readily distinguished from other ores of iron by its black streak and powder, and magnetic properties.

The description here given is that of pure magnetic iron ore, but this substance is very often associated with foreign matter, as quartz, mica, hornblende, feldspar, etc., which alter the color and general character of the ore, according to the kind, quantity, and texture of the foreign matter. It is one of the most valuable ores of iron; and from it the greater part of the iron of this State is manufactured. It occurs in veins and beds, and is disseminated through igneous and metamorphic rocks. In this district it occurs chiefly in the igneous and metamorphic rocks of the Highlands, and valley of the Wallkill.

The following are among the most important localities:

WAYWAYANDA MINE.

This mine is situated on the Wawayanda Mountain, half a mile from the New York State line, and two and a half miles northeast of the Wawayanda Lake. The prevailing character of the rock, in which the ore occurs, is gneiss. It is exceedingly variable in composition and texture. Mica enters but slightly into any of the rocks throughout the whole mountain, and in many places it is entirely absent. When entirely absent, hornblende, or magnetic iron ore, in grains, takes its place, forming a syenitic gneiss. The rock in some places is composed only of feldspar and quartz, the former being its principal ingredient.

Four deposits of ore have been opened and worked. Their prevailing course is northeast and southwest, and their dip from twenty to forty degrees to the southeast.

Commencing at the southeasterly deposit, and taking them in their numerical order, we find that the first is not worked at the present time, and has not been for several years, because the ore is more accessible and more abundant in the other deposits. On account of the water in the shaft, and the dilapidated condition of its timbering, I was unable to make a personal examination, but I was, however, informed by the mining captain, that it has been worked to the depth of one hundred and ten feet, and one hundred on the deposit; and that the ore is from twelve to fourteen feet in width, at the bottom of the shaft.

The second deposit occurs fifty feet northwest of the first. It has been worked to the depth of eighty feet, and one hundred feet on the deposit; and at its present depth is thirty feet in width.

The third deposit is seventy-five feet from the second. Here the ore occurs in the form of a bed, or irregular deposit, varying from two to twelve feet in width. At its present depth, one extremity of the workings shows the ore six feet in width, and the other two feet.

The fourth deposit, forty-five feet from the third, is from four to five feet in width, and has been worked to the depth of sixty-five feet.

About a quarter of a mile southwest of the Wawayanda Mine, on the property of Mr. Green, openings have been made into the third and fourth deposits, from which a large quantity of ore has been taken. All these deposits are exceedingly irregular, having no well defined walls. They occur between two strata of gneiss of different characters. The underlying stratum is generally a very hard and crystalline syenitic gneiss; the overhanging is chiefly composed of feldspar and quartz; the former in large imperfect crystals and greatly predominating. They are frequently displaced and altered by dikes of granite, which in some cases are injected into the deposit, and in others, cut it off entirely and throw it aside. Numerous sketches and sections illustrating the dislocations have been taken, and will accompany the detailed description of this mine in the final report, together with the composition of the ores, metallurgy, etc.

The ore from this mine is of an excellent quality, a large proportion of it being entirely free from foreign substances. It is highly magnetic, and possesses polarity. Iron pyrites sometimes occurs in very small quantities at the junction of the dikes and ore, which renders them easy of separation. It is chiefly smelted in a charcoal furnace upon the borders of Wawayanda Lake, and produces an iron peculiarly adapted to the manufacture of car wheels. Almost all of it is consumed by Whitney & Son, of Philadelphia, for this purpose. The mine and furnace are owned by Oliver Ames & Sons, of Boston, who commenced operations here about nine years ago. Until January last the work had been suspended for about four years, and since this time has been carried on with great activity.

Following the course of the Wawayanda Mountain towards the southwest, indications of the existence of magnetic iron ore are every where visible. In some places it is disseminated in grains through the rock, forming one of its constituent minerals; in others it occurs in "strings," or small veins, from one to several inches in width. In some places, large deposits are indicated by the magnetic needle.

OGDEN MINE.

The next important deposit of magnetic ore which has been opened and worked, is upon the Wallkill Mountain, three miles southeast of Franklin Furnace. It was opened in the year 1772 by Abram Ogden, and has since then been worked, at intervals, by different parties, its name always changing with the name of its proprietor. It has been known, at various times, by the name of Kinney's, Sharp's, and Bird's Mine. At present it is owned by the New Jersey Franklinite Company, and worked by Edward De Camp, of Charlottenburgh, whose name it bears. The ore occurs in the form of an irregular vein or deposit varying from ten to thirty feet in width. Its general course is northeast and southwest, and its dip is at an angle of ten degrees to the southeast. It is now worked forty feet from the surface, and is fifteen feet in width. The ore which it yields is of a variable quality, some being entirely free from foreign substances, while with a large proportion of it may be found the constituent minerals of the gneiss, and, in some cases, iron pyrites in small quantities. This ore is smelted in Hopewell Forge.

VULCAN MINE.

This mine is situated on Vulcan Head, on the property of Richard R. Morris, Esq., about half a mile southwest of the Ogden Mine. Two deposits of ore have been opened by means of shafts sunk to the depth of thirty feet. The first shaft exposes a mass of ore ten feet in width, dipping towards the southeast at an angle of fourteen degrees. The ore is highly magnetic, and contains a considerable quantity of feldspar and iron pyrites associated with it. The second shaft exposes a mass of ore nine feet in width, associated to a considerable extent with grains of quartz and feldspar; but free from iron pyrites. Small specks of carbonate and sulphuret of copper are disseminated through some parts of it, but not in a sufficient quantity to injure it as a furnace ore, for which it will answer an excellent purpose.

Following the summit of the Wallkill Mountain towards the southwest, I observed many indications of large deposits of ore. Undoubtedly very extensive beds may be opened in this vicinity, which at no distant day will prove a source of great profit to their proprietors.

SHERMAN'S MINE.

This mine is situated on Slack Brook, three quarters of a mile southeast of Sparta. Several deposits of ore are exposed on either side of the brook, varying from three to ten feet in width. They are very irregular, having no well defined walls, and, in many places, it is difficult to ascertain their limits, because the ore is disseminated to a considerable extent through the adjoining rocks.

SPECULAR IRON—PEROXIDE OF IRON—RED IRON ORE—RED HEMATITE.

This ore of iron, when pure, has a metallic appearance; is of various shades of color, and is composed of seventy metallic iron and thirty oxygen, in one hundred parts. It is easily distinguished from other ores of iron by its reddish streak and powder. In nature it rarely occurs in a pure state, but generally mingled with lime, silica, alumina, &c., when its value depends on the nature and proportion of the foreign material. It is generally found in beds or irregular deposits associated with igneous and metamorphic rocks, more frequently in the latter, or at the junction of the two. A great part of the iron manufactured in different countries is from this ore, and although it requires much more heat to smelt than other ores, yet it produces an iron of excellent quality.

In this district this ore occurs in the white crystalline limestone, and is generally found at or near the junction of that rock with gneiss, syenite and granite. Large bowlders of it are found all along the southeastern border of the white limestone formation from the New York State line across the State to Pennsylvania. A careful examination of the district will undoubtedly be the means of developing extensive deposits of this valuable ore. Among the localities that have already been worked to a considerable extent, I will refer to but two, viz.,the Simpson and Andover mines.

SIMPSON MINE.

This mine is in Vernon Township, half a mile from Smithville, and two and a half miles northeast of Hamburgh. The ore occurs in the form of a bed or irregular deposit, from six to ten feet in width, in the white limestone. Excavations have been made into it to the depth of twenty feet, from which considerable quantities have been removed and smelted in the old Hamburgh Furnace, yielding an iron of superior quality. This ore has a brownish red color, a fine steel-grained texture, and a metallic lustre. A large proportion of it is quite pure and almost entirely free from foreign materials.

ANDOVER MINE.

This mine, celebrated as one of the oldest and richest iron mines in this country, is in the township of Newton, near the village of Andover, and in the same geological range and formation as the mine last mentioned. It has been worked at different times from the year seventeen hundred and sixty to the present, and is noted for furnishing an ore peculiarly adapted to the manufacture of steel.* The ore occurs in the

* Hon. Jacob W. Miller's address before the New Jersey Society, 1854.

form of a large irregular deposit, from sixty to eighty feet in width, and forms the southwestern side of a hill rising upwards of one hundred and fifty feet above water level, and from which during the last seven years over one hundred and twenty thousand tons of ore have been removed. The principal part of the ore is specular iron of different shades of red, gray and blue, and of various qualities. Its color, texture and lustre depend chiefly on the foreign materials with which it is mingled, among which are carbonate of lime, alumina, silica, magnesia, manganese, and magnetic oxide of iron. The following are the statements and analyses which Mr. James C. Kent, the chemist of the Trenton Iron Company, has, at my request, been kind enough to furnish me:

"OFFICE COOPER IRON WORKS,
December 15, 1854.

"The Andover mines, situated at Andover, Sussex County, New Jersey, were originally worked by an English Company prior to the Revolutionary War, from which period up to the year eighteen hundred and forty-seven, they remained unworked. In the latter year they were purchased by Peter Cooper, Esq., for the Trenton Iron Company, who have since continued mining, and, in seven years, have taken from them upwards of one hundred and twenty thousand tons of ore.

"The ores are principally the peroxide of iron, and the chief varieties are the 'blue' and 'red.'

"The following analyses, selected from a number I have made at different periods, give the composition of the varieties above mentioned.

	Blue.	Blue.	Red.	Red.
Peroxide of Iron,	90	70	65	70
Oxide Manganese,	3	2	4	10
Carb. Lime,		16	16	12
Silica,	6	8	10	6
Alumina,			2	
Magnesia,			1	
	99	99	99	99

"There are other kinds of ore occurring in smaller quantities. I subjoin analyses of the most interesting:

	Brown Ore.	Resinous Ore.	Carbo Silicate of Manganese.	
Peroxide Iron,	30	40	Protoxide Manganese,	34
Carb. Lime,	35	12	Lime,	11
Silica,	30	30	Silica,	33
Alumina,	3	3	Alumina,	1
Oxide Manganese,		15	Protoxide Iron,	1.5
			Carbonic Acid,	18
	98	100		98.5

"These ores, though not unusually rich, are remarkable for the facility and rapidity of their reduction in the smelting furnace.

"The large quantity of the best fluxing materials, such as manganese and carbonate of lime, contained in the ore themselves, renders necessary the small addition of but ten per cent. of fluxing matter in working the ores in the furnaces.

"In one of our furnaces (forty-two feet high and eighteen feet across the boshes), we have made two hundred and thirty tons of pig iron per week for six weeks in succession, with one and a half tons of coal per ton of iron; and the yield for a single week in one furnace has been as high as two hundred and fifty-one tons, an amount unprecedented in the annals of European furnaces. A considerable proportion of the iron produced is of the kind termed 'lamellated.' This iron is a type of the perfect combination of carbon and iron, with the carbon in larger proportion than in any other kind of iron. This species presents in the fracture a silvery brightness, and is beautifully crystallized, some of the crystals having brilliant faces, measuring two inches across. Another variety is the 'radiated,' which presents a fibrous fracture, the fibres radiating from the centre to the outside of the pig.

"The pig iron made at the furnace is puddled at the Rolling Mill of the Company, and the anthracite blooms thus made are converted into the various kinds of bar iron, rails, &c. At the wire mills the blooms are worked and drawn down to the finest wire, unsurpassed in quality; steel of the best description is also produced from the iron; and when wrought iron of great strength and toughness is required, as in the shafts for our largest class steamers, the Andover iron has been thoroughly tested and pronounced unrivalled.

"The Trenton Iron Company have three furnaces at present in operation, requiring to supply them sixty thousand tons of ore per annum. A large proportion of this ore is taken from the Andover mines, yet notwithstanding this heavy demand upon them, the mines promise to yield for many years to come an abundant supply.

"JAMES C. KENT."

LIMONITE—HYDROUS PEROXIDE OF IRON—BOG IRON ORE—YELLOW CLAY IRON STONE.

This ore, when pure, is composed of the hydrous peroxide of iron, and contains about sixty parts of metallic iron in one hundred. It almost always occurs mixed with foreign substances, as lime, alumina, silica, &c., which give to it a variety of forms, and from which its name is derived. Its prevailing colors are various shades of brown and yellow; and its streak and powder are yellow brown. The variety called bog ore sometimes contains phosphorus, and yields a cold short iron, unfit for those purposes which require a tough tenacious metal, but admirably adapted for casting. This ore, in its various forms, occurs in beds associated with rocks of all ages. In this district the greatest deposits are found among the metamorphic rocks of the Wallkill Valley. Bog ore occurs, not unfrequently, in the Blue Mountains, and in the valley of the Delaware, but not in sufficient quantities to be of much practical importance.

On the farm of Chandler Wood, half a mile southwest of the New Turnpike, on the Blue Mountain, is a bed of this ore apparently of considerable extent. It is situated in a marsh at the foot of a sandstone ridge. Its origin may be undoubtedly traced to the iron pyrites which abounds in the sandstones and grits of this mountain, and which, being decomposed, is carried down by the water, and deposited in the low, swampy lands situated at the base of the ridges.

POCHUCK MINE.

Two miles and a half northeast of Hamburgh, between the base of the Pochuck Mountain and a ridge of white limestone, occurs an extensive bed of brown hematite in stalactitic, mamillary and botryoidal forms, of a fibrous and massive structure. Excavations have been made on the surface, two hundred yards in breadth, and from sixty to eighty feet in depth, from which large quantities of ore have been taken, and smelted in the Hamburgh Furnace. The greater part of the ore occurs in concretionary masses embedded in clay and sand, also in beds of clay of various colors, which have been formed by the decomposition of a quartzose feldspathic rock. Large masses of a quartzose rock, of a honeycomb or cellular structure, containing fibrous limonite of a very pure quality, are associated with the above, having been apparently subjected to an intense heat. This mine has not been worked for a number of years, on account of great depression in the iron business.

EDSALL MINE.

Two miles northeast of Upper Hamburgh, another extensive bed of limonite has been worked. It is situated in a slight depression between the base of the Wallkill Mountain and a small knob of highly ferruginous feldspathic gneiss. Excavations have been made two hundred feet in length and breadth on the surface, and forty feet in depth. The ore is of the same general character, and associated with the same soft feldspathic rock as in the Pochuck Mine.

In following the course of the Wallkill Valley, along the base of the mountain towards the southwest, limonite may be seen in numerous places, mingled with the soil, indicating the existence of other beds, of equal extent and value, through this district. Examinations for this ore should be made at the base of the mountain, in depressions and valleys, and in the vicinity of the white or metamorphic limestone.

FRANKLINITE AND RED OXIDE OF ZINC.

Franklin and Sterling Hill in this district, have long been celebrated for the intricacy of their geological formations, their numerous rare minerals, and extensive and valuable metalliferous deposits. They have attracted men of science from all parts of the world, with a view to collecting specimens with which to enrich their cabinets, and to turning the inexhaustible quantities of franklinite and red oxide of zinc to some practical purpose. Although, from time to time, many attempts have been made to render them available for the manufacture of zinc, iron, or some of their compounds, it was not until within a few years that any favorable results have been obtained. These are among the most valuable contributions which have been made for many years to metallurgical science, and will be long regarded as illustrations of American enterprise and perseverance.

The nature of this report will simply allow the observation that the franklinite and zinc ores are among the extensive and valuable resources of this part of the State. Sketches, maps, sections, etc., illustrating their geology, mineralogy and metallurgy, have been carefully prepared, and will accompany full and detailed descriptions of them in a future report.

FRANKLINITE.

This ore occurs massive, of a compact, coarse and finely granular structure, also crystallized in octahedrons. It has an iron black color, metallic lustre and a dark reddish brown streak and powder, and acts slightly on the magnet. It is composed of iron, manganese and zinc, containing, according to Berthier, of oxide of zinc, 17; of iron, 66; and of manganese, 16 parts; and, according to Dickerson, of oxide of zinc, 21.77; of iron, 66.12; of manganese, 11.99; and of silica, 0.13.

RED OXIDE OF ZINC.

This ore occurs in masses of a granular and foliated structure, also in grains mechanically associated with franklinite, and disseminated in white crystalline limestone. It has a dark red color, and orange yellow streak. When pure, it contains, according to Whitney, 19.74 oxygen, and 80.26 zinc in 100 parts, but it also contains a small per centage of oxide of manganese, to which its red color is ascribed.

These two ores have been found in no country but this, and in no region of it except at Franklin and Stirling Hill. Here they occur in extensive deposits, associated together, and connected with the white crystalline limestone. At Stirling Hill there are two of these deposits from three to fifteen feet in width. Their general course is northeast and southwest, and their dip forty degrees to the southeast. The red oxide of zinc, mechanically associated with franklinite, and, in places, disseminated to a greater or less extent through the limestone, occupies the upper portion of the deposit, while the lower portion is composed of grains and crystals of franklinite mechanically associated with willemite (silicate of zinc), disseminated through the limestone. The greater, or southeasterly deposit, occurs in a limestone bluff, which rises abruptly from one hundred and fifty to two hundred feet, forming a steep southeastern slope. It has been worked four hundred yards on its outcrop, in one place, on the property of the New Jersey Zinc Company, to the depth of two hundred feet. Near the surface, the zinc portion of the deposit was from two to three feet in width; at its present depth it is from six to eight feet in width, and affords an excellent quality of ore. The franklinite portion of the vein is very irregular. In one place it is from fifteen to twenty feet in width, and of a remarkably pure quality; but, in either direction from this spot, it becomes thinner, and, in many places consists of a few crystals of franklinite very sparingly disseminated through the limestone. The second, or northwesterly deposit, has been recently opened on the property of the Passaic Company. It has been worked to the depth of about forty feet, and as yet does not exhibit the regularity found in the former. A tunnel is now being driven into the base of the hill, which will strike the deposit about ninety feet from its outcrop.

At the present time, two companies are engaged in mining the zinc ores of this locality, and in manufacturing directly therefrom the white oxide of zinc. The one is called the New Jersey Zinc Company, and the other the Passaic Zinc Company. The former was organized in 1848; and their works, situated in Newark, are in successful operation, producing annually between three and four thousand tons of the white oxide of zinc, which is sold as a paint, and is preferred for many purposes to white lead. A small furnace has been recently erected at their works, in which the refuse matter, chiefly franklinite, is smelted for iron.

The works of the Passaic Company have been recently established at Jersey City, where preparations have been made for manufacturing the white oxide on an extensive scale.

The only remaining locality at which these ores have been found, is at Mine Hill, in Franklin, where the franklinite greatly predominates over the other mineral. Two extensive deposits have been exposed, and worked to a considerable extent, crossing Mine Hill for a distance of three quarters of a mile in a northeasterly and southwesterly direction. They occupy the summit of the hill, which rises one hundred and fifty feet above water level; and to this depth the ore may be removed at a trifling expense. The following section on the southwestern slope of the hill, commencing at the northwest, and crossing the formations towards the southeast, represents the relative position of the two deposits of ore.

1. Syenite.
2. Magnetic iron, from two to six feet in width.
3. White Limestone, from four to ten feet in width.
4. Franklinite, twenty feet in width.
5. White Limestone, sixty feet in width.
6. Franklinite, twenty feet in width.
7. White Limestone.

The latter deposit of Franklinite (6) has been recently exposed for several hundred yards on its outcrop, exhibiting a mass of nearly pure ore, varying from twenty to fifty feet in width. At an opening in the deposit at the northeastern part of the hill, a considerable quantity of red oxide of zinc is mixed with the franklinite; as far, however, as the deposit is exposed, but very little zinc occurs. The magnetic iron ore (2) herewith associated, has been formerly worked to a great extent, yielding large quantities of excellent ore which was smelted in the old Franklin Furnace.

The New Jersey Franklinite Company, organized in 1852, is actively engaged in erecting furnaces and suitable buildings within a few yards of the deposits, for the purpose of smelting the ore, which will at the same time yield a superior article of iron as well as the oxide of zinc. One furnace is nearly completed, and will be put into operation in the course of a few weeks. The iron manufactured from the franklinite ore is of an excellent quality, and peculiarly adapted to the production of the best kind of steel. There are many circumstances which render Franklin an admirable location for the successful prosecution of an enterprise of this character. It not only furnishes an inexhaustible quantity of ore, but with the exception of fuel, every other article required in the manufacture of iron and zinc. Building materials of every description, including granite, marble and sandstones; clay for the production of bricks; limestone for plaster, masonry, &c., are in abundance. In addition to all these advantages, nature has here also furnished a never-failing water-power, by which operations of every kind may be greatly facilitated.

SHELL MARL—CALCAREOUS SINTER—CALCAREOUS TUFA—TRAVERTIN.

These terms are applied to deposits of lime from solution in water. They occur generally in springs, ponds, shallow lakes and low marshy lands. Water holding carbonic acid gas in solution, has the property of dissolving carbonate of lime, which is deposited in the form of a fine powder, whenever the carbonic acid gas escapes. This gas is held in solution by rain water, and many spring waters, which, in percolating through limestone rocks, or in passing over their surface, dissolve a portion of the lime, and carry it into ponds, lakes and marshes, where it is deposited in the form of a white calcareous powder. It is there absorbed and secreted by testaceous animals, whose outer covering, or shell, is thus formed. In those situations where a large quantity of calcareous matter is held in solution, these small testaceous animals grow in great abundance, and live but a short time, their places being taken by other generations, w ich in t rn die; and thus large deposits are formed, called *shell marl.* In those situations where but little calcareous matter is held in solution, new generations of testacea, in forming their own shells, consume those of pre-existing ones, and thus the rapid accumulation of shells is retarded. And, again, where a superfluous amount of carbonate of lime is held in solution, which is very often the case in limestone districts, the lime is deposited with the testaceous remains, which still more rapidly increases the deposits. Shallow ponds, or lakes, where the deposition of shells and lime is rapidly carried on, finally become filled up to the water line; so soon as the water passes off, peat begins to form, and by its annual growth and decay, a deposit of this material is quickly accumulated upon the marl. When in such cases, the peat begins to form on the surface, the testaceous animals do not cease to exist, but on the contrary, continue generation after generation to increase the deposit of marl under the peat, while at the same time the peat is continually increasing upon the surface. It is in this form that extensive deposits of marl occur in almost every part of this county. Wherever such deposits have been examined, they are usually found to rest upon a bed of clay, sand or gravel, and are succeeded by muck or peat. At or near the junction of the peat and marl, a layer of living testacea generally occurs, mingled with the peat. From twenty-five to thirty inches below this, the living animals disappear, their places being occupied by their remains in a decomposed state. The shells most frequently found in these deposits are the Limnea jugularis, Valvata tricarinata, Cyclas similis, Planorbis bicarinata, and some other species.

Springs holding a large quantity of lime in solution, sometimes deposit it on the surface in the form of a loose porous mass. It often happens that twigs and leaves are enveloped in these deposits, and their impressions thus preserved in a most beautiful and perfect manner. Such deposits are called calcareous sinter, calcareous tufa or travertin. Extensive deposits of calcareous sinter and shell marl are found in every part of this county. The most important localities are in the limestone districts. A large deposit of shell marl is found along the course of Chambers' Mill Brook, in Montague Township, on the farm of Isaac Bonnell, Esq. This deposit covers an area of from seventy-five to one hundred acres. It is situated in a low meadow or marshy land, surrounded by limestone hills; and this meadow has, at one time doubtless, been covered by a shallow lake or pond. Near the centre of the deposit, an examination was made to the depth of eighteen feet, giving the following section:

Peat and muck, 3 feet.

Marl and peat containing living testacea, 4 feet.

Marl, very fine, made up of decomposed shells, 11 feet.

The instrument not being of sufficient length, the whole thickness of the deposit was not ascertained. In other places where examinations were made, the peat was found to be from five to ten feet in thickness; and from six to ten feet from the surface, were found embedded the branches and trunks of trees from one to two feet in diameter.

On the Little Flatkill, two miles southeast of the town of Montague, upon the property of I. Cole, Esq., is found another deposit, covering an area of fifty acres. The peat resting upon the marl, is from four to six feet in thickness; and the marl from six to eight feet, resting upon a bed of sand and gravel. On the farm of Mr. Isaiah Vannetten, one mile and a half northeast of Hainsville, is another deposit covering an area of twenty acres, and overlaid by a deposit of peat from three to eight feet in thickness. On the farm of Mr. Benjamin P. Van Syckle, in Sandiston Township, three miles northwest of Tuttle's Corner, and two miles southeast of Dingman's Ferry, is found a deposit of calcareous sinter, covering an area of at least five acres. It is exposed on either side of a small stream to the depth of several feet. A well fifteen feet deep has been dug into it without passing through its whole extent. Though very hard and compact upon the surface, it becomes softer and more pulverulent as it descends. In it are found numerous nodules, or concretionary masses, which have been formed by the deposition of the lime around a twig or some other substance as a nucleus for the aggregation of calcareous particles. The source of this deposit may be traced to a spring, half a mile distant, near the house of Mr. James Struble. This spring issues from the base of limestone ridge, and empties into a small reservoir or pond, whence it passes to Mr. Van Syckle's land. In the bottom of this reservoir grows the Chara, a genus of aquatic plants. While growing at the bottom of ponds and streams, it has a dark green color, but upon being removed and exposed directly to the atmosphere, it soon becomes white and crumbles to a fine powder composed chiefly of the carbonate of lime. Large quantities of it are constantly forming at the bottom of this pond, and it requires to be removed, from time to time, in order to prevent the pond from being filled by its rapid accumulation.

Another extensive deposit of calcareous sinter is found on the limestone slope at Dingman's Ferry, a little above the

Delaware River. It covers an extensive area, and is from fifteen to twenty-five feet in thickness, as may be seen by examining either side of a small stream passing through it, and from which the calcareous matter has been deposited. On the surface, where it is exposed directly to the atmosphere, it is very hard; and emits a ringing sound when struck with the hammer. A few feet from the surface it is soft and pulverulent, and of a light gray color. It contains numerous beautiful and perfect impressions of leaves, branches, etc.

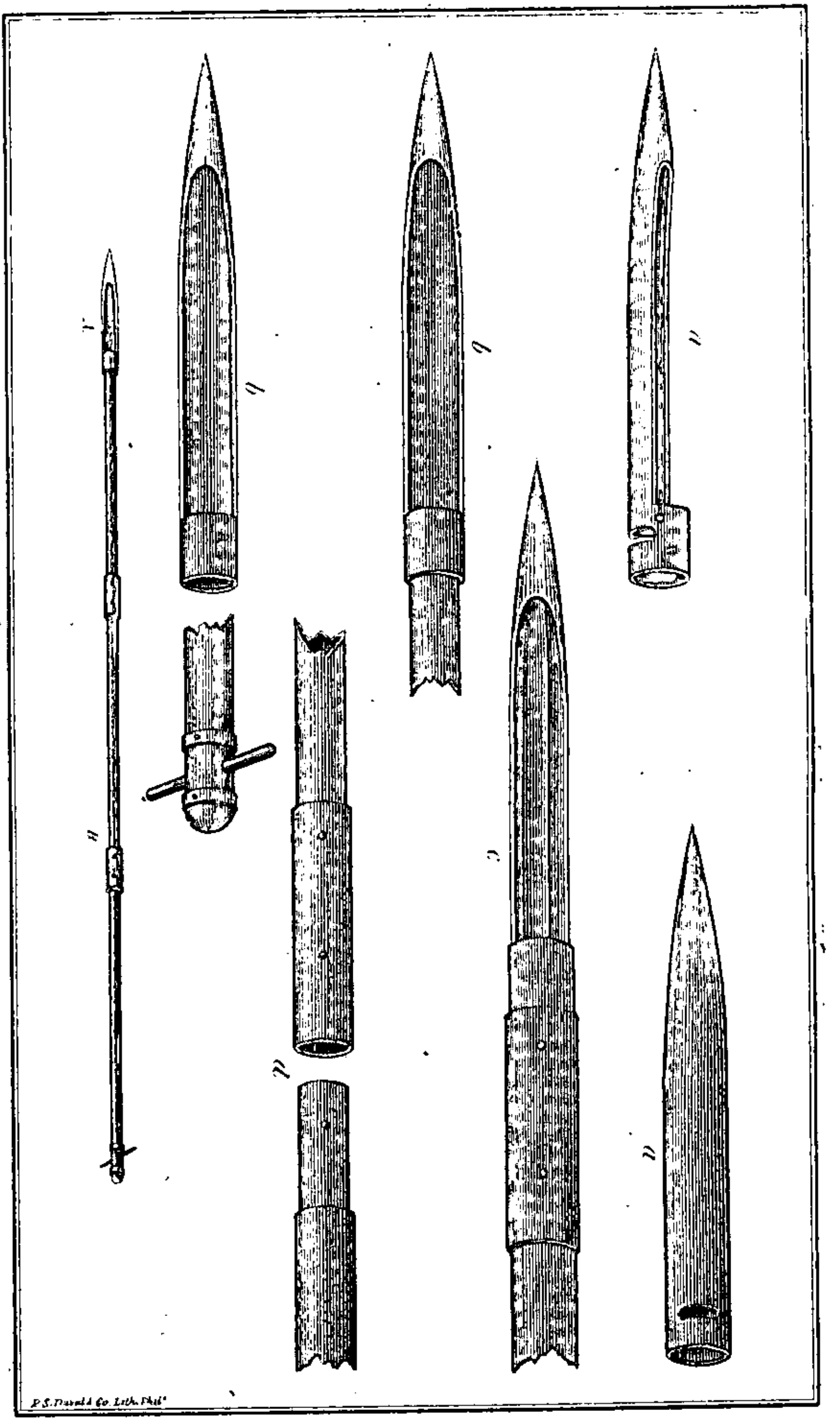
Inexhaustible quantities of marl and calcareous sinter may be obtained from the above localities at a comparatively trifling expense.*

In the Kittatinny and Wallkill Valleys, deposits of marl are numerous. They are found several feet in thickness, at the bottom of the lakes and ponds, marshes, and meadow lands so abundant in these districts. A very common name for these small collections of water is "White Pond," of which several are so called in the county. This name is given to them on account of the deposits of shells distinctly visible at their bottom.

Peat and marl are found in abundance in Vernon Township, on Black Creek, the meadows opposite the town of Vernon covering an area of several hundreds of acres. The peat here varies from four to fifteen feet in thickness, and the marl from one to ten. Numerous other localities have been noticed and will be referred to in a future report.

Deposits of marl occur most generally in peaty meadows and marshes; and in such places may be easily examined by thrusting through the surface a pole or rod, to which the marl, if present, will adhere. It may also be done by means of a spade or shovel; but the examination is sometimes tedious, on account of the presence of water, which often removes the marl from the pole, or renders the use of the spade laborious. An instrument admirably adapted to such examinations has been employed during the past year. It is so con-

* For analyses of specimens from each, see the annexed Report of Mr. Wurtz.


P.S. Duval & Co. Lith. Phil.

structed that a quantity of peat, marl, soil, etc., may be taken from any depth without mixing it with the other materials surrounding it.

The accompanying figures will give an idea of its construction: A B is the whole instrument, sixteen feet in length. A is its point or borer; B its handle. The point or borer, A, is twelve inches in length, and one inch and a half at its greatest diameter. It is formed of two half cylinders, an exterior, *a*, and an interior, *b*. They are so arranged that when put together, as at *c*, the exterior rolls upon the interior, causing the whole to present the form of a conical or tapering cylinder. The handle is made of strong wood, and in detached portions, four feet in length, which may be connected at pleasure, by means of an iron band, as at *d*. The object in having the handle in detached portions is for convenience of transportation, and for increasing its length as circumstances may demand. The instrument being closed, as represented at A B, it is forced into the peat or marl to the depth at which the examination is to be made; then by turning the handle to the right, the pressure on the exterior cylinder, forces it behind the interior, and in this manner the instrument is opened. It is then forced downward six or eight inches, or the length of the cylinder, when the hollow becomes filled. The handle being then turned towards the left, the cylinder encloses a portion of peat or other matter taken from the spot where the instrument stopped. Its precise depth is indicated by the number of feet and inches represented on the handle.*

USE OF SHELL MARL AS A MANURE.

In Europe, as well as in some parts of this country, shell marl has long been considered one of the most valuable of fertilizers. It not only possesses every property of lime in

* For a description of this instrument, from which it was made, I am indebted to Leo Sesquereaux, of Columbus, Ohio, a gentleman who has made extensive examinations of the peat and coal lands of Europe and this country.

its action upon soils, but it very often contains phosphoric acid, ammonia, organic matter, and other substances which increase its value.* Its principal constituent is carbonate of lime, in the form of what is called "mild lime," because free from that causticity which quicklime, slaked by water or air, possesses, and which is very often injurious to soils. Its pulverulent state gives it an advantage over lime, for it simply requires to be removed from the deposits and spread on the land, or composted with muck or peat, or exposed in heaps for a time, as circumstances may demand; while lime, before it can be applied to soils, must be quarried, burned, slaked, &c. It may be advantageously employed in certain forms and quantities, and under proper circumstances, to all soils. The quantity and form in which it should be applied is indicated by the character of the soil. On peaty soils, or those which contain a large amount of vegetable matter, it may be used in great quantities, either by spreading it broad cast, directly after taking it from its bed, or after it has been drawn to some convenient place and suffered to remain in heaps exposed to the air, six or eight months; or even after it has been burned and slaked like limestone. In the latter case it becomes caustic lime, and should be used only upon soils which contain a great quantity of inactive vegetable matter, as is often the case in low peaty lands, or where there is a large deposit of muck. Such lands are abundant in Sussex County. They are chiefly situated in springy places, on streams, etc., as the numerous peat and bog meadows on the Little and Big Flatkill, the drowned lands on the Wallkill, the marshes and swamps on the Paulinskill, Black and Papakating creeks, and, in fact, on all the streams, large and small, in the county. There are thousands of acres of such lands in this part of the State, lying perfectly useless, and in many cases generating malarious diseases, which, on being reclaimed by thorough drainage and a free use of lime, would be deprived of their malarious poisons, and rendered the most productive soils in the State.

* See analysis by Mr. Wurtz in the annexed report.

In the use of lime as a fertilizer, it may be established as a general rule, that it is only to such lands that it should be applied in its caustic state.*

Shell marl, either alone or composted with peat and muck, may be advantageously used in large quantities on clayey, sandy, and loamy soils. The principal object in composting it with peat and muck is, at the same time, to add organic matter to the soil. If the soil contains already a sufficient quantity of organic matter in an active or proper state, it may be applied alone. Its mechanical action on many soils, particularly on hardpan, or clayey soils, rendering them more pulverulent and open, is of great importance. It may be advantageously employed upon poisonous soils. Copperas or sulphate of iron renders land sterile. Whenever a soil is derived from the debris of a rock wherein is found iron pyrites, (sulphuret of iron,) it will contain sulphate of iron, and very often in sufficient quantities to destroy vegetation. An instance of this was observed in Frankford Township, near the County Poor House. In its vicinity was a ridge of slate containing a large amount of pyrites, which, being very soft, is constantly undergoing decomposition, and forming sulphate of iron, and this is carried over the soil and mingled with it by the wash of the ridge.

To a calcareous soil, or one which has been formed from the debris of limestone rock, it may be applied in small quantities alone, or composted with large quantities of vegetable matter. On the northwestern slope of the Blue, or Kittatinny Mountain, the course of the Little Flatkill is near the dividing line between the limestone of the Helderberg Series, and the red sandstone and shales of the Medina Sandstone. The soil on the limestone hills between the Little Flatkill and the Delaware

* By caustic lime, is understood the hydrate of lime, or that form produced by slaking freshly burned or quick lime with water. Its caustic property is greatest directly after being slaked. From that time the carbonic acid of the atmosphere, uniting with it, drives off the water, and taking its place diminishes its caustic property. This action continues until all the water is driven off, and it becomes carbonate of lime, or mild lime.

River is chiefly of a loamy, calcareous nature, formed by the disintegration of the various kinds of limestone and sandstone bowlders which are very abundant over its surface. On the other side of the Little Flatkill, between it and the summit of the mountain, the soil is of a sandy nature and deficient in organic matter. On this soil the shell marl, either alone or composted, would be of great advantage. On the other side of the Kill it should be applied, as a general rule, in smaller quantities, together with vegetable matter. Thus it will be seen that various circumstances, such as the nature and character of the soil, manner and form of application, &c., should guide us in the use of this material as a fertilizer; and when all these things are properly considered, it will undoubtedly prove a cheap and effectual means of enriching the soils of this county. It may be used to a certain extent in place of gypsum, of which there has been a great consumption here. By referring to the analyses of Mr. Wurtz in the annexed report, it will be observed that this material, (sulphate of lime or gypsum,) is sometimes found as one of its constituents. No general rule can be given in regard to the quantity of marl which may be applied per acre. This must depend on the various circumstances to which we have already referred, as well as on the composition of the marl, its per centage of carbonate of lime, &c.

Although this valuable fertilizer is found in such extensive and accessible deposits in every part of the county, it has been but very little used. This is doubtless owing to the injudicious manner in which trials of it have, from time to time, been made. On account of its great accessibility, and through ignorance of its nature, it has been applied in such large quantities as to destroy vegetation and render the soil sterile for a number of years. On the property of Mr. James H. Struble, in Sandiston Township, is a barren spot of land to which marl, or calcareous sinter, was applied eighteen years ago. Since this time, as I was informed, no vegetables would grow except when a heavy coat of barn-yard manure, or vegetable matter, is applied to it, and then but one luxuriant crop can be obtained. This experiment not only proves the injurious effects of too large a quantity of this material, but it also speaks volumes in its favor. It has been used by Mr. Van Syckle, in this vicinity, and by others in different parts of the country, with great success. These facts, together with the high estimation in which it is held in the State of New York, and wherever it has been extensively and judiciously used, should be sufficient to dispel the prejudice so prevalent among the farmers of this county, that it acts as a poison to vegetation.

I am, Sir,

Your very obedient servant,

WILLIAM KITCHELL.

NEWARK, N. J., *January* 15, 1855.

REPORT

OF PROFESSOR GEORGE H. COOK, ASSISTANT GEOLOGIST.

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

DEAR SIR:—In pursuance of my duty as Assistant Geologist, charged with the survey of the southern part of the State of New Jersey, I respectfully submit the accompanying Report.

The instructions received were to make a geological survey of the eastern half of Monmouth County, and report upon the same at the close of the present year. In accordance with these, the survey has been prosecuted either in the field or in the laboratory from July twenty-seventh to the present time. It has not yet been brought to a conclusion, but is in such condition that it can be completed at an early day.

At the commencement of a survey of this kind, many of the examinations must be of a general character, and such as have a bearing upon all the work which is to follow. For this reason, while the main part of my examinations have been made in the eastern part of the county, I have made one excursion to its western part, and another entirely across the State, and down to Salem. I trust that the work already done will be found useful, and that the foundation is laid for prosecuting the survey with accuracy and dispatch.

Very respectfully,

Your obedient servant,

GEO. H. COOK.

RUTGERS COLLEGE, *December* 30, 1854.

REPORT.

GENERAL REMARKS.

That part of New Jersey which, in the Geological Survey, is assigned to the southern division, includes all that portion of the State lying south of a line drawn from Staten Island Sound, near Elizabethport, to the Delaware River, a little below Trenton. The line follows the southeastern border of the red shales and sandstones which stretch across the central part of the State. Its general direction is straight, and its bearing a little west of southwest. The extreme length of the district is one hundred and ten miles; and its greatest breadth about seventy-five miles. Its area is estimated at not far from three thousand four hundred square miles.

In its physical geography, it is remarkable for its lack of hills, its sandy soil, its extensive pine woods, and for the almost entire absence of rocks.

The Nevisink Hills are three hundred and ten feet high,* and a chain of hills of a somewhat less elevation extends from them in a westerly direction to Freehold. South of these the country seldom rises more than sixty feet above the level of the sea.

A belt of clayey or loamy soil, several miles in width, extends across the northern border of the district, and down the Delaware River to the bay; and streaks of clayey soil are generally found on one or the other of the banks of the streams

* See Gordon's Gazeteer, p. 1.

running into the Atlantic. With these exceptions the soil is a light sand, and extensive tracts of it are still covered with pines and scrub oaks.

A kind of cemented gravel or pudding-stone, firm enough to be used for the commoner purposes of building, is found in some of the higher hills, and thin layers of limestone, which can be burned into lime, are found in a few places; but solid beds of rock are nowhere met with.

"The whole of the district is tolerably well watered; but the streams are neither large nor rapid, and are remarkable for the depth of their beds, which cause, indeed, almost the only inequalities in its surface." "Most of the streams have crooked courses, and flowing through a flat country, are commonly navigable some miles from their mouths. Unlike the rivers of hilly countries, they are steady in their volumes, and uniform supplies of water can be more confidently relied upon."*

There being but little water power, manufacturing is not carried on to any considerable extent. Deposits of bog iron ore are found, and a small amount of iron is made from them; and there is an abundance of excellent sand for glass making, which, with the cheapness of fuel, has caused the establishment of numerous glass-houses. The principal business of the inhabitants is agriculture. In this, remarkable advances have been made within a few years. In 1834, Gordon says, "An immense forest covers probably four fifths of this district, and forty years ago it was not worth more than from six to ten cents an acre. From this they have risen to an average price of six dollars an acre."

The following statement, compiled mostly from the United States Census of 1850, shows nearly its present condition.

* See Gordon's Gazetteer.

COUNTIES.	FARMS IN ACRES.		Average value per acre.
	Improved.	Unimproved.	
Third of Mercer,	31.793	7,196	$54 13
Half of Middlesex,	57.969	21,053	41 21
Monmouth,	145.739	82.440	50 40
Ocean,	26,466	28,387	19 86
Burlington,	132 017	40,670	67 56
Camden,	53 968	77,416	35 40
Atlantic,	15,006	34,585	13 80
Gloucester,	68,810	52,897	37 37
Salem,	105.956	38,942	45 88
Cumberland,	48 469	71,646	22 10
Cape May,	14 310	37,653	15 87
Total,	700,503	492,885	Mean 41 70

The following table, compiled from the same sources, will furnish data for comparison with the whole State, and also with the neighboring States.

STATES.	Area in acres.	FARMS IN ACRES.		Average value of farms per acre.
		Improved.	Unimproved.	
Massachusetts,	4,640,000	2,133,436	1,222,576	$32 50
Connecticut,	3,040,000	1,768,178	615,701	30 50
New York,	29,440,000	12.408,968	6,710,120	29 00
New Jersey,	4,384,640	1,768.991	984,955	43 67
Pennsylvania,	30,080,000	8,628,619	6,294,728	27 33
Delaware,	1,356,800	580,862	375,282	19 75
Maryland,	7,040,000	2,797,905	1,836,445	18 81

In these tables the improved lands include only such as produced crops; the unimproved, such as did not produce crops, but were connected with the farms. Unoccupied land is not included under either of these heads.

A comparison of the first and second table shows, that while the value of the land in farms is a little less in the southern division than the average of the whole State, it is still greater than that of any other State mentioned, and it is greater than that of any other State in the Union. I have not been able to ascertain the areas of the counties separately, and cannot give the amount of land in farms, compared with that still unoccupied. But if we suppose one half of the State to be in the southern division, a little more than one half its area must be in farms, which is less than in Massachusetts, Connecticut, New York, and the northern half of New Jersey; and greater than in Pennsylvania, Delaware, and Maryland.

The climate is mild or even warm, and the early springs and light soils enable the farmers to furnish the first supplies of garden produce to the markets of New York and Philadelphia, and a large part of such supplies for those cities is drawn from New Jersey. Of other crops, Indian corn and potatoes are raised in largest quantities. Wheat, rye, oats, and sweet potatoes are extensively cultivated. The amount of live stock is much above the average of our country.

The rapid advance of agriculture in this district is due in part to its location, in part to the improvement of the country generally, but more is to be ascribed to the use of a kind of marl which is found here in immense quantity. The belt or strip of land under which this is found lies obliquely across the State from Sandy Hook Bay southwest to Salem. Its length is about ninety miles, and its breadth fourteen miles at its eastern extremity, and six miles at its western. Its area is nine hundred square miles, or five hundred and seventy-six thousand acres; and its benefits are shared by a considerable district of country lying on each side of it, so that the whole area improved by it is swelled considerably beyond the above amount. It has been worth millions of dollars to the State in the increased value of the land and produce, besides the influence it has exerted in awakening and fostering a spirit for agricultural improvement. Requiring labor and not money from those who would enjoy its benefits, it has been found admirably adapted to encourage and reward enterprising industry.

The attention of men of science has been frequently called to this interesting formation on account of its value in agriculture, and also for it numerous and remarkable fossils; bones, shells, sharks' teeth, &c., being common in it. Its geological character was first distinctly shown by Professor L. Vanuxem, Dr. Morton, and Mr. Conrad, of Philadelphia, in eighteen hundred and twenty-seven. In eighteen hundred and thirty-five, the legislature ordered a geological survey of the State to be made. This was done by Professor H. D. Rogers, and his final report was presented in eighteen hundred and forty. This report included a very full account of the marl, both geological and chemical. Numbers of analyses of the varieties of it have been made by other chemists; some of these are important, and will be referred to again. Under such circumstances, the present examination was entered upon with a good deal of distrust; and nothing but a knowledge that the openings into the marl were much more numerous and extensive than when Professor Rogers closed his survey, and that thus an opportunity for study was now presented which was not then available, could have induced an attempt to re-examine what had already been so well done.

DESCRIPTIVE GEOLOGY.

From examinations in the field, the following facts are proved:—

1. The clays and marls, which constitute the basis of most of this part of the State, are in regular and continuous layers.

2. These layers are not level, but incline or *dip* towards the southeast. They have been observed to descend from twenty to fifty feet in a mile.

3. Since these layers were formed, the action of water, or other causes, has worn away and changed the surface of the country.

In passing across the country from the north towards the south, we come upon the different layers in orderly succession; in examining the pits which have been opened for marl, the successive layers are always found in the same order; examinations upon the sides of hills where they have been cut into, show the same order that is found in the lower grounds to the south of them; and the same fact is observed in the banks of streams which cut through the layers.

From the fossils found in these beds, geologists have determined that the marls and the clays north of them, and between them and the red sandstone, belong to the cretaceous or chalk formation,* and that the beds on the southern border of the marl belong to the tertiary. The sands and some of the clays south of these, are probably of more recent origin.

The general principles stated above, are all exemplified in Eastern Monmouth; the clays are found on its north side, the marls across the centre, and the sands on the southern side.

I. The clays occupy the county between the northwest line of the county and the northern sides of the hills which extend from the Nevisink to Mount Pleasant, and on to near Englishtown. On the shores of Sandy Hook and Raritan Bay, the clay is thickly covered with sand. In the valleys between some of the hills mentioned, it extends considerably further south. It is almost black when wet, but is gray when dry. It contains a good deal of micaceous sand. The trunks and branches of trees, in the form of lignite, are found in it in great quantities, and frequently associated with sulphuret and sulphate of iron. Irregular streaks of green marl are also found in it; in some places enough to make it valuable as a manure. Characteristic fossils are also found. The examinations made thus far have not been sufficient to furnish precise descriptions of the position or qualities of the different layers or even of the beds of this stratum.

II. The marls are found in various parts of the country from the south line of the clays to a line drawn from the At-

* A "formation," in geology, is "that collection or assemblage of beds or layers, strata or portions of earth or minerals, which seem to have been formed at the same epoch, and to have the same general characters of composition and lodgement." (Webster.) In this report I will use the terms stratum, bed, and layer, for the successive subdivisions; thus dividing the formation into "strata," each stratum into "beds," and each bed into "layers."

lantic shore, near Great Pond, in Deal, to the Manasquan River, between Upper and Lower Squankum.

The substance here called marl, is not the ordinary calcareous clay or earth, which is distinguished by its light color and its effervescence with acids, but is a kind of earth, most of which is in little rounded grains, about the size of fine gunpowder; its color is usually some shade of green; the crushed grains are always green; and they are so soft that they can easily be crushed on the nail; they scarcely effervesce with acids. Besides the grains in the marl, there is generally a little white sand and some clay; the latter being of various shades of black, brown, drab, or green, and so mixed in as to give color to the whole; great numbers of shells are found in some of the layers; these of course cause the marl to effervesce. The marl grains are known in geology as *greensand.*

Though the whole series of beds which is exposed in the district now under examination, is called the *marl stratum*, yet marl grains are not found in all the beds, some of them consisting entirely of sand, and others of clay.

There are three distinct beds of marl in the stratum: the *first* includes those found north of the north branch of Shrewsbury River, Swimming River, and Yellow Brook; also those found on the head waters of South River, north of Freehold. A few pits have also been opened below tide level at Red Bank. The *second* includes those near the head of the south branch of Shrewsbury River; those near Eatontown; those along the valley of Hockhockson Brook, above Tinton Falls; those a little south of Colt's Neck Village; those about a mile and a half south of Freehold, and those south of Blue Ball; it also includes the yellow marls south of Eatontown and about Long Branch; the same bed is also found near the tops of the hills south of Red Bank and that south of the Phalanx Dwellings, and I think in some of the highest points of the Nevisink Hills. The *third* bed includes the marls of Deal, Poplar, Shark River, and Squankum.

The bed of yellow ferruginous sand which is so conspicuous a feature in the soil of the Nevisinks, at Red Bank, at

Colt's Neck, and indeed entirely across the State, lies between the first and second beds of marl.

A bed much resembling beach sand, with a very few marl grains scattered through it, lies between the second and third marl beds.

The several beds of marl are each made up of distinct layers, which vary in appearance and in properties.

In the first bed five distinct layers may be recognised.

1. A layer of sand and fine gravel, from two to four or more feet in thickness. This is very distinctly separated from the clay which lies immediately under it. It contains numerous fossils, a considerable proportion of marl grains, and is valuable as a manure. It is known as *sand marl.*

2. A layer of nearly pure marl grains, of variable thickness, averaging perhaps four feet. A little blackish clay is mixed with the marl, from which it is generally known as *black marl.* It contains but few fossils. As a manure it is highly prized. Though always found, it is not very distinctly separated from the next layer.

3. A layer of from twelve to sixteen feet in thickness, known as *blue* or *gray* marl, from its containing a considerable amount of a drab colored clay, inclining to bluish or grayish. It has numbers of very large and heavy oyster shells in it—generally there is a streak from eight inches to two feet thick, which is almost solid with shells. This layer is very highly prized as a quick and lasting fertilizer. It changes gradually into the one next above.

4. Three or four feet of *black marl,* almost exactly like that of No. 2. It is not found distinctly marked in all places.

5. Dark colored marl six or eight feet thick, containing fewer and fewer of the marl grains in its higher parts, and at last only to be distinguished from the dark clay into which it runs, by the thin flaky shells scattered through it.

The thickness of this bed of marl is at least thirty feet. The whole can be seen in the side of the Nevisink Hills on the shore of Sandy Hook Bay. They have all been passed through in the pits of the North American Phalanx, and Mr.

William Hartshorne had them bored through for me in his pits, north of Freehold. All except the top layer is well exposed in the pits of Wm. Conover, near Marlboro'. And they can be seen in succession, by passing along the valleys of any of the streams which run through the marl, as the Spottswood north and south branches of South River, and in the Hop Brook from Taylor's Mill to Marlboro'.

The following circumstances may produce a little difficulty, at first, in verifying the preceding statements. Whenever the clay, which lies immediately over this bed of marl, has been worn away, and the marl lies above the bed of neighboring streams, the rains and surface water penetrate it, to a greater or less depth, and leach off; dissolving out the fossils and leaving earth in their places; changing its color to a rusty red; and forming numerous flaky crusts, or sometimes strong cakes of impure oxide of iron, in it. Such marls are called *dry bank* or *hill* marls. These changes have taken place to a much greater extent in some localities than in others. Marls which lie so as not to be subject to the action of surface water, or drainage, are called *wet bank* or *meadow* marls.

The characteristic fossils of this bed are Exogyra costata, Gryphaea convexa, Ostrea falcata, Terebratula sayii and Belemnites americanus. A great many others are found, but they are not so numerous and not so generally present in all localities.

Lying immediately upon the bed of marl which has just been described, and not separated from it by any well marked division, is a layer of black clay. It contains scales of mica and grains of sand. In small quantities it cannot easily be distinguished from the clay of the stratum below the marl. It frequently contains sulphate of iron (copperas); and being often mistaken for marl has been used to the injury of the farmer. When composted with quicklime it is thought to be useful. It is from ten to twenty feet thick.

The red or ferruginous sand lies upon the clay just mentioned. It is separated from it by a well marked line of division. This bed is of great thickness; not less than one hundred feet at Red Bank, and in the Nevisinks it is equally thick. Whenever this sand has any degree of firmness it is full of the impressions and casts of shells and other fossils. The lower part of this bed is a very friable sand; towards its upper part a greenish clay is found mixed with the sand, giving to it a good degree of firmness; the rock at Tinton Falls is an example of this. The upper part of this bed, from four to six feet, is a layer of greenish indurated clay, in some places hard enough to be called a rock. It slakes on exposure to the weather. No marl grains are found in it; but it is called marl by many farmers, and is profitably used as such.

The *second bed* of marl is not so extensively developed in this part of the country as the first one; though it is considerably thicker. Its several layers may be described as follows:—

1. A layer of marl containing but very few fossils; its lower part almost clean grains; clay is mixed with the grains in the upper part, in many localities. The color of the grains in this layer, and indeed in the whole bed, is green with a shade of yellow, unlike those in the first bed, in which the color is green, with a shade of black or dark blue. I have not in any place in this part of the county found the layer worked more than fourteen feet, though I believe it to be much thicker. In the pits of Mr. Imlay, on Crosswicks Creek, a short distance below New Egypt, it is nearly twenty-five feet.

2. A layer of from ten to fourteen feet of marl, with numerous shells. A streak in the upper part of this, for two or three feet, is almost solid with shells of the Terebratula harlani; and another layer near the bottom of it is equally solid with shells of the Gryphaea convexa. This layer gradually loses its marl grains, at the upper part, and runs into

3. A layer of broken shells with more or less sand intermixed, and containing scarcely any marl grains. The color of this marl is *yellow* or *gray*. In the neighborhood of Eatontown it is called *yellow marl*. No localities have been visited in Eastern Monmouth where it has been penetrated more than fourteen feet, but near Salem it has been opened for more than twenty feet.

There are no good localities where all these layers are to be seen together. The nearest approach to it is in the pits of Mr. Strickland, near Blue Ball, where the top of the first, the whole of the second, and the bottom of the third layers are shown. The meeting of this bed and the clay of the sand bed under it is well shown in the marl pits of J. S. Trafford, Daniel Polhemus, and John S. Cooke, above Tinton Falls. Also in the pits of Mr. Lafetra and Mr. Lippincott, on the north side of Parker's Creek, near Eatontown. The *yellow marl* is dug near the Turtle Mill at Long Branch. Also by Dr. Lewis and others, of Eatontown. The bottom of Edward Wolcott's marl, near the latter place, cannot be distinguished from the top of Strickland's.

A large number of species of fossils are found in these different layers. Those mentioned under (2) are the most common and characteristic: The Gryphaea convexa of this bed is much smaller and thinner than that found in the first.

The bed of sand between the second and third beds of marl has nothing remarkable about it, except the grains of marl scattered through it. Its meeting with the top of the second bed is not known to have been found. It can be seen under the third bed in the pit of Elisha West, of Deal, that of Rulief Vandeveer, of Poplar, that of Thomas Longstreet, of Squankum, and it is said under that of John Shafto, of Shark River. The bed itself has been opened near Elisha West's, in Deal, and the sand used as a fertilizer on account of the marl grains in it. It bears a striking resemblance to the beach sand of the neighborhood which has also been used for the same purpose. No opportunity has occurred for measuring the thickness of this bed, but from the inclination of the beds above and below, it may be estimated at not less than thirty feet.

The *third bed* of marl may be described as consisting of three layers, as follows:—

1. Twenty feet of green marl. This contains a considerable percentage of greenish clay: it is distinguished as a quick and powerful fertilizer; the most noted marls of Squankum, Shark River, Poplar, and Deal are from this layer.

2. Fifteen or twenty feet of a pale greenish clay or earth. No marl grains are found in this layer, though it is called marl and possesses active properties as a manure. It is flaky in its structure, and when exposed to the air fades to a light ash color.

3. From five to fifteen feet of the above clay, largely mixed with marl grains.

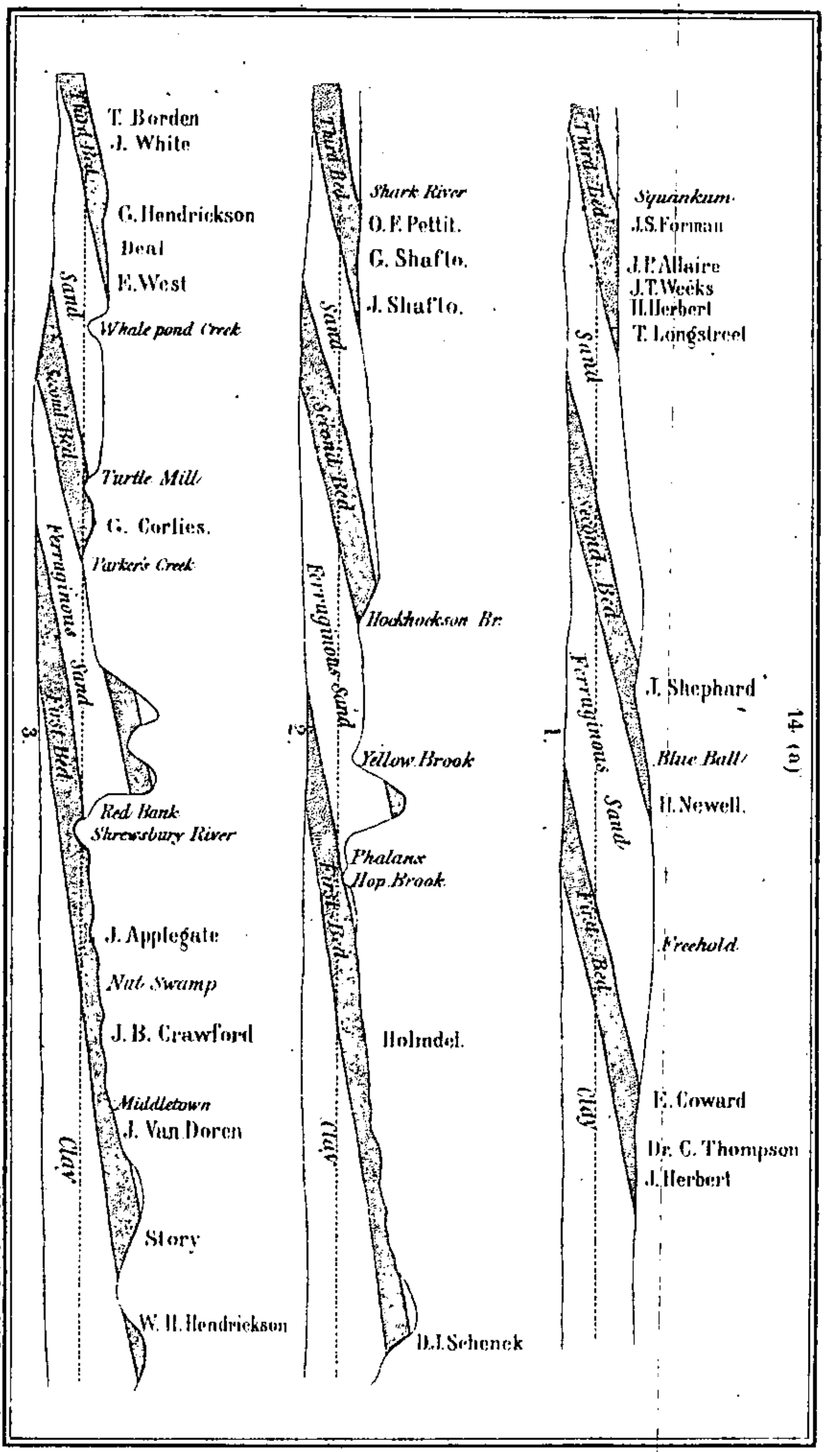
The last named layer is opened to the greatest thickness in the pits of Jacob White, Peter Drummond and Amos White, in Deal; in that of O. F. Pettit, Shark River, and in that of J. S. Forman, near Lower Squankum, it is not so thick. In all these it can be seen running into the layer next below.

There are no localities where all these layers can be seen in a single place, but they can be seen in succession in numbers of places, as in the pits of Elisha West, G. Hendrickson and Thomas Borden, of Deal; in those of J. Shafto, H. Hurley, G. Shafto, and J. L. Tilton, of Shark River, and in those of T. Longstreet, T. Weeks, and J. S. Forman, of Squankum.

Fossils are not very abundant in this bed. A few casts, and still more rarely shells, have been found in the lower layer; it is not known that any have been found in the middle layer; in the upper, casts and impressions of shells are found. They have not been examined with sufficient care to determine the species; they are, however, entirely different from those of the two lower beds.

The accompanying sections across the marl stratum, show the positions of the several beds. The scale of distances is two miles to one inch. The scale of heights about 400 feet to an inch: the heights, however, have not been accurately measured. These sections are taken at right angles to the stratum.

In addition to showing the positions of the several beds, they also exhibit the effects of peculiar configurations of surface on the extent of the marl bed exposed: thus though the same beds are shown in each of the three sections, the amount of marl at the surface appears to be quite different in the same bed as seen in the different sectional views. The first bed ap-



3.
Third Bed
Sand
Second Bed
Ferruginous Sand
First Bed
Clay
T. Borden
J. White
G. Hendrickson
Deal
E. West
Whale pond Creek
Turtle Mill
G. Corlies.
Parker's Creek
Red Bank
Shrewsbury River
J. Applegate
Nut Swamp
J. B. Crawford
Middletown
J. Van Doren
Story
W. H. Hendrickson
2.
Third Bed
Sand
Second Bed
Ferruginous Sand
First Bed
Clay
Shark River
O. F. Pettit.
G. Shafto.
J. Shafto.
Hockhockson Br.
Yellow Brook
Phalanx
Hop Brook
Holmdel.
D. I. Schenck
1.
Third Bed
Sand
Second Bed
Ferruginous Sand
First Bed
Clay
Squankum
J. S. Forman
J. P. Allaire
J. T. Weeks
H. Herbert
T. Longstreet
J. Shephard
Blue Ball
H. Newell.
Freehold
E. Coward
Dr. C. Thompson
J. Herbert
14 (a)

pears three or four times as extensive in the second and third sections as in the first.

III. The sands which form a strip along the southern border of this county join the marls in a very irregular line, ridges of them extending up almost to the middle of the county, while in the valleys of the streams, the marl comes to the surface several miles further south. They have not yet been examined with sufficient care to render it necessary to make any report upon them.

The interest felt in the marl stratum by a very large portion of the inhabitants of Monmouth, has induced me to devote most of the time, thus far, to ascertaining and systematizing facts relating to it. The examinations of the clay stratum and of the sands promise to be of much practical utility, though the soils where they occur have not yet been brought to the high state of cultivation of the marl region, and they are generally thought of less value.

The regular order of occurrence of the different beds of marl in the district surveyed led to a desire to examine their relative position in the southwestern part of the State. For this purpose the stratum was crossed from Allentown to New Egypt, and again in the vicinity of Salem, and the same order of succession of beds was found.

The marl pits of N. Woodward, at Cream Ridge, belong to the first bed. The ridge itself is part of the ferruginous sand bed. The pits at Hornerstown, and those of Mr. Imlay and Mr. Horner, near New Egypt, are in the second bed; so also are the gray marls, such as those in Governor Fort's pit. The pits of Mr. Irons, south of New Egypt, and others from there on to Poke Hill, in Burlington County, belong to the lowest layer of the third bed. The upper layers have not been found in that vicinity.

The marls in Salem County, at Mannington Hill and at Woodstown, belong to the second bed. At Batten's Mill, above Swedesboro', the first marl bed is seen. The ferruginous sand lies between the two. The third bed has not, to my knowledge, been found in Salem County. The marl at Mullica Hill belongs to the second bed. William H. Snowden, of that village, showed me a collection of tertiary shells from a locality about two miles south or southeast from there, and among these were some casts of shells of the same species with those found in the lower layer of the third bed. I hear that he has since found the bed containing those characteristic fossils.

From the report of Professor J. C. Booth on the Geology of Delaware, it appears that at least two of these beds are found in that State. The stratum is known to extend into the States farther south.

The hasty examination given to the different beds west of Freehold, does not enable me to decide whether they retain the same thickness, or whether the first and third beds grow thinner towards the southwest. They are not as well exposed or as extensively worked; the greater portion of all that is used, being taken from the second bed. Other causes than the thickness, however, affect the amount of their exposure. For example, the increased breadth of the marl stratum on the eastern side of the State is partly due to its northern border being on elevated ground and its dip towards the southeast only a little more than the slope of the country in that direction; while on the western side of the State, the stratum is diminished in width from its northern border being on low ground and its dip to the southeast, contrary to the surface of the country, which rises in that direction. The several beds are much better exposed in a rolling country than in one that is even or flat; thus, in the district surveyed, the first bed, though thinner than either of the others, is by far more exposed than both of them together. The country in which it occurs is uneven and hilly; the marl may then be found either in the valleys or the side hills, and these are so common that almost every farm has a marl pit on it, and in some a pit is opened in every field. The country is much more even and level where the second and third beds are found, the valleys of the streams making almost the only inequalities of the surface, and it is in these principally that the marls are dug. The practice in this respect is so uniform that many persons suppose they are only to be found in the valleys of streams. A knowledge of the fact that the beds are to be found on high as well as on low ground, that they continue nearly uniform in quality and thickness in straight lines across the State, and that they descend towards the southeast with a very regular slope, will, it is hoped, lead to a more general opening of pits in neighborhoods where marl is not now known to exist. Marls have been carted long distances, and deposited on lands which were underlaid by marl, and such, from my own observation, I am satisfied is still being done in many places. In addition to the advantages to the farmer from having an abundant supply of marl close at hand, the value of good marl pits should be taken into the account. Pits ten feet square, and as deep as the purchaser chooses to dig them, are sold for from five to seven dollars. An acre contains forty-three thousand five hundred and sixty square feet, or more than four hundred and thirty-five such pits, worth, at the lower price, two thousand one hundred and seventy-five dollars, and at the higher price, three thousand and forty-five dollars. Such lands are worth searching for, and, if the work is judiciously done, they will be found. The following directions may aid in making examinations.*

Knowing that the general direction of the beds is a little west of southwest, a line traced in that direction from any pit already opened, will continue on the same bed. Or a line run between two pits of the same bed, will continue on the same throughout. Searches by digging down or by boring may be

* Borings for marl can be easily made with a common auger; an inch and a half one is large enough. Its shank may be lengthened as much as is required by welding on a rod. The handle should be made to slide on this rod, and fasten with a set-screw or wedge. The auger needs raising every few inches to clear it, and to examine the material penetrated, some of which will be found sticking in the twist of the instrument. With such an auger, a hole from ten to twenty feet deep can be made in a few minutes.

made anywhere on such lines; the lowest ground will usually have the least thickness of soil or *top dirt*. If this dirt is found too thick for profitable working, other places may be tried, for the marl is worn or gullied in its upper surface sometimes, and the best points for opening may not be hit at the first trial. If the lines are run over uneven ground, allowance must be made for the dip or descent of the beds, which is towards the southeast, and at the rate of from twenty to fifty feet a mile. This dip will cause beds to appear further to the northwest if the ground is higher, and to the southeast if it is lower than that started from.

COMPOSITION OF THE MARL, AND THE CAUSE OF ITS FERTILIZING ACTION.

The value of this deposit as a manure, and the surprising influence it has upon the agriculture of a large district of country, have drawn the attention of scientific farmers and chemists to its composition.

Mr. Seybert, of Philadelphia, made a careful analysis of this marl, which was published in 1822, in the second edition of Cleaveland's Mineralogy. He found ten per cent. of potash in it.

James Pierce, Esq., examined the marl beds of New Jersey, and published an interesting account of them in Silliman's Journal, Volume VI., page 237, in 1823. He attributes the virtue of marl principally to its shells and other calcareous ingredients.

Dr. R. Harlan, in a paper containing remarks on the Geology of West Jersey, in Volume IV., page 15, of the Transactions of the Academy of Natural Sciences of Philadelphia, in 1824, attributed its value in some cases to its fossil shells, in others to the iron pyrites in it, and in still others to the clay which it contained.

A paper on the same subject, Volume VI., page 59, Transactions of the same Society, in 1828, by Professor Lardner Vanuxem, says, "the marl of New Jersey and Delaware appears to owe its fertilizing property to a small quantity of iron pyrites (which passes to sulphate of iron by exposure to the air), and also to animal matter, to its color, and to its effect when mixed with sand, of diminishing the calorific conducting power of the latter."

Prof. Rogers, in his Geological Report of New Jersey, considers that there is abundant evidence "to prove that the true fertilizing principle in marl is *not lime* but *potash*."

Prof. J. F. W. Johnston, in his Notes on North America, made in 1850, Volume II., page 308, says, that on analyzing some of the green grains and sand, he found "from one to one and a half per cent. of phosphate of lime," and to this he attributes its fertilizing power.

In the Working Farmer for April 1, 1853, are several analyses of marl by Dr. Charles Enderlin, of New York. His specimens were from the pits of the North American Phalanx. He found two and a half per cent. of phosphate of lime in one specimen. He also found that the alkali was not all potash, but part soda. The fact of soda being a constituent of the marl was published in Silliman's Journal, second series, Volume IX., page 83, for 1850, from an analysis by William Fisher.

Numerous other references might be given, but the above are enough to show that the question is still an interesting one.

The following analyses show the principal constituents. Sulphates of iron, lime and alumina, phosphates of iron and lime, chloride of sodium, organic matter, &c., which can be detected in it in small quantities, will not materially affect the proportions of the principal substances.

The first (1) is the analysis made by Mr. Seybert, the second (2) is the average given by Professor Rogers, and the third (3) is the analysis made by Mr. Fisher.

	(1)	(2)	(3)
Silex,	49.83	48.50	53.26
Alumina,	6.00	7.30	3.85
Protoxid of iron,	21.53	22.80	24.15
Potash,	10.12	11.50	5.36
Soda,			1.60
Lime,		.50 or less.	1.73
Magnesia,	1.83	trace.	1.10
Water,	9.80	7.90	10.12
Loss,	.89		
	100.00	99.50	101.17

The preceding statements and analytical results show that the subject is by no means a plain one. To me it is one of deep interest, and I have taken every pains to inform myself upon the practical agriculture of the district, and the influence which marl has exerted in bringing it to its present high condition. With this knowledge my chemical examinations have been conducted, but they are not yet in such a state of forwardness as to be presented complete. A few approximate results will be given.

In the following table the amounts of phosphoric acid and lime are given, in the first and second columns. They are averages from several analyses of specimens from different pits. The third and fourth columns give the amount of phosphate and carbonate of lime. The phosphate is calculated from the phosphoric acid, and it probably exists in the marl in this form. The only doubt of it arises from the fact that phosphate of iron is a common mineral in this stratum. Careful examinations have not been made to determine the amounts of potash and soda; enough, however, has been done to show that they are always present, and constituting from five to ten per cent. of the whole.

Percentage of Phosphoric Acid, Lime, Phosphate of Lime, and Carbonate of Lime, in marls from the different layers.

BED.	LAYER.	Phos. Acid.	Lime.	Phos. Lime.	Carb. Lime.
1.	1. Sand marl,	0.76	1.00	1.55	0.37
	2. Black marl,	0.63	1.50	1.29	1.50
	3. Blue or gray marl,	1.14	8.50	2.33	13.04
	4. Top marl,	0.00	7.23	0.00	12.91
Fer. Sand	Green clay,	1.20	1.65	2.25	0.71
2.	1. Grain marl,	0.76	0.90	1.55	0.19
	2. Green marl and shells,		10.20		18.21
	3. Shells, yellow marl,	0.00	27.44	0.00	49.00
3.	1. Green marl,	2.80	2.40	5.71	0.00
	2. White marl,	0.78	1.50	1.59	1.23
	3. Blue marl,	1.04	1.70	2.13	1.09
	Dry-Bank marl.	1.14	0.30		0.00
	" "	1.39	0.50		0.00

The results presented agree, generally, with the experience of farmers. The marl containing the largest amount of phosphate of lime, is the first layer of the third bed; the green marl of Squankum, Deal, Shark River and Poplar. It is noted for quick and powerful action when applied in light dressings; from five to twenty loads on an acre produce good effects, and it is sometimes used in even smaller quantities. No. 3 of the first bed is well known as an excellent marl. From one hundred to two hundred loads are commonly applied to an acre, and such dressings last fifteen or twenty years. It will be observed that this layer contains less phosphate, but much more carbonate of lime than the one just mentioned; and probably this is the cause of its more permanent action. The first layer of the second bed seems, from the analysis, to be much better than practice has found it. The difference may be owing to the coarseness and cleanness of its grains, for when mixed with quicklime and applied to the soil, it produces excellent effects. The dry-bank marls, it will be observed, are deficient in lime; phosphoric acid is found in them in the usual amount. These specimens were from the first bed, and probably the third layer. They have usually been thought equal to the wet-bank marls of the same bed, for a short time, but to wear out sooner. Other comparisons will suggest themselves to the minds of inquiring farmers.

"POISON" OR "BURNING" MARLS.

Marls are found in all parts of the stratum, which are said to be *burning* or *poison* in their properties; so much so as to destroy vegetation. In some cases where they have been freely applied to the soil, they have destroyed its fertility for years. These marls are not confined to any particular layer or bed, but are found in spots or patches in all of them. The dark clays above and below the first marl bed also possess the same properties, and being frequently mistaken for genuine marls, have done serious injury to crops upon which they have been applied. The same is true of the brownish clay, called *rotten stone*, which is found on top of any of the layers of the third bed. In all these cases the injurious effect is due to sulphate of iron (*copperas*), or to that substance mixed with sulphate of alumina (a kind of *alum*). The latter substance is not near as common as the former. Either of them can be easily distinguished by the taste; the copperas is well known by its astringent, inky taste; the other by the taste of alum. When marls, or earths containing them, are exposed to the air, yellowish white incrustations of these salts form on their surfaces. If other tests are desired, take some of the marl and boil it in two or three times its weight of water, in a clean earthen or porcelain dish; then strain the water clear from the marl. The copperas and alum will be in solution in the water. If some of this water is poured into strong tea, it will turn it black; if poured into lime water it turns it a dirty white; and if added to the blue liquid made by pouring hot water on leaves of red cabbage, the color is changed to a red. If aqua ammonia (*hartshorn*) is poured into it, there is a reddish or greenish sediment formed.

Professor Rogers, in his report, recommended that such marls be exposed to the weather some time before using, that the copperas and alum might leach out. As a still better method, he recommended composting them with quicklime, using perhaps a bushel of lime to a hundred bushels of marl. Wherever this remedy has been tried it has been found effectual, and upon soils which have been injured by the application of such marls it has restored their fertility. It is not so generally practised as it ought to be, most farmers thinking it cheaper to get marl from beds not contaminated with these substances. The action of the lime upon the copperas produces *plaster*, but this is already in the marl, as is shown by its forming a white crust or powder on the surface of marls which are exposed to the open air, as well as by the sparkling little crystals of it which may be seen in many cases. Plaster is not generally found to produce any effect upon soils which are well marled. Still the use of lime with those marls cannot be too strongly recommended, the very fact that copperas and alum are present proving a want of lime, and whenever there is a sufficient amount of quicklime, or of carbonate of lime, in a marl, these substances cannot exist. The use of lime too may give activity to marls, which by themselves are almost valueless, causing the grains to crumble and give up their fertilizing constituents to the growing crops.

Wells which are sunk in the marls frequently contain so much of the copperas and alum in their waters, as to be unfit for making tea or coffee, turning the tea black. A little saleratus or pearlash, or even woodashes, boiled in the tea-kettle with the water, corrects this.

As directed, specimens have been taken from all the layers which have been examined, and from those of the marl, great numbers from different pits in the same bed. The collection of fossils is not as complete as is desirable—such an one requiring more time than it has been possible to devote to it.

A large number has been collected, however, and for many more the survey is indebted to the generosity of friends. Valuable and interesting specimens of fossil bones, teeth, shells, &c., have been received from Capt. T. Weeks of Squankum, Mr. W. Lippincott of Shrewsbury, Mr. J. S. Cooke and Mr. Polhemus of Tinton Falls, Mr. C. T. Matthews of Colt's Neck, Mr. Azariah Conover of Middletown, Rev. Mr. Riley and Mr. H. G. Cooke of Holmdel, and Mr. W. Hartshorne of Freehold. Some remarkably fine specimens of crystallized phosphate of iron were presented by Mr. P. Lafetra of Shrewsbury. The greatest liberality has been shown in regard to specimens, and the collection by donation would have been much larger, had care been previously taken to preserve them. It is hoped that the donations will be much greater the coming season, when it becomes known that as large a collection as possible is desirable to illustrate the geology of the State. Important service can, in this respect, be rendered to the survey.

In studying out the position and peculiarities of the various beds of marl, great assistance has been received from gentlemen residing in the county. All have willingly furnished any information required. Especial notice is due to Mr. W. H. Hendrickson and Mr. G. C. Murray of Middletown, Rev. G. C. Schenck of Marlboro', Mr. C. Sears of the Phalanx, Mr. J. S. Cooke of Tinton Falls, Rev. Mr. Finch of Shrewsbury, and Mr. W. Hartshorne of Freehold. Also, to Hon. W. W. Newell of Allentown, and Ex-Governor Fort and Mr. Thomas B. Jobs of New Egypt, Ocean County, and to Messrs. David and J. J. Pettit of Mannington, and Dr. D. M. Davis of Woodstown, Salem County.

GEORGE H. COOK.

REPORT

OF HENRY WURTZ, CHEMIST AND MINERALOGIST.

NEW JERSEY STATE LABORATORY,
Trenton, January 1st, 1855.

To Dr. William Kitchell, State Geologist:

SIR:—On entering upon the duties of my appointment on the first day of November last, my first care was to select a suitable place for a laboratory, in which to perform the analytical and other work required of me by my instructions. Such a place having been procured, it was necessary to devote more than half of the very limited time set apart for the work of this season to the furnishing and fitting up of such laboratory, procuring the requisite apparatus, and preparing the reagents and other materials required, in that state of perfect purity necessary to the performance of reliable analyses; so that when I found myself prepared to commence work, from three to four weeks only of the specified period remained, a time altogether too short for the performance of any extended chemical investigation.

Operations were commenced, however, all at once, upon *six* of the specimens collected by you, comprising four varieties of calcareous marls and two of calcareous sinters, and although it has been found impossible to bring these analyses quite to a final close, yet by dint of constant application, an amount of labor has been accomplished which could scarcely have been expected, not less than fifty-five quantitative determinations having been made, besides the large amount of qualitative investigation necessary; and the results already obtained possess several wholly unexpected and important points of interest, which hold out high promise of the value of more extended and thorough explorations and investigations of these abundant calciferous deposits.

My results, thus far obtained, are as follows:

I. A.

Marl, taken from the surface of a deposit found upon the estate of Isaac Bonnell, in Montague Township, Sussex County.

It presents the appearance of a light gray pulverulent mass, principally made up of the *debris* of small fresh-water shells, and is mixed with radicles of grass or other roots, and a few small black specks of peaty matter. When heated upon a sheet of platinum, it blackens, smokes with a peaty odor, and burns easily to a nearly white ash, which exhibits a curious kind of repulsion for the platinum while hot, passing into a sort of spheroidal state, and floating in the air, remaining in this condition for a long time, certainly after the expulsion of all volatile matter, and at a temperature too low to cause evolution of carbonic acid, thus indicating the development of a true repulsive force. After cooling, it is found caked together into a compact mass. These phenomena seem to me to be pyroelectric. When heated in a close tube, gives off a considerable quantity of water, which is strongly ammoniacal, together with a tobacco-like odor (indicating the presence of ammonia-crenate of lime).* This ordor is very strong and persistent, filling the whole laboratory with a smell precisely resembling that of an old foul tobacco pipe. At a stronger heat a quantity of tarry matter distilled over. Water boiled for a long time with the marl acquires a faintly yellowish tint, and

* Berzelius, as quoted in Loewig's "Chemie der organization Verbindungen," I. 485.

an odor strongly resembling that of a grist-mill, remaining perfectly neutral in its reaction, and becoming at the same time exceedingly difficult to filter clear. Solutions of the marl in acids possess a light amber color, and little or no smell.

The ingredients of this marl,* with the percentage proportions thus far determined, are—

* Some brief remarks upon the methods used in these analyses will be in place here, although when the analyses shall hereafter be presented in a complete form, minute descriptions of the methods will be given.

The phosphoric acid was detected by the molybdate of ammonia reaction, and the same reaction used, according to the suggestion of Sonnenschein, in its quantitative determination, that is, by precipitating it with molybdate of ammonia, redissolving the washed precipitate in ammonia, precipitating with sulphate of magnesia, and weighing as bibasic phosphate of magnesia. This process seems to present more of the elements of reliability, for determining phosphoric acid when present in small quantities, than any other yet proposed, but it was nevertheless found that the considerable solubility of the yellow molybdic precipitate in the wash-water has a greater influence than has been supposed, and that the determinations made are therefore probably too low. Observations were made, however, which induce the hope of so modifying the method of Sonnenschein, as to eliminate this source of error, and thus render it as accurate as it is convenient.

Manganese, when present, was detected by Crum's test, with nitric acid and deutoxide of lead, the delicacy and certainty of which cannot be too highly appreciated.

The carbonic acid was determined by means of a small apparatus similar to that described in Rose's Handbuch, last edition, Volume II., page 801.

The amorphous silica by boiling the substance with pure caustic soda solution for a long time in a platinum vessel, evaporating the filtered solution with an excess of chlorohydric acid, collecting the separated silica on a filter, washing, drying, burning, and weighing.

The portion of the marls insoluble in chlorohydric acid was dried upon a weighed filter at 100 deg. C., weighed, and afterwards burnt, and weighed again, the difference between the two weights being, of course, the insoluble organic substances present. The organic acids soluble in chlorohydric acid were determined together with the combined water, by the loss, except in the case of analyses II. B., in which the whole amount of water and organic matter was determined by burning a weighed portion of the marl as perfectly as possible, then restoring the lost carbonic acid by evaporating with carbonate of ammonia, drying and weighing, the difference being, of course, the whole percentage of volatile and combustible ingredients, from which, by deducting the organic matter in the insoluble portion determined as before, was obtained the sum of the organic matter in the soluble portion and the combined water.

The hygroscopic water was determined by drying at 100 deg. C., until the weight was constant.

1. Ingredients soluble in water.

Chloride of calcium, considerable.

Chloride of sodium, } traces.
Chloride of magnesium, }

Organic salts of lime, such as ammonia-crenate, ammonia-apocrenate, and ammonia-humate, } considerable.

2. Ingredients soluble in chlorohydric acid.

Lime,	50.27	Corresponding to Carbonate of Lime, 89.76.
Magnesia,	0.62	Corresponding to Carbonate of Magnesia, 1.30.
Carbonic acid,	38.57	
Combined water, } by loss. Organic acids, }	4.10	
Sesquioxide of iron, with traces of alumina,	0.45	
Phosphate of lime,	0.30	
3. Ingredients insoluble in chlorohydric acid.		
Amorphous silica, mean of two determinations,	0.43	
Organic substances, including humic acid, vegetable fibre, etc.,	4.19	
Hygroscopic water,	1.87	
Nitrogen, undetermined.		
	100.00	

I. B.

Marl from the same locality, but taken from *ten feet below* the surface of the deposit.

Some of the determinations given will be repeated before the completion of he investigation.

It may be well to state that all filters used by me, both in qualitative and quantitative operations, have been previously washed with chlorohydric acid and water until perfectly pure. The Swedish paper used in this investigation eft after such treatment, in a filter of ordinary size, no appreciable ash. I will also state that the re-agents used by me, are nearly every one prepared by my own hands, in a state of perfect purity, and many according to improved methods not yet given to the world.

H. W.

Resembles I. A. in its appearance, and in its behavior under the influence of heat in a close tube, and on platinum, except that it does not assume the spheroidal state, nor become caked together on cooling. Water boiled upon the marls acquires the same color and odor as from I. A., and becomes neither acid nor alkaline in its reaction. Solutions of the marl in dilute acids possess a dark amber color, and a strong smell of *formic acid*, indicating the presence of the imperfectly known products of the decay of vegetable tissue called ulmine, ulmic acid, etc. Heating with a little excess of nitric acid partly discharges the color.

The ingredients of this variety are:—

1. Soluble in water.

Sulphate of lime, considerable.

Ammonia-humate of lime,
Chloride of calcium,
Chloride of magnesium,
Chloride of sodium, } traces.

2. Soluble in chlorohydric acid.

Lime,	50.38	Equivalent to carbonate of lime, 89.97 p. c.
Magnesia, with a trace of oxide of manganese,	0.36	Equivalent to carbonate of magnesia, 0.76 p. c.
Carbonic acid,	38.90	
Combined water, Organic acids, } by loss.	4.34	
Sesquioxide of iron, with trace of alumina,	0.16	
Phosphate of lime,	0.66	
3. Insoluble in chlorohydric acid.		
Amorphous silica,	0.37	
Organic substances, including humic acid, decayed vegetable fibre, etc.,	3.54	
Hygroscopic water,	1.29	
Nitrogen, undetermined.		
	100.00	

On examination and comparison of the results of these two analyses, several considerations present themselves. In the first place, the presence of soluble salts of lime is an unexpected result. It is unfortunate that time has not yet allowed determinations to be made of the quantities of these soluble salts which are present, but their presence at all in appreciable quantity is of much practical importance. It is in the form of soluble salts only, that lime can act directly as an aliment of plants, that is, in this form only can it be taken up by their rootlets. Farther investigation will probably indicate practicable means of increasing the production of these soluble salts, and of thus greatly augmenting the value of such marls as fertilizers.

Lime, however, is not the only ingredient of importance indicated by the analyses. Nearly every other substance found to be present has more or less influence. The magnesia, oxide of iron, phosphate of lime, and amorphous silica are all absolutely necessary constituents of all fertile soils, while the organic acids, and other products of vegetable decay, which appear to be present in quite important quantity (six or seven per cent.), also contribute indirectly their influence. The organic acids, especially, undoubtedly act by forming compounds with lime, and other bases present, which are soluble in the liquids of the soil, thus necessitating their introduction into the circulation of plants by the endosmotic absorption of the roots; and if the now mooted question, which will probably receive some discussion in future reports, whether the nitrogen of vegetable tissues be derived from ammonia or not, admits of an affirmative decision, the organic acids must also act indirectly, though powerfully, by retaining the ammonia produced during the decay of the animal matter of the shells, in a highly soluble form, and also by absorbing atmospheric ammonia, or even, as indicated by Mulder,* through the development of ammonia by the combination of the nitrogen of the air with the hydrogen produced by their own decomposition. It will be

* As quoted in Loewig's "Chemie der Organischen Verbindungen," i., 474.

observed that the analyses indicate the presence of ammonia, derived undoubtedly from the decay of animal tissues, the proportions of which, however, have not yet been determined, both from deficiency of time and want of the necessary appliances.

The *amorphous silica*, whose presence is shown by the analyses, merits a few words of comment. It is the ingredient in soils which furnishes to many plants, especially to the cereals, such as corn, wheat, etc., the *silica*, which is absolutely necessary to the formation of their stalk or stem. Silica, which is the most abundant of all mineral substances, forming certainly more than one half of the mass of the earth, so far as the latter is known, occurs in soils in three different forms; first, in the crystalline form, as quartz, sand, etc., in which form it is wholly insoluble, and may be considered inert, so far as the nutrition of plants is concerned; secondly, in combination, in fragments of feldspar, hornblende, and other silicates, in which it is also comparatively inactive; and thirdly, as amorphous or *soluble* silica, or *opal*, as it is called by mineralogists, the only form of much importance in agriculture, since in this form it is soluble in the liquids of the soil. Far too little attention has been paid in analyses of soils and fertilizing minerals to their content of opal or soluble silica, whereas a soil may be rich in every other necessary ingredient, and yet, if deficient in this respect, be perfectly sterile for many crops; a remark which may indeed be made with reference to each and every one of the soil-constituents which are required to the building up of vegetable structures; these substances bearing precisely the same relation to the plant as the mineral ingredients of the bones do to the animal, or as the constituents of the shells do to the egg, being consequently just as absolutely indispensable in the one case as in the other.

This subject of the alimentation of plants will of course be repeatedly resumed in future reports, based, it is hoped, upon far more extended investigations of fertilizing materials, as well as of soils, than this one, and it is not, therefore, considered advisable to enter upon any extended discussion of the subject at present. Two reliable analyses, however, of the grain and straw of wheat, made by Weber, in the laboratory, and according to the method, of H. Rose,* will be quoted here, in order to furnish an idea of the mineral ingredients whose presence in the soil is necessary to the nutrition of that grain.

	In the grain.	In the straw.
Percentage of ashes found,	1.28	3.82
Constituents of ash.		
Potash,	23.18	0.68
Soda,	3.09	
Lime,	3.23	6.93
Magnesia,	11.75	1.69
Sesquioxide of iron,	1.11	0.99
Sulphuric acid,		0.74
Amorphous silica,	1.18	67.90
Phosphoric acid,	46.36	5.05
Chloride of potassium,		15.13
Chloride of sodium,	10.00	0.89
	100.00	100.00

One of the many prominent points of interest here presented, is the large quantity of silica found in the wheat straw, (sixty-eight per cent.), insomuch that, the whole content of ash in the straw being 3.82 per cent., a simple calculation shows that a ton of such straw would contain more than fifty pounds of silica, and would require more than six tons of the marl I. A. to satisfy it with this element in its nutrition. So that upon a soil already deficient in amorphous silica, such marl, unless applied in a very large quantity, would not furnish it in the requisite proportion. Weber's analyses show also other ingredients in the wheat ashes, which do not exist in the marl, showing very clearly that a farmer who should attempt to restore exhausted wheatlands by the use of such a marl alone, would stand several chances of disappointment,

* Liebig & Kopp's Jahresbericht, für 1849, p. 656.

from the deficiency in the soil of necessary ingredients, unknown to him, which are not contained in the marl. These considerations illustrate how analyses of soils, when properly executed, as very few, it may be asserted, have been, may be of very high value to the agriculturist.

A comparison of the results of the two marl analyses, in consideration of the different depths from which they were taken, is interesting, and will be more so, when determinations of the quantities of the several soluble salts and of the nitrogen shall have been obtained. The main differences between the two are in the nature of the soluble mineral ingredients, which, in the surface-marl I. A., are principally chlorides, and in that from the lower part of the deposit I. B., principally sulphates; and in the organic matter, which, in the surface-marl, has been more altered by the action of atmospheric oxygen. More extended investigation in this direction will undoubtedly develope important practical results as to the selection of the marl, and its treatment preliminary to use.

Another result of the above analyses of Mr. Bonnell's marl, worthy of attention, is the large proportion of carbonate of lime which it contains, very few of the ordinary calcareous marls being equally rich in this ingredient. In fact, after deducting the water and organic matter, both of which would be expelled in burning it for lime, it contains about ninety-nine per cent. of pure carbonate of lime, and would undoubtedly burn into a very pure and excellent lime for building, and all other purposes.

II. A.

A grayish marl, taken from *four* feet below the surface of a deposit on the land of Isaac Coles, Montague Township, Sussex County.

A qualitative examination only of this marl has yet been attempted. It appears to resemble II. B. in every respect, except in containing much less phosphoric acid, sesquioxide of iron and alumina, and more vegetable remains.

II. B.

A dark gray marl, from the same locality as II. A., but taken from *eight* feet below the surface.

When heated in a close tube, it behaves, in every respect, precisely like I. A.; also when heated upon platinum, a repulsive force for the metal being developed as in the case of I. A. The ignited marl evolves with chlorohydric acid a fœtid smell of sulphohydric acid, and with acetate of lead paper a strong reaction of the same is obtained. This was at first attributed to the presence in the charred mass of sulphide of calcium, proceeding from deoxidation of the considerable quantity of sulphate of lime found in the marl by the organic matter during the ignition, but it was found that the same evolution of sulphohydric acid took place from the substance when charred after complete removal of all traces of sulphates by long washing with water. It could therefore arise only from the presence of *sulphide of iron*, and as no traces of sulphohydric acid could be obtained from the unignited marl, bisulphide of iron, or *iron pyrites*, must be the ingredient in question, being converted into protosulphide by the ignition.

Water boiled with this marl acquires a yellowish color, and a strong smell like that in I. A., but also resembling some kinds of stagnant vegetable mud, remaining, however, perfectly neutral in reaction. Acid solutions have a light amber color, and smell somewhat of formic acid.

Its ingredients are as follows:

1. Soluble in water.

Sulphate of lime, large.

Ammonia-crenate of lime, } small.
Ammonia-apocrenate of lime, }

Chloride of sodium, considerable.

Chloride of magnesium, } traces.		
Chloride of iron,		
2. Soluble in chlorohydric acid.		
Lime, ...	9.71	Corresponding to carbonate of lime, 17.34 per cent.
Magnesia, ...	0.42	Corresponding to carbonate of magnesia, 1.09 per cent.
Carbonic acid, ...	7.25	
Combined water, } by direct determination, Organic acids,	3.19	
Sesquioxide of iron, mean of two determinations, ...	1.28	
Alumina, mean of two determinations, ...	2.12	
Phosphate of lime, ...	0.80	
3. Insoluble in chlorohydric acid.		
Amorphous silica,	1.21	
Organic matter, humus, decayed vegetable tissues, etc.,	5.52	
Coarse sand, with *debris* of minerals containing silica, alumina, oxide of iron, and magnesia, which may be considered as inert matter, Iron pyrites,	66.57	
Hygroscopic water,	2.08	
Nitrogen, undetermined.		
	100.25	

A most remarkable and wholly unexpected result of this analysis is the detection of *iron pyrites* in the marl, and from the fact of finding it also in another of the marls whose analysis is given below, the presumption would seem to be, that it is probably present in many of these deposits. Farther examinations will decide this point. In the mean time, its presence in these two marls can only be looked upon as highly favorable to their availability as fertilizers.

From the presence of an excess of carbonate of lime, it is impossible that any of the protosulphate of iron, formed by the oxidation which iron pyrites, in the form in which it occurs in these marls, undergoes on exposure to the air, and which might be injurious to the soil, should exist in the mass without being immediately decomposed, with the formation of the powerful fertilizer, sulphate of lime, or *gypsum*. And that this action is continually going on in the mass, is indicated by the large quantity of sulphate of lime actually found in the aqueous solution. It may be said with certainty, with regard to such marls as these, that the longer they are exposed to the open air, in a moist state before use, the more powerfully fertilizing they will become. So that an important point as to the preliminary treatment of these marls is thus already definitely decided by these brief investigations. The origin of the iron pyrites in these deposits is a very curious question, and, in fact, the whole subject is one of great interest, and will amply repay fuller investigation. The presence of the iron pyrites was discovered at too late a day to admit of any attempt at determination of its quantity.

The quantity of carbonate of lime in this marl, as also in the one next described, is small, but on account of the presence of the sulphide of iron, and the continual formation of gypsum, which must consequently take place on exposure to the atmosphere, they will, in all probability, be found fully equal, if not much superior, in power, to the marl first described, although they will not be nearly so lasting in their action.

The other ingredients of this marl are not without importance, the proportions of amorphous silica and phosphate of lime, for example, being much greater than in the marl No. I.

III.

Marl from the land of Isaiah Vannetten, Montague Township, Sussex County, taken from four feet below the surface of the deposit.

A very dark colored, moist, peaty mass, containing remains of decomposing rootlets. On drying by exposure to the open air, pulverizing and sifting, it was found to contain transparent silicious particles. When heated, it blackens, smokes, and burns with flame, leaving a residue which before the blow-pipe assumes a reddish color, from the presence of oxide of iron. When heated in a close tube, it gives off much water, with ammoniacal and tarry products, and a strong tobacco-like odor like I. A. The charred mass, as in II. B., evolved with chlorohydric acid a large quantity of sulphohydric acid gas, and as in the present case no sulphates are present, which could be converted into sulphides by the organic matter on ignition, there can be no question of the presence of iron pyrites in the marl, even without further examination.

Water boiled with this marl acquires a yellowish color, and an odor similar to that in I. A., remaining perfectly neutral. Acid solutions have a dark amber color, which is not perceptibly discharged by boiling with nitric acid; and a very strong smell of formic acid.

The contents of this marl are :—

1. Soluble in water.			
Chloride of calcium, Organic salts of lime,	large indications.		
Chloride of sodium, Chloride of magnesium, Chloride of iron,	traces.		
2. Soluble in chlorohydric acid.			
Lime,		8.45	Corresponding to carbonate of lime, 15.09.
Magnesia,		0.43	Corresponding to carbonate of magnesia, 0.90.
Carbonic acid,		6.12	
Combined water, Organic acids,	by loss,	3.62	
Sesquioxide of iron, Alumina,		2.49	
Phosphate of lime,		0.31	
3. Insoluble in chlorohydric acid.			
Amorphous silica,		1.15	
Organic matter, consisting of			

vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc.	8.20
Iron pyrites, Inert matter consisting of coarse sand, with silicates of alumina, oxide of iron and magnesia,	66.97
Hygroscopic water,	2.26
Nitrogen, undetermined.	
	100.00

The same remarks appended to marl No. II., apply with equal force to this, the two being almost precisely similar in composition. One important difference, however, is that this marl contains no sulphate of lime. On exposure, however, to the air, it cannot fail to be developed in the mass sooner or later. The proportion of phosphate of lime, also, is much smaller than in II. The proportion of decayed vegetable matter and of organic salts of lime is unusually large in this marl, and has undoubtedly been the means of protecting the iron pyrites from oxidation.

IV.

Calcareous sinter, from Metler's farm, Dingman's Ferry, Sandiston Township, Sussex County.

A yellowish gray mass, of spongy structure. It is naturally quite pulverulent, but on exposure to the atmosphere becomes so much more so as to be easily crushed to powder between the fingers like coarse chalk, a property which, of course, much enhances its availability as a fertilizing substance. When heated in a close tube, it gives off a faint trace of ammonia, with a little water. The ignited mass, on solution in chlorohydric acid, leaves a slight black residue, which, besides amorphous silica, contains carbon, thus indicating the presence of organic matter in the substance. Water boiled with it evolves an odor like that of moist chalk, acquires no perceptible color or reaction, but dissolves salts of lime in appreciable quantities. Acid solutions have a light amber color and no smell.

The contents are:

1. Of the solution in water.

Chloride of calcium, considerable.

Ammonia-crenate and Ammonia-apocrenate of lime, Chloride of sodium, Chloride of magnesium,	traces.

2. Of the solution in chlorohydric acid.

Lime,	54.57	Corresponding to carbonate of lime, 97.44.
Magnesia,	trace.	
Carbonic acid,	42.57	
Sesquioxide of iron,	0.37	
Phosphate of lime,	0.22	
Organic acids, Combined water,	undetermined.	

3. Of the insoluble residue.

Amorphous silica,	1.00
Organic matter (humic acid),	0.17
Hygroscopic water,	0.32
	99.22

An analysis of a calcareous sinter, from this same locality, is given by Prof. Rogers in his report, page 109, where he describes it under the name of *travertin*. The results do not differ much from mine, except that no detection or determination of the important ingredient, amorphous silica, was effected. The presence of phosphate of lime also was not noticed by Prof. Rogers, owing to the entire want, at that time, of any method of detecting this highly valuable ingredient with certainty, except when present in large quantity. The specimen analyzed by Prof. Rogers also does not seem to have been of equal purity with mine, his analysis indicating but 93.53 per cent. of carbonate of lime, while mine gives 97.44 per cent.

The considerable quantity of chloride of calcium (also not observed by Prof. Rogers), which is indicated by my analysis, is a very interesting fact. It is to be regretted that a specimen of the water from which this calcareous deposit was formed, was not also collected, in order that its composition might be compared with that of the deposit itself. Farther remarks upon the presence of the chloride of calcium are reserved until this can be done, and also a determination made of the amount of this salt contained in the mineral.

As remarked by Prof. Rogers, this calcareous sinter should give, when burnt, a very white and good lime.

V.

Calcareous sinter from the farm of Benjamin P. Van Sickles, Petersville, Sandiston Township, Sussex County.

Stalactitic in its structure, and contains small pebbles of quartz and sandstone. When heated upon platinum, it presents the same curious phenomenon of repulsion as I. A. The presence of organic matter was indicated by a brown color of the residue left after solution of the ignited substance in chlorohydric acid, which brown color disappeared before the blowpipe. The solution formed by boiling water with the pulverized substance has a smell like moist chalk, no color or alkaline reaction, and contains much chloride of calcium and other chlorides. Acid solutions have no smell, and little or no color.

1. Solution in water contains:

Chloride of calcium, considerable.

Chloride of sodium, } traces.
Chloride of magnesium, } traces.
Organic salts of lime. } traces.

2. Solution in chlorohydric acid:

Lime,	43.68	Corresponding to carbon. lime, 78.01.
Magnesia,	0.14	Corresp'ng to carb. of magnesia, 0.29.
Carbonic acid,	34.44	
Sesquioxide of iron, with trace of alumina,	0.80	
Phosphate of lime,	0.43	

Organic acids, Combined water, } undetermined.	
3. Insoluble residue:	
Amorphous silica,	0.38
Organic matter,	0.20
Inert matter, consisting of silica, with traces of oxide of iron, alumina and magnesia,	19.39
Hygroscopic water,	0.36
	99.82

Work has been commenced also upon some other minerals, comprising some limestones and marbles, but the results are not complete enough to possess much interest, and I shall not therefore present them at present.

I am,

Very respectfully,

HENRY WURTZ,

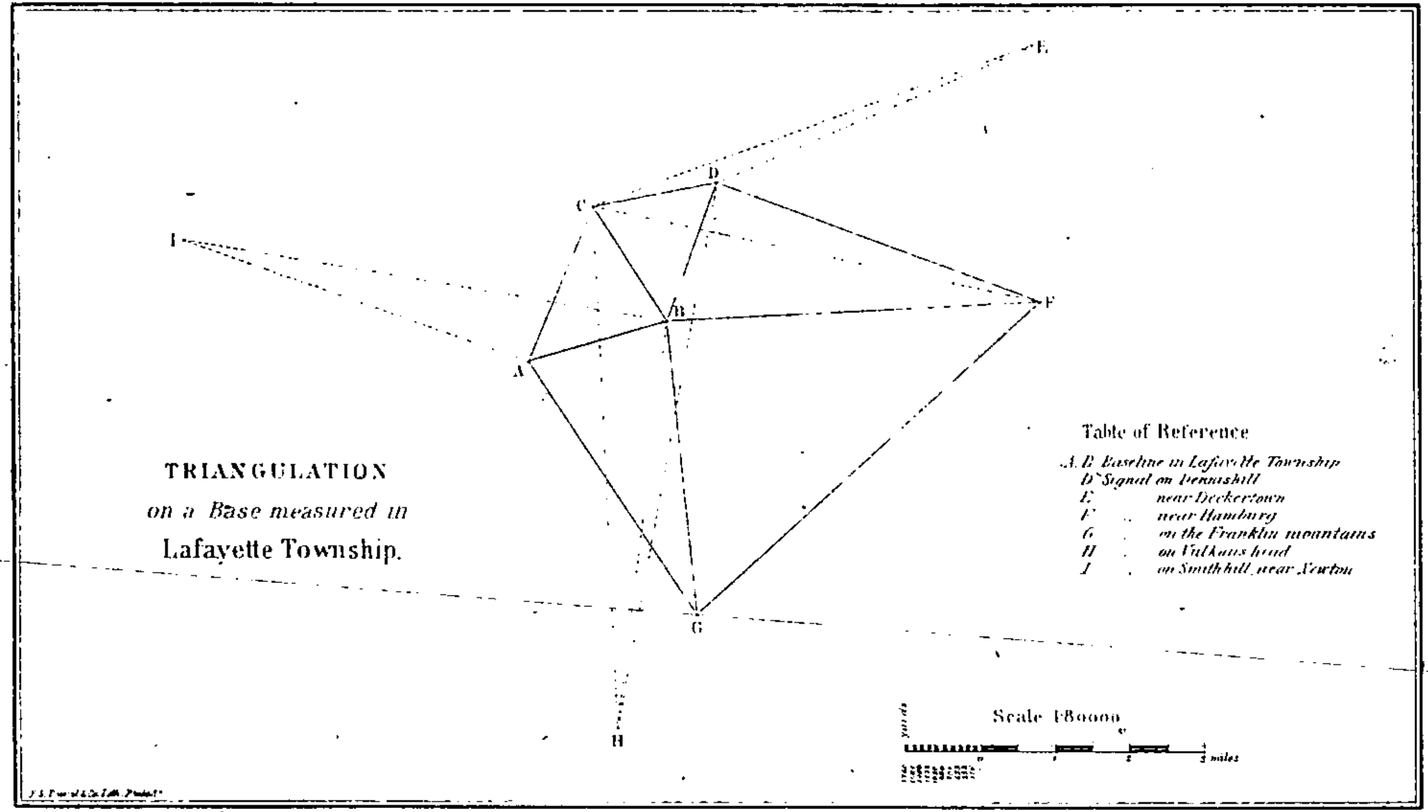
New Jersey State Chemist, Mineralogist and Metallurgist.

REPORT

OF EGBERT L. VIELE, TOPOGRAPHICAL ENGINEER.

HAVING been intrusted in June last with the duty of preparing a reliable map of the State, upon which could be accurately delineated the results of the geological explorations, it became my first care to determine the most feasible; and at the same time most economical method which could be pursued in prosecuting the undertaking. To this end, an examination was made of the records and maps deposited in different county seats, and also those on file at the State capital. From these no information could be obtained beyond that which is laid down on an existing map of the State, which map is merely a compilation from those records, showing the principal towns and roads, but exhibiting no reliable physical features, so important to the proper exposition of geological formations. Under these circumstances it was evident that an actual survey alone could furnish the map required. A plan based upon the extension of the coast survey over the State was submitted to the Governor, and discussed by several of the most eminent men in the State, then attending a session of the supreme court at Trenton. It was conceded to be the most judicious plan that could be followed, and adopted by the Governor as being the only one which would give to the State such a map as its geographical position and its great mineral wealth required.

The method pursued in a survey of this nature is as follows: A line from three to ten miles in length is measured with


TRIANGULATION
on a Base measured in
Lafayette Township.
Table of Reference
A.B Baseline in Lafayette Township
D Signal on Dennishill
E near Deckertown
F near Hamburg
G on the Franklin mountains
H on Vulkans head
I on Smithhill, near Newton
Scale 1:80000
miles
A
B
C
D
E
F
G
H
I

the greatest care and accuracy upon a plain as nearly level as can be found. This is called a *base line*, from each extremity of which, by means of a theodolite, the angles are measured, which are included between several prominent surrounding objects previously selected as trigonometrical points. From each of those points the angles are measured between the lines joining the points and the extremities of the base line. There is thus formed a series of triangles, from the known parts of which the unknown are determined by calculation, and we thus ascertain the length of the sides of the triangles or the distances between the trigonometrical points. From these sides as bases other trigonometrical points are determined, until the entire tract of country to be surveyed is covered over with a network of triangles, of as large a size as is consistent with the means employed. This is called a primary triangulation, within which a series of secondary triangles is formed in the same manner. The interior details between the secondary points are filled in by means of the plane-table. These details consist of the contour lines of the elevations, or horizontal sections of the hills, taken at equi-distant intervals—the direction and sinuosities of the water courses; the houses, roads, farm lines, etc. Observations for latitude and longitude are made at several of the most conspicuous stations, from which the geographical position of all the points can be determined, and their places projected on the map with extreme accuracy.

For the purpose of the Geodetic Survey, the coast of the United States has been divided into eleven sections, in each of which a base line of from five to ten miles is measured. The coast of New Jersey is included in the second of these sections, the base of which is on Fire Island. The primary triangulation extends across the State from Amboy to Trenton, and down the Delaware River. The secondary triangulation follows the same course, and also extends along the whole coast. About two thousand square miles of topography have been completed, based on this triangulation. Observations for latitude and azimuth have been made at a number of stations of the primary triangulations. The difference of latitude, longitude, and azimuth, between these and the other stations have been compiled, and the results published in tabular form, giving the names of the several stations or triangulation points, the latitude and longitude of each station, and the distances between the several stations.

The course to be pursued in completing the survey of the State is a very plain one: simply to begin where the coast survey left off, carry out the triangulation, and fill in the topography. Half the labor and expense of the undertaking is saved to us, by what has already been accomplished. The records of the work done are complete for every step of progress, and a monument of some kind marks every triangulation point. Had the appropriation of last year been sufficient, operations would have been commenced on a side of the coast survey primary triangulation as a base, and the topographical parties would have worked from the centre of the State to the north and south simultaneously. Under the circumstances, however, it was deemed most judicious to show as much topographical and geological development as possible, in the short time that would elapse before the meeting of the Legislature, in order that the whole subject might be presented in a clear light. To this end, the boundary line between New York and New Jersey was selected as the base of operations, on the supposition that this line, having been laid down by a joint commission, offered a well-defined base line. Time, however, and individual carelessness, had served to obliterate or destroy every vestige from the Delaware to the Blue Mountains; even the initial point was wanting. A serious delay occurred in re-establishing this line so far as the records that could be obtained enabled it to be done. The line determined on coincided with the one formerly regarded as the boundary line in the division of property bordering upon it; although, during the last few years, it had been shifted to one side or the other, according to the ideas of the local surveyors. Having established a starting point, levelling for a geological section was commenced along the boundary line, and a base for topography was measured in the township of Montague. The principal points were established by a reconnoissance, in order that the topography might be checked by a secondary triangulation when a theodolite could be procured. A second base line was afterwards measured in the township of Wantage, and the same course pursued as in Montague, and so on for all the townships that were surveyed. But one plane-table was in use until September, when one was borrowed from the Coast Survey, and afterwards a theodolite from the same source. From the beginning of the work, Professor Bache, the Superintendent of that Survey, has taken a cordial interest in its progress, and expressed a willingness to aid it by any means in his power.

A summary of the operations of the past season is as follows:—The party entered the field on the eleventh of July, consisting of three principal assistants, aided by four volunteers, who gave their services in return for learning engineering. Three more assistants were added when the instruments were received from the Coast Survey. On the 30th of November the field operations were brought to a close. During that period, the parties completed three hundred and sixty-one miles of topography, (being three fourths of the county of Sussex,) and seven hundred miles of levelling for geological sections, besides many minor details. In consequence of the late period at which the theodolite was received, and the inadequacy of the means, the complete triangulation of the county was not accomplished, but enough was done to test the general accuracy of the topography. A sketch of this accompanies the report. Since the parties left the field, a sufficient length of time has not elapsed to complete in the office all of the work which has been done, but so much as may be mapped at the time the subject occupies the attention of the Legislature, will be forwarded to Trenton for inspection. The scale upon which it is proposed to execute the map, is 1–80,000, the same as the published maps of the Coast Survey, and as the topographical map of France. This is somewhat less than one inch to the mile, which is the scale of the ordnance map of England. The scale proposed for the county maps is 1-30,000, or about two inches to the mile.

It might appear almost superfluous to enlarge upon the nature and importance of this work, considered with reference to the intrinsic value of a topographical map of the State. The great attention which has been given in this country, during the last few years, to the study of physical geography, and the rapid strides of education and intelligence, has created a demand for something more than mere guide maps of the different States of the Union. The National Legislature, true to the impulse of the times, has nobly responded to the efforts of science—hundreds of thousands of dollars have been freely expended in exploring and preparing charts of the seaboard. A network of triangles covers the coast from Maine to Texas—minute soundings have brought to light the hidden rock and treacherous shoal. The capacities of the inlets, rivers, and harbors of the Atlantic coast have been determined, and a basis of accurate survey established, which the States bordering on the ocean are invited to take advantage of, and continue this great work, so that the States adjoining them may take it up and continue it on until it meets a corresponding effort from the Pacific side. Thus giving to the country and to the world what England commenced a hundred years ago—what France, Italy, Austria, Norway, and Sweden and Russia, have spent millions to obtain, viz:—A correct topographical map, from which future generations may learn the nature and extent of the vast resources, developed and undeveloped, of this favored land. Under the auspices of an enlightened legislation, the State of New Jersey has been the first in the Union to commence this undertaking on purely correct principles. Its completion will be an era in her history, and a lasting monument of the intelligence of her people.

EGBERT L. VIELE,
Topographical Engineer.

DR. WILLIAM KITCHELL,
State Geologist and Superintendent.