# REPORT

ON THE

# GEOLOGICAL SURVEY

OF THE

## STATE OF NEW JERSEY.

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PHILADELPHIA:
DESILVER, THOMAS & CO.

1836.

EXECUTIVE DEPARTMENT,
*Trenton,* 16*th Feb.* 1836.

*To the Legislative Council and General Assembly:*

I have just received from Professor Rogers, who was appointed under an act of the last session, to make a geological survey of the state, a detailed report of his operations during the past season; and I have great pleasure in presenting it, with the accompanying map and profiles, to the legislature.

The work has been accomplished, thus far, to my entire satisfaction; and I entertain a confident hope that the result which is now submitted to you will meet your approbation and be favourably received by our constituents.

P. D. VROOM.

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HOUSE OF ASSEMBLY OF NEW JERSEY.
*February* 17, 1836.

*Extract from the Minutes of the House.*

"The Speaker laid before the House the following communication from his Excellency the Governor, accompanied by the report of Professor Rogers, appointed to make a geological survey of the state.

"Ordered, that one thousand copies of the said report, with the map and profiles attached thereto, be printed under the supervision and direction of Professor Rogers, for the use of the Legislature."

Attest. RICH'D P. THOMPSON,
*Clk. of Assembly.*

# REPORT.

*To His Excellency Peter D. Vroom,*

SIR,—In compliance with the appointment which I had the honour to receive from you under the date of April the 24th, 1835, to make a Geological and Mineralogical Survey of the State of New Jersey, as ordered by act of the Legislature, I beg leave to submit the following Report:

Bearing in mind your instructions as to the scope and object of the survey, namely, to bring to light the native mineral productions of the State, in a manner to make the examination as serviceable as possible to the interests of its agriculture and other branches of industry, I beg permission to state that I have directed my more especial attention to those points in the Geology of each district, immediately connected with the developement of these resources. The various tracts of *Marl*, *Limestone*, and other mineral substances useful as agents for fertilizing the land, the numerous *ores*, *sands*, *clays*, *building materials*, and substances of value in the arts have been explored and examined, while no pains were spared to trace them in their range across the State, as minutely as was consistent with the design of a general survey, and the time allotted to the duty.

It being impracticable, with the means at command, to investigate in detail, every portion of so large a territory, a plan of survey was adopted, intended to unite a considerable share of research, respecting those points of chief utility alluded to, with a general study of the Geology of the State at large.

This plan consisted in laying down upon the Map of the State, (Gordon's) a series of straight lines, five in number, so drawn as to cross, nearly at the same angle, all the various formations. The

regions adjacent to these lines, embracing a width of several miles on both sides of each, were then selected for more particular and detailed examination, and the extent and boundaries of the several formations as far as determinable, were delineated upon these portions of the map.

The five geological sections or profiles thus surveyed embrace all the strata, and afford a general insight into the principal features of the stratification, of the State.

During this examination, specimens of the materials susceptible of useful application, have been gathered from the districts adjoining these profiles, and likewise from much of the intervening country, all the most important localities throughout which were visited for that purpose.

Such of these substances, as seemed to require a minute investigation, have been submitted to *Chemical analysis* in the hope that the precise information, thus procured of the composition and properties, of the several mineral productions of each region, may tend to incite a spirit of wholesome enterprise to their developement in the useful arts: such enterprise will extend itself, in proportion as the latent resources of the State, are made known to its citizens, and it will be sound, just in proportion to the degree of care and accuracy employed in the development.

In accordance with this plan, I have explored more minutely than in other parts of the State, the Geology of the five following tracts, the structure of which will be better understood by referring to the profiles constructed to elucidate them.

First, a line of country extending across Bergen and Sussex counties, from the vicinity of Fort Lee, on the Hudson river, to near Dingman's Ferry, on the Delaware.

Secondly, a tract stretching from the sea-shore, in Monmouth, to the Water Gap of the Delaware, in Warren.

Thirdly, a tract extending from the bend of the Delaware, at Easton, parallel with the general course of the river to Trenton, and thence prolonged to the sea-shore, south of Barnagat.

Fourthly, a section across Gloucester county, reaching from the Delaware river, at Camden, to the sea-shore, near Leed's Point.

Fifthly, a tract traversing Salem, Cumberland, and Cape May counties, from the Delaware to the sea-coast.

Besides exploring systematically the regions lying within several miles of the profile lines here laid down, various other examinations were made by tracing the formations in the longitudinal direction, or in other words, along the boundaries which separate each two contiguous strata.

This was done more especially in the survey made of the *green sand or marl formation*, passing through Monmouth, Burlington, Gloucester, and Salem counties. The country lying both upon the N. W. and S. E. of this tract, was in many places carefully explored, in order to trace the prolongation of the marl, beneath the surface, and ascertain its existence over wider limits than were before supposed to exist. Nearly all the important localities, moreover, in the green sand district, were visited with a view to make selections for analysis of the several varieties of this substance, which, from its rare powers as a fertilizing agent, seems to claim especial and minute investigation. On both sides of the tract where the green sand marl is found naturally exposed, I have in part succeeded in following the stratum to where there was but little previous confidence that it extended.

The utility of these researches to the agriculture of the districts interested, may hereafter be considerable, especially should the depth at which the marl spreads itself below the soil, be determined with any approach to accuracy. The chemical investigation of the several qualities of the marl, will, it is believed, result in some useful information, tending not only to direct a proper selection of the material, but to guide the agriculturist in the manner of applying all the several varieties of it to the soil.

# INTRODUCTION.

*General View of the Formations comprised in the State.*

IT is apparent to even a casual observer, looking at the surface of New Jersey, that its area is pretty equally divided into two very dissimilar regions, whether we refer to their physical geography, their mineral strata, or overlying soils. The boundary line which separates the whole territory of the State into these two districts, which both in geological structure and agricultural character may be regarded as so strongly contrasted, will, it is believed, be found, when more accurately determined at some future day, to be a somewhat undulating line, extending from the Delaware river, at Bloomsbury, below Trenton, across to the river Raritan, below the mouth of Lawrence's Brook. To the south and east of this division line, the strata of the rocky or consolidated sort are extremely few, the deposits being chiefly loose sands and soft clays of various composition, while the prevailing soil is sandy and the surface flat. To the north and west of the same limit, the strata are all, on the contrary, of the stony character, or what in ordinary phrase is meant by rocky, and each set or formation is covered by its peculiar class of soils in which the predominant character is less sandy than in the other section of the State. These differences result from and point to a wide natural disparity in the materials composing the two regions, in the period when their component strata were brought together, or in other words, their geological age. They are likewise significant of a no less important difference in some of the causes that have operated in impressing so strong a contrast in their external features upon the two sections.

The rocks to the north-west of the limit alluded to, belong in part to the stratified primary class, in part to the lower groups of the secondary series, or that which embraces the non-fossiliferous and fossiliferous strata, lower in the list of our formations than the anthracite coal of this country.

The district in question embraces likewise numerous ridges and outbursts of rocks of the Trap class, more recent, in all proba-

bility than the rocks above-mentioned, though still of an obviously remote age.

The section of the state lying south and east of the same line, comprises formations of a much more recent period, inasmuch as the strata of that tract belong to the upper or later portions of our secondary series, and to the still newer tertiary.

Some of the strata in this region contain a sufficiently copious supply of organic remains to enable the geologist to determine, with some approximation to accuracy, the position which these beds should occupy in the series of North American secondary and tertiary formations. On the other hand, the rocks in the northern division of the state, with the exception of a single stratum, enclose very few fossils, and it becomes, therefore, a task of considerable difficulty to decide with confidence, whereabouts we should place them in the system of the American secondary strata and to what equivalents among the European rocks we should refer them. These difficulties, time and laborious research alone can dissipate, and I am, therefore, more solicitous to express myself in this report with caution upon these the higher generalizations of the science, than to commit myself to decided opinions at a time when systematic geological investigations among us may be said to be only in their infancy.

The order which I design to pursue in describing the several tracts of the state, is to treat each formation, that is, each group of strata produced at about the same period, separately; and I shall commence with the latest formed deposits first, and pass to the next older in regular succession. The little that admits of being said in this place respecting the soils of each district, will be given in the sections referring to the respective strata upon which they repose, because soils in the great majority of instances are derived from the rocks which lie beneath them.

In conformity, therefore, with the course proposed, the lower or southern half of the state will be described first.

# CHAPTER I.

*Geology of the counties of Middlesex, Monmouth, Burlington, Gloucester, Salem, Cumberland and Cape May.*

## GENERAL DESCRIPTION.

This section, which embraces the greater part of Middlesex, the whole of Monmouth, Burlington, Gloucester, Salem, Cumberland and Cape May counties, includes strata belonging to two separate geological eras—the *Tertiary*, and the *Upper Secondary* periods of modern geology.

The deposits of both classes are very nearly horizontal. This and the usual level outline of the surface itself have caused the several strata of the region to be almost every where concealed by an extensive though not deep layer of sand and gravel, which has been strewed over them at some period subsequent to their original deposition. As it is a fact very generally true, more especially in widely expanded level countries, that the soil and superficial layer of loose earth is, in most part, derived from the subjacent strata, whether rocky or unconsolidated, we see whence it happens that the surface matter of this portion of the state is in general so remarkably sandy; for sea-shore or ocean sand has been a large ingredient in the original formation of most of the deposits of the district.

The obscurity arising from this cause, together with the absence of any deep valleys or high vertical banks, such as in many regions, exhibit the edges of the numerous strata in their order of superposition, renders it extremely difficult, in the present stage of research, to lay down, at least with precision, the exact relations of the beds which occupy some sections of this extensive level district. The following may be assumed to represent with sufficient accuracy for present purposes, the order in which the strata of this region would succeed each other in the descending series, were they all to occur together.

A. Sand and gravel lying beneath the vegetable soil to a variable depth, but generally many feet thick. This usually overlies all the other deposits indiscriminately.

B. A bed consisting of bluish or lead-coloured clay, with sand in variable proportions, embedding, in the few localities where

alone the formation has hitherto been discovered, a profusion of fossil shells in a state of decomposition, which give to the more clayey portions of the mass the properties of *a calcareous marl.* This stratum is of the *Tertiary* class, and reposes upon the succeeding.

C. A blue, somewhat plastic clay, often sandy and micaceous, and interstratified with variegated ferruginous sands. It frequently contains leaves, parts of trees, lignite, amber, and other vegetable products, and rests very generally upon the green sand or granular marl, with which material it is very often confounded. It sometimes contains a quantity of free sulphate of iron (copperas) and sulphate of alumine, and is consequently deleterious to the soil. Whether this deposit is of secondary or tertiary date has not thus far been fully ascertained, though little doubt remains that it is *secondary.*

D. A group of beds of the *upper secondary series*, bearing a certain degree of analogy to the green sand formation of Europe. The principal members of this group are—

1. A brown coarse ferruginous sand-stone, and conglomerate, made up of transparent quartz sand, fragments of felspar and quartz pebbles, cemented by a dark brown ferruginous paste. This sandstone often contains grains of the green sand so abundant in the strata lower down. It crowns the tops of the hills. It is doubtful to what group it belongs, though probably to the secondary. It is also uncertain whether these beds or the stratum C. are lowest in the series.

2. A yellow ferruginous sand, being analogous in composition to the sandstone ; containing often a sensible proportion of the green grains. Sometimes thirty feet thick. This, which is a very extensive bed, is believed to be the same which in one or two localities, as in the Nevesink hills for example, exists as a soft sandstone stratum, containing the secondary fossils usually in the state of *casts.* If so, it is of the secondary group, and is connected immediately with the green sand bed upon which it very generally rests. In some of the central parts of the marl region this stratum is a loose sand, but full of organic remains in the state of solid casts formed in the interior of numerous bivalve and univalve shells.

3. A yellowish granular limestone, sometimes siliceous. It occurs in thin detached layers, a few inches thick, divided by a

loose calcareous earth. It abounds in organic remains of upper secondary origin. This, like the former stratum, overlies directly, in some parts of the region, the green sand or "*marl*" stratum, and seems intimately related to it. It contains often a considerable proportion of the green grains which constitute the material here called marl.

4. Lastly, the green sand or "marl" stratum, consisting of the peculiar *green sand* mineral, mixed, in greater or less proportion, with clay and ordinary quartz sand. This is the lowest bed of the series, and forms the basis of the formations at present known in this section of New Jersey.

The area embracing the strata here enumerated, comprises the whole southern half of the state, bounded by the lower edge of the rocky strata which lie between Trenton and Perth Amboy. If we trace a slightly undulating line from a little below Trenton to the western side of the Sand-hills, and prolong it from thence to Perth Amboy, we shall have a pretty near approximation to the limit separating the two portions of the state. This southern area may be conveniently divided, for our present purpose, into three parallel sections, by two nearly straight lines, which I consider to be, as yet, only approximately ascertained. These lines enclose the "marl tract" of the state. That upon the north-western side we may venture to delineate as commencing near Middletown Point, and passing in the neighbourhood of Mount's Mills, Allentown, Crosswicks, Burlington, Moorestown, Woodbury, and Sculltown to Salem. The south-eastern line is not so well determined, but we shall trace it from the Atlantic coast, near Deal, towards Squankum, and from thence cast of New Egypt and Vincentown, past Blackwoodtown and Woodstown, to join the first line near Salem. The most western of the three divisions thus designated forms a narrow belt of scarcely more than six miles breadth, extending from the Raritan river and bay, through the centre of Middlesex, to the bend of the Delaware at Bordentown, and thence parallel to the river, as far as Lower Penn's Neck, in Salem county. The strata of this narrow belt of territory are those described in the previous summary under the heads (A.) (C.) and (D 1.) The south-eastern division, by far the most extensive of the three, is bounded by the south-eastern line of the Delaware, from Salem to Cape May, and the Atlantic coast from Deal to

the same point, and is composed of the strata (A.) (B.) (C.) and (D 1.) The middle section, or that included between the two lines, and designated as the "marl tract," will be found, I believe, to embrace the *whole series.* Let it be here distinctly understood, however, that we do not mean that the whole series in the order laid down, are assembled together in any *one place*, for one or several of the middle beds are frequently absent.

In general features, the whole of this southern region of the state is an extensive and nearly horizontal plain, the mean elevation of which above the sea is probably not greater than forty or sixty feet. It is highest in the north-east of Monmouth, where the Middletown and Nevesink hills are between 250 and 300 feet above the sea, and it seems to descend gently from this quarter and from the central division or the marl tract, on both sides, towards the ocean on the south-east, and towards the Delaware and the Millstone on the north-west. Rising above this slightly undulating plain are a number of low insulated hills of which the Nevesinks are the highest. These hills are, many of them, single detached conical eminences of regular rounded outline, sometimes having a circular base, but more usually showing an oval outline, the longer dimension of the hill, in the greater number of cases, being directed north-east and south-west, or parallel to the length of the "marl tract," and also to the strata in the upper half of the state. In other parts of the region, especially in Monmouth, these hills have the form of short ranges, with a waving outline, as if shaped by the same actions which gave form to the single conical ones. These eminences are not confined to the limits of the "marl tract," but rise indiscriminately from the general surface in all parts of the low country. One striking and invariable feature about them is, that towards their summits we meet with the brown ferruginous sandstone and conglomerate described in (D 1.), generally in solid beds, and horizontally stratified. The presence of this rock is indicated by the large quantity of fragments, most commonly rounded and water-worn, produced during the destruction and washing away of a large portion of the same stratum.

That nearly the whole surface of the region was at some former period upon a level with the tops of these hills must be inferred from our finding this sandstone stratum always at about the

same elevation, and in the horizontal position in which it was deposited, implying that the bed in question had been prolonged over all the intermediate area. We are strengthened in this inference upon observing the prodigious mass of small fragments and gravel, evidently traceable to this rock, which strews the general surface of the plains between these detached and often widely distant hills, which seem thus to be remnants or outstanding portions of a once much more extensive stratum. In geological language they are denominated hills of *denudation,* that is to say, formed by the washing away, or laying *naked,* of the strata which formed the surface of the region around them. From what quarter the mighty rush of waters proceeded which swept off so extensive a part of the upper rocks of this large section of the state, and what course it took, are questions upon which we arc unprepared to speculate, though from the prevalence of a north-cast and south-west direction in the longer dimensions of the hills, we may see a probability of one day arriving at more definite conclusions. I may enumerate as among the more conspicuous of these detached hills, the Nevesinks, the range south-east and south of Middletown Point, the two hills near Red Bank, those near Colt's Neck, the Forked river mountains near Barnagat, Mount Holly, also Arney's Mount near Juliustown, the mount at Evesham, and the Sand-hills between Princeton and New Brunswick. Many more might be specified, and in a detailed geological map of the region it would be desirable to include them all, from their being the chief repositories of a stratum furnishing the only building stone of the country.

It is not intended to assert that this brown sandstone does not occur except near the tops of the hills, for I am aware that in many neighbourhoods it may be found beneath the soil where no positive eminences or knolls exist; yet even here the rule will hold true, that the rock occurs only near the highest places. The streams of this region are very numerous, and the valleys through which they empty themselves all give evidence that they neither acquired their chief outlines or their present size from the insufficient waters which meander through them. It is on the contrary obvious to every observer, that the valleys were scooped out and shaped by the same sudden drainage which has given to the hills the configuration before described.

To have a correct conception of the relations and distribution of all these strata which occupy the three sections specified, let us imagine the materials of all except the two uppermost beds, to have been deposited or brought together in succession, *horizontally* or nearly so; and suppose that in the subsequent emergence of the whole from beneath the water, the central region including that here marked out as the "marl tract," was raised to a rather greater elevation, and exposed then or subsequently in a greater degree than the rest of the territory, to the destruction and removal of wide portions of the upper beds of the series. Such an idea is in accordance with the practically important fact, that there is a gentle dip of the lower strata *both ways,* from the centre of the marl belt. This supposed washing away of a part of the upper strata, likewise accounts for the immensely extensive superficial bed of transported sand and gravel, covering the surface in an almost uninterruped sheet over all the three sections. The middle one differs from the other two in features and resources, chiefly because the lower stratum or marl bed is occasionally *laid bare.* This slight declining of the strata from the marl tract in opposite directions; on one side towards the ocean or south-east, on the other towards the valley of the Delaware river or to the North-west, must give of course a gently convex outline to the surface of the lower beds, and must lead to the important conclusion that these inferior strata so valuable for their fertilizing contents, spread away unseen in those directions over perhaps a very extensive area. The "marl tract" might therefore on fair geological grounds, have been made to embrace a far wider area than I have thought fit for the present to assign to it; but it was deemed wiser to restrict the name to the belt of country, where in the low grounds the inferior bed—the marl stratum—is believed to be every where accessible within the moderate depth of a few feet. If what is here said of the dip of the lower beds be correct, and it is supported by the examination of a great number of localities, it becomes at once apparent, that the further we retire on either side, from the region in which the marl stratum is exposed, the less probability we have of reaching it, except by sinking to a considerable depth; and we see why, in the two districts outside of it, we have within our view only the upper beds of the series.

SECTION 1.—*District South-east of the "Marl tract."*

This large district, the boundaries of which have already been stated, may be described as an extensive sandy plain, presenting scarcely any undulations, and covered with a dense forest growth consisting chiefly of pine and shrub oak. Its average elevation is probably forty or fifty feet above the level of the sea. Upon the ocean, and Delaware bay, and river, as high up as Salem, it is skirted by a belt of marsh of variable width, often as much as five miles broad; and between this marsh and the upland sandy plain, there is an uninterrupted parallel belt of land at an intermediate level, distinguished by its clayey soil, and by a considerable degree of fertility. A number of low, insulated hills, some of them having an elevation above their base of eighty or one hundred feet, are dispersed at distant intervals over the wide and monotonous plain. The banks of the streams are very low, and furnish therefore no means of seeing to any depth the stratification of the region.

The materials of chief importance in the district, are the pure *white sands* for glass-making, *clays* for pottery, *bog iron ore* for the numerous iron works, a small tract of *calcareous marl* of the Tertiary age for agriculture, and the brown coarse *ferruginous sandstone* of the hills, for building purposes.

*White sand for Glass-making.*—The principal locality which has hitherto been made to furnish this valuable material, is upon the Maurice river, about three miles below Millville in Cumberland county. The spot has been long resorted to from various parts of state, and even from distant states, in consequence of the very superior purity of the sand, and the facility with which it may be reached. No doubt, innumerable other places throughout the very sandy district before us, would be found to yield a material equally good, but scarce any other point yet explored offers the same readiness of access. The bank presents a number of layers of the sand, more or less approximating to absolute purity; but previous to its being employed in the glass-house, it is always necessary to submit it to a careful washing, in order to discharge a small quantity of yellowish and slightly ferruginous clay, with which it is intermingled in the bank. After the washing, it is a pure transparent quartz sand of a very uniform size in the grains, which is a point of much importance.

These white sands belong to the superficial stratum (A); but

whether we are to consider them as having been accumulated by a single and violent rush of currents across the region, or by more regular and prolonged actions, occurring during a previous period which produced the Tertiary deposits of the country; we are unable, from the total absence of fossils or organic remains, and the present imperfect state of geological research in this region, to decide.

*Clays.*—Underlying the above-mentioned superficial sandy stratum, we often meet, especially in the valleys of the streams, with the blue tenacious clay and its associated beds, described under the head (C). Occasionally this deposit contains a stratum of clay, or clay mingled with fine sand, of a purity sufficient for the ordinary purposes of pottery. A material corresponding to this description occurs on the Atsion river. Many of the clayey beds are characterized by the large proportion of *copperas* and sulphate of alumine, *(alum earth)* which they possess, and which often show themselves in a yellowish crust upon the surface of the stratum. Of these clays and their contents, more will be said when we treat of them in connexion with the "marl tract."

Much additional research is called for, in order to develope the clay beds of this region, which possesses, there is little reason to doubt, much of this substance in a state of considerable purity. Time has not permitted much investigation into these deposits.

*Brown ferruginous sandstone.*—The circumstances under which this stratum occurs, have in the general way been already mentioned. It is found high up upon the sides, or crowning the tops of all the insulated hills scattered over this district; it lies in masses of all dimensions, from considerable blocks to pebbles the size of gravel, strewing the adjacent portions of the plain, and constitutes in fact in its disintegrated state, an essential part of the surface matter of the district. Being the only native material of the nature of building stone, known or employed throughout the lower section of the State; it becomes a matter of interest to ascertain and trace its numerous detached beds, so as to represent their place and extent, upon the map. It is obvious that the topography of the map of the state is not sufficiently minute for such a purpose; and it is equally manifest, that the task, however useful, would far exceed the scope and time allotted to this general survey. Though I am not able therefore to specify the localities of this rock, which

indeed are very numerous; it may be of benefit to those who are endeavouring to procure it, to mention the fact, that the higher the ground the more likely we are to find it in mass, and that it is by no means confined to the distinctly formed hills, but occurs extensively in the *higher* parts of the intermediate country. We may state, moreover, that the larger and *more angular* the loose fragments scattered around are, the greater is the probability, that the rock exists in a solid stratum near at hand. The rock consists of two varieties, the one a coarse sandstone, the grains of quartz being cemented by brown oxide of iron, giving colour to the whole mass; and the other a similar sandstone, containing in addition, small white or yellowish pebbles of quartz, giving it the character of a pudding stone. In many instances, I have found the finer grained variety to lie beneath the other, but whether this be a universal rule or not, I cannot at present say.

*Bog Iron Ores.*—Though this district is characterized by an abundant supply of bog iron ore, which sustains in fact a principal part of its manufacturing industry, I am able to say little at present on the subject, through want of time to execute all the chemical analysis essential in ascertaining the points of chief practical importance in the selection and use of this material.

The origin of the deposits of bog ore of the region before us, we can readily understand, by adverting to the very ferruginous nature of nearly all the strata of the district, both the green sand and the beds overlying it. It is the most distinctive peculiarity of the water, not only in the marl region proper, but throughout the adjacent tracts, that it contains very generally a considerable quantity of the oxide of iron, which it procures in its passage through the upper strata. Upon coming into the open air and parting with the carbonic acid, the agent by which it is enabled to retain the oxide of iron in the dissolved state, it quickly lets this precipitate, and hence the accumulations of bog ore in all situations where the low grounds are entered by springs passing out of the more ferruginous beds of sand and clay. As some of these, the marl stratum, more especially, contain occasionally a notable proportion of the phosphate of iron, we discover how it is that much of the bog ore is contaminated with phosphoric acid, imparting to it the property of producing a cold short iron. The source of the ore accounts for the interesting fact that, after being dug, the deposit

is again renewed after the lapse of a series of years. In some places, the requisite period does not exceed twenty years. It is essential to the continual deposition of the ore, that the soil in which it is precipitated should not be drained, but that it should be incessantly washed by the ferruginous springs. Where the water from these is enabled readily to escape, while the surface of the ore is laid bare and exposed to the rains, the oxide of iron vanishes almost as rapidly as it before accumulated. The lumps retain, it is true, the cellular structure of bog ore, but the matter left in them consists almost entirely of the more earthly portions, owing to the decidedly solvent power of rain water for the oxide of iron in the loosely cohering state in which it exists in the ore. The rain water seems to owe its capacity of dissolving the iron in the ore to the small quantity of carbonic acid which it collects in its passage through the atmosphere.

We derive one important hint from these facts; it is that those who are making use of this variety of ore, should avoid keeping large accumulations of it exposed to the weather as we so frequently witness at the furnaces in the sections of the state where the bog ore abounds. It should be dug, in fact, only as it is needed.

*Tertiary Calcareous Marls.*—These are highly interesting in a two-fold point of view: first, in reference to our agriculture, as occurring in the midst of a region of sandy soils where the green sand marl, lime, and other like sources of fertility are remote; and secondly, in reference to the progress of our scientific geology, from being the only *tertiary formations* yet discovered in the state, and at the same time the extreme north-eastern limit of the very extensive range of the tertiary deposits of the Atlantic border of the Middle and Southern States.

The geology of these beds is at present somewhat obscure, though the small list of fossil collections from them proves that they belong to one of the oldest periods of our tertiary class of formations. Their range is very circumscribed, the only locality of much importance being near the western corner of Cumberland county. Nevertheless, the deposit demands a brief description from its present economical value to the neighbourhood where it occurs, and the clew which description may furnish to finding a corresponding stratum in other sections of the seaboard region of

the State. The principal deposit of these tertiary marls occurs in Cumberland county, upon the upper part of Stow creek and its tributaries, but whether it extends farther through the country concealed by the superficial sands, or, what is rather more likely, occupies what was originally a *cove* or *bay* in the midst of the adjacent *secondary* strata, are points too obscure to be so soon determined. At Elwell's pits, about two miles north-west of Roadstown, the deposit shows the following features. The superficial stratum of the neighbourhood is rather coarse yellow sand, which is five or six feet thick in the bank where the marl is excavated. Beneath this, there is a layer four or five feet thick, of a reddish yellow clay, abounding in traces more or less obscure of fossil shells in an extremely rotten and decayed condition. Beneath this there is a bluish green clay containing a multitude of the same fossils in a somewhat less decomposed state, though very soft and tender. These two fossiliferous beds are in some places twelve feet thick, and rest upon a dark greenish blue adhesive sand, bearing a close resemblance in all points to the tenacious sandy clay deposit described in the summary as the stratum (C). In the bed of the adjacent bank it has the very prevailing deep brown colour of this bed, and strongly arrests our notice, from the large quantity of the *astringent* substances (copperas, &c.) which it so generally contains. The mass of loose friable clay, both yellow and green, exhibits a very considerable proportion of *carbonate of lime* derived from the decomposition of the shells: enclosing also the calcareous matter of these fossils themselves. It is a greenish marl calculated to be especially beneficial upon the very sandy land of the vicinity. It will be found valuable as a fertilizer in proportion to the percentage of lime which it contains, the crumbling state of the shells, and its freedom from sand. The description here given of Elwell's marl, will apply pretty well to the other marls, excavated upon the same streams, with this reservation however, that the shells in some localities are less rotten and in their nature less destructible. This is the case when they are oyster shells. These occur in one part of the deposit at Davis's bank ; and also in the greater number of the openings higher up the stream, where also the clay seems to possess a rather large share of sand. The important question as to which is the best marl of the neighbourhood, will be best determined for the pre-

sent by the agriculturist himself, on testing the various specimens with dilute muriatic acid.

I have accompanied this account with the following analysis of these marls carefully made, for the purpose of ascertaining for the inhabitants of the quarter interested, the relative efficacy of different marls from several localities.

In excavating marl in this neighbourhood, it is all important to avoid mixing with the calcareous stratum any of the *astringent* matter which lies immediately beneath. This is, as I shall presently show, noxious to the crop and seriously detrimental to the land. It will be known by its *taste*, and its never containing any fossils.

Another neighbourhood of nearly the same nature and geological age, occurs about a mile and a half south-east of Fairton, and near the Rattlesnake run. It is a very thin stratum of a similar bluish clay, containing a small proportion of decomposed shells, and resting, like the Stow creek marl, upon the same astringent argillaceous sand. It also is of two varieties, one containing only oyster shells and much sand ; the other being more clayey, and possessing a larger amount of calcareous matter (lime), with the fossils in a very decayed state. The deposit here being but newly brought to light, it has not been much developed, though it obviously deserves to be zealously explored.

Much of the value of a marl of this description seems to depend upon the kind of fossil shells which furnish the lime. These may be very indestructible, the case most generally with the oyster; or on the contrary so easily decomposed, as to be found generally in a chalky and decayed state, such as is necessary to constitute a good marl. The largest, and at the same time one of the most abundant fossils in the Stow creek marl, is the *Perna maxillata*, a thick, flat, pearly shell, dividing into numerous thin scales, and valuable in any marl bed from the readiness with which it decays and distributes its calcareous particles.

1. A specimen of average richness from the marl pits of Mr. Elwell, yielded

| | | |
|---|---|---|
| Lime, - - - | 25.5 | } Carbonate of lime 45.5 per cent. |
| Carbonic acid, - - - | 20.0 | |
| Greenish residue chiefly clay with some oxide of iron, - | 54.0 | |
| Loss, - - - | 00.5 | |
| | 100.0 | |

The shells in a very rotten chalky state, principally *Pernas*, and a good many small turrited univalves.

2. **A** specimen of the better variety in Mr. Davis's pits, afforded

| | | |
|---|---|---|
| Lime, - - - | 20.6 | } Carbonate of lime 36.8 per cent. |
| Carbonic acid, - - - | 16.2 | |
| Greenish residue clay and sand containing some oxide of iron, | 63.0 | |
| Loss, - - - | 00.2 | |
| | 100.0 | |

The shelly matter much decayed, consisting of *Pernas*, and *Turritella*, chiefly.

3. The Fairton marl affords from the best variety

| | | |
|---|---|---|
| Lime, - - - | 19.0 | } Carbonate of lime 34. per cent. |
| Carbonic acid, - - - | 15.0 | |
| Greenish residue of clay and sand, | 66.5 | |
| Loss, - - - | 00.5 | |
| | 100.0 | |

The shelly matter fragments of *Perna*.

The inferior variety, consisting of sand with a little clay and shells of a species of oyster in an undecayed condition, contained, in two examinations made, not more than four per cent. of carbonate of lime, after the shells were picked out.

### SECTION 2.—*District north-east of the "marl tract."*

The long narrow section lying along the Delaware river from Salem to Bordentown, and prolonged from thence across Middlesex to the Raritan bay, and which is included between the marl tract and the line tracing the limit of the older rocks, is similar in nearly all its features, and its mineral deposits, and strata, to the great tract just described as lying between the marl belt and the ocean. The chief difference of importance is the absence of any calcareous shell marl corresponding to that of Cumberland county, above spoken of. All the other materials, excepting also the pure white sand, are to be found under apparently the same circumstances. The higher grounds are covered, as in the other region, with the broken fragments of the ferruginous sandstone, indicating plainly the existence of that stratum in its regular horizontal position, wherever the elevation is at all considerable. The insulated high ground, called the Sandhills, has been adduced before, as exhibiting a pretty large expanse of surface, over which we may trace the remnants of that rocky stratum which at one time probably overspread much of the lower half of the state. The meadows and low ground upon the smaller streams possess much bog iron ore, and between Mullica Hill and Woodstown their banks occasionally disclose a stratum of very excellent *yellow ochre.*

The stratum which we almost invariably meet with throughout this section, after we penetrate through the superficial sands, is that which I have defined under paragraph (C) in the general description of the beds. It occurs here, as in the south-eastern district, in the condition of a bluish or black clay more or less sandy, and distinguished especially by its styptic taste, and its noxious effects upon the soil. Subordinate to this stratum, or more properly, replacing it and shading into it upon the same horizontal range, will be seen in many places, white or yellowish sands, and a white sandy clay. This stratum in all its more predominant characters may be seen in the various cuttings upon the Camden and Amboy rail road, and also in the "clay banks" upon the Delaware river above Burlington. Upon the side next to the "marl tract," this bed (C), which, as I shall presently show, lies above the marl, contains a sensible proportion of the green fertilizing particles of that material. It may therefore be called a *spurious marl.* Its application to the soil is to be carefully avoided, unless accompanied by the special *precautions* to be specified in this report. It is very often mistaken for the true *green sand,* or marl, from which, however, it can readily be distinguished. But the proper place for any further details on this head will be in the next section.

To the series of beds belonging to this stratum, I refer the valuable clay bed which is dug at South Amboy, traces of which exist in one or two other places in the district.

*Potter's clay*.—This highly useful material occurs in a bed several feet thick, ranging along the shore of the Raritan bay from South Amboy, for a space of about two and a half miles, to the marshes called the Cheesequakes. The stratum is nearly horizontal. Its upper surface is washed by the tides upon the beach; a mile farther to the south-east, it rises twenty-five feet above the shore, and a few hundred yards beyond this, it gently sinks again, so that two miles from Amboy it is overlaid by the ordinary dark copperas bearing stratum. There are two principal banks or quarries where this clay is procured on a rather extensive scale. In that nearest to S. Amboy, which goes under the name of Churchill's, the mass has been excavated to the depth of twenty-five feet. The lowest stratum, which is that principally employed, is a grayish blue clay, which, on drying, becomes nearly white. Besides a large proportion of pure argillaceous matter, it contains a quantity

of silica (pure sand or quartz) in a minutely subdivided condition. There are also scattered through it numerous *dark specks*, which seem to be sulphuret of iron in a state of decomposition. After the surface of this clay has been exposed for some time to the air, these specks acquire a light yellow colour, which most probably arises from the additional oxidation of the iron. It is a curious practical fact, that the clay of this bed in which these dark specks are seen, is preferred in the manufacture of the stone ware for which the material is chiefly used. Resting next above this layer there is a variegated or mottled variety, often most beautifully streaked with red, green, and other coloured blotches. This, which is called *peach blossom clay*, is mixed with the former sort to make a particular variety of the pottery. About a fourth of a mile further to the south-east is another very extensive clay bank, the property of Mr. C. Morgan. At this spot, the lowest layer which is seen above the beach, is a variegated gray sand of unknown thickness, its surface being at about the level of the tide. Immediately upon it is the bed of clay, which varies in thickness from nine to twenty-one feet. It closely resembles Churchill's in composition, and is a very superior clay for making the kind of pottery called stone-ware. In a part of the bed the clay contains a little mica in very minute scales. This is said greatly to injure its value as a material for making pottery. Other portions contain the dark specks supposed to be useful. Some bands in this portion of the stratum are reddish, and furnish the peach blossom clay. A white astringent efflorescence, most probably a double sulphate of alumina and iron, or a kind of alum, is found upon a certain layer near the upper part of the bed. This is in all probability derived from the decomposition of the sulphuret of iron, which seems to have been so characteristic a component part of the wide series of clayey strata of which this clay bed is a member. The surface of the clay stratum, though slightly undulating, is pretty nearly horizontal. Immediately upon the upper surface of the clay there is in many places a layer of sand of a few inches thickness, which here and there contains vegetable relics, such as fragments of wood completely carbonized, or in the state of lignite, and also small pieces of nearly pure charcoal. *Amber* also occurs here, being called rosin by the workmen.

Resting on the top of this is a bed of variegated sand in streaks

of white, grey, red, and other colours. This is in some place ten feet thick, and over it, at various elevations, is a stratum generally about two feet thick, of the tough dark blue astringent clay, showing a yellowish efflorescence of copperas on its surface. It contains, as this stratum very frequently does, a good deal of mica in minute scales, and a considerable proportion of common siliceous sand. This upper upper bed increases in thickness as we advance towards the meadows of the Cheesequake; and S. E. of Morgan's excavations, none of the underlying clay has been found in sight. In all probability it lies at, or a little below, the level of the beach, though it is possible that it may thin out or graduate into the dark clay that elsewhere is seen to lie above it.

On the top of the uppermost bed of sand above described, but somewhat nearer to South Amboy than the commencement of the dark astringent clay, there is a yellow and generally much coarser sand extending up to the soil at the surface. In this place its total thickness above the white clay is twenty feet at least. The materials of this uppermost layer are sometimes as coarse as gravel; and it seems to belong to the superficial diluvium, as it has an irregular undulating outline strongly contrasting with the nearly straight surfaces of the beds beneath. A similar exhibition of the diluvial sand and gravel reposing upon the other sands and dark clay here described, may be witnessed at various places upon the Camden and Amboy rail-road, and conspicuously in the banks at White Hill, where the line separating the two classes of strata is very conspicuous and *undulating*, as if the original surface of the lower bed, had been scooped out into gutters, by the currents that brought along the sand and gravel now forming the upper diluvial stratum.

There is another deposit of a somewhat analogous white clay, about five miles S. E. of Trenton, near the Albion mill, half a mile from the White Horse. Here, however, the clay is more largely mingled with a finely divided white sand, which seems to exist in rather too great quantity to fit it for making the finer kinds of stone-ware. From the relative level of this to the dark astringent stratum, I am inclined to believe that the latter here *underlies* the white sandy clay. The dark stratum has all its usual well marked features; but as the two have not been seen *in contact*, there is a possibility that they may observe the same relative position as the

corresponding dark bed and white clay do at South Amboy. To determine with certainty that the white clay holds invariably a position *beneath* the other, would be a generalization of some practical value in assisting us in further discoveries respecting this valuable material.

But we must leave this and many more such questions undetermined for the present.

### SECTION 3.—*Geology of the "Marl Tract," embracing portions of Middlesex, Monmouth, Burlington, Gloucester, and Salem counties.*

This must be regarded as one of the most important regions of the State, from its being the depository of a material endowed with the rarest powers as a fertilizing agent, spread under the soil in a quantity which must altogether defy the wants of the community to exhaust. The marl bed, though but one of several strata which occur within the territory, so much surpasses all the others in usefulness, that I have directed my examinations in the district now before us, almost exclusively to the development of that deposit. It will be understood that the lines which I have marked out as limiting the area of the marl bed or lower stratum, are not intended to designate the positive boundary of that stratum, but rather to mark the space, outside of which, I imagine, from my *present data*, that the surface of the marl descends too deep to be readily accessible to the agriculturist.

From the nature of the case, the precise depth of the deposit below the soil, must of course be imperfectly known in many portions of the tract, and I therefore wish the lines in question to be considered as only conventionally adopted to meet the existing state of our information.

It will be seen from profiles No. 3, 4, and 5, and from what has before been stated, that these two lines, loosely defining the limits of the marl tract, mark pretty nearly the division between the *true* or lower marl, and the overlying *spurious marl*, or *dark astringent clay*. As, however, the latter bed abounds over much of the area containing the true marl, and as its properties, moreover, are of great importance, I shall treat of it in this place, and shall enter upon the description of it first.

*Dark astringent clay stratum.* Wherever this bed is seen, and it may be examined almost any where upon the Camden and Am-

boy rail-road, or a few miles above the mouths of all the creeks which empty into the Delaware river below Trenton,—we find it invariably exhibiting certain very distinctive features. Usually it is a blue, deep lead-coloured, or black clay, somewhat tough and plastic when moist, and apt to bake into a rather hard mass upon drying, and to assume a light lead colour, or bluish grey. It is rarely free from a considerable quantity of common sand, often in a very finely divided state, and has also occasionally more or less mica in a state of minute division. In Maryland, a stratum in all respects analogous in composition, if not in relative position, to the green sand, or marl stratum, has been examined by Professor Ducatel, and called by him in his last Report, "Black Micaceous Sand." Its dark colour seems mainly due to a small share of carbonaceous matter, and it is not unfrequently seen to contain remains of vegetation, as carbonized wood, amber, &c. Its odour is that of marsh mud, or the ooze of the ocean. This smell is often overruled, however, by the strong odour of sulphur which it emits, in consequence, it is presumed, of the decomposition of the *sulphuret of iron*, with which it is largely charged. To the sulphuret of iron, reacting with the argillaceous matter, or the clay, we must attribute the copious quantity of sulphate of iron, (*copperas*,) and sulphate of alumine, (*alum earth*,) with which it is oftentimes impregnated, imparting to it, its characteristic astringent taste and hurtful properties. Sometimes it is of a brown colour and is then always highly astringent.

These astringent matters make themselves obvious upon the surface of the clay where it is partially dry, in the form of a light yellowish incrustation of the well known appearance of efflorescing copperas. This may easily be recognized by its strong, styptic, inky, taste. The tongue indeed furnishes a good means of telling whether the moist clay itself contains much of the astringent principle.

The bed has occasionally other colours and aspects than those here mentioned, but enough has been said to enable any one to recognize it. In many places, especially from Middletown point across to Bordentown, and thence on to the S. W. parallel to the Delaware, the stratum contains, besides the ordinary siliceous (flinty) sand, a sensible admixture of the green grains characteristic of the marl bed beneath it. These exist sometimes in a suffi-

ciently large proportion to impart a fertilizing action to the whole material; and it has been in repeated instances dug and applied as a marl, most generally through a misconception of its true nature. One result generally attends every such experiment. If employed in a very limited quantity, a temporary injury arises, though its ultimate effects on the soil are beneficial; but if used incautiously, a serious and long continued *sterility* is the consequence.

Whether or not any part of the stratum is sufficiently impregnated with the sulphates of iron and alumine, to hold out encouragement to the chemical manufacturer that copperas and alum may be procured from it in quantity, is a problem, for the solution of which, there must be instituted a number of preliminary inquiries, as well geological, as chemical. In the present state of information, I consider it to be premature to express a decided opinion, though thus far, I do not think that I have met with the astringent matter in sufficient concentration to justify any present anticipations. What a more detailed investigation might develope we cannot say.

With a view to exhibit more definitely the composition of this earth, I have submitted samples of it to chemical analysis. The following results from a specimen procured from the base of the Nevesink hills, on the Raritan bay, will show the average composition of a very abundant variety of the stratum.

Analysis of the blue Astringent Micaceous Clay:

| | |
|---|---|
| Silica, | 35.75 |
| Alumina, | 39.25 |
| Protoxide of Iron, | 12.10 |
| Sulphuric acid, | 1.95 |
| Carbonaceous matter, | 1.00 |
| Potash, | 0.30 |
| Magnesia, | 0.25 |
| Muriate of Soda , | *a trace.* |
| Oxide of Magnesia, | *a trace.* |
| Water and Volatile Matter, | 7.00 |
| | 97.70 |

That certain portions of this bed may be rendered available in enriching the soil, I entertain a strong hope. The statement already made, that there sometimes exists in it a considerable share of the *green sand*, or in other words, the fertilizing material of the marl, is enough to encourage those who may possess it, and not the genuine marl, to give it their attention. Notwithstanding the

very frequent, we may say, almost invariable occurrence, of the astringent matters, which are, in themselves, so unequivocally deleterious to the vegetation; precautions may be adopted and means used, which very possibly may make it a valuable auxiliary to the farmer, in places where the genuine marl lies remote. The recommendations respecting the mode of using it will be found in the short section of this chapter, which treats of marling.

Other details, as to the aspect which it assumes in various localities, will appear when speaking of the several places where it lies, in connexion with the true marl, in the neighbourhoods more minutely examined by me.

### THE MARL STRATUM.

*Description*.—The essential, predominant, and often sole ingredient in this bed, is a peculiar mineral always in the form of small dark grains, about the size of grains of gunpowder. Their form is roundish, and they are very often composed of two or three smaller ones united together, a distinctive feature by which they may at once be recognized from other dark kinds of sand. Though they contain on the average about fifty per cent. of Silica, (the basis of flint,) they are not gritty but can be readily bruised between the teeth, or upon the nail, and some varieties, when moistened, admit of being kneaded into a half plastic mass, like impure clay. The prevailing colour of the grains is a *deep green*, though sometimes the tint is as bright as that of Verditer. It is often a dull greenish blue, and not unfrequently a dark chocolate colour.

Though I believe that this mineral is not invariable in its composition, or in its shade of colour, yet I conceive the green to be its essential hue, and the other tints to arise frequently from a minute coating over each grain, of the clayey matters from which the bed is rarely altogether free. I am induced so to think, by finding that the action of acid for a short time upon the grains, almost invariably brings out the green, which is also produced in all cases when we *bruise* a grain of whatever external colour, upon the nail, or on a sheet of white paper. The bright green streak given, whenever a granule of this substance is thus crushed, affords us perhaps the readiest and most unerring test by which to recognize it from all other varieties of sand.

Though upon the most carefully conducted experiments I find

important variations in the relative proportions of the several component substances which unite to form this green granular mineral, yet the following analyses may be considered as presenting a fair average of its composition.

An analysis made some years ago, by Mr. Seybert, gives silica 49.83, alumina 6.00, protoxide of iron 21.53, potash 10.12, magnesia 1.83, water 9.80, in the 100 grains.

The same mineral, from a stratum at Havre, in France, has been examined by M. Berthier, an able French chemist, who reports the following proportions: silica 50, protoxide of iron 21, alumina 7, potash 10, water 11, in the hundred parts.

My own analyses of the same substance from several of the most important marl localities in the state, will be presented in a tabular shape with my other analyses at the end of this report. It will be seen that some of these marls exhibit as much as 14.5 per cent. of *potash*, and 10.4 per cent. of lime, and it must cease, therefore, to be a mystery why this substance possesses a power of fertilizing the soil, surpassing that of any material, whether mineral or animal, hitherto discovered.

Though the green granular substance here described makes up the essential and far largest portion of the marl stratum, it must not be supposed that it exists always alone. There is sometimes a very considerable quantity of clay mixed intimately among the grains, and as this is of different colours in different localities, it becomes, when it is abundant, the chief source of that variety in external aspect which the mass (called *marl*) assumes. This clay composes occasionally as much as fifty per cent. of the whole bed. Its ordinary tint is a dull blue or lead colour; it is sometimes yellowish, from the presence of oxide of iron, and again has a chocolate colour, a brown, or even a white when dry. Though it influences greatly the general appearance of the marl, it is in reality, a very inert portion of it, and must be considered rather as usurping the place of a material (the green grains) of much more active and beneficial properties.

Too large a portion of this clay will be known, by the marl being very sticky. It is to the clay in the marl, that I trace the strong *sulphureous odour* so very generally observed in it, and in this and other respects the intermingled clay seems to be identical with that which often constitutes a stratum by itself, overlying the marl and described in the previous section. It resembles it in co-

lour, exhibits not unfrequently the same astringent yellow *efflorescence of copperas*, contains a sensible share of mica and often a good deal of common siliceous (flinty) sand. Indeed this latter material white sand, is no uncommon substitute in whole or in part for the clay itself, and of course, when largely present, it has some share in determining the suitableness of the marl to certain soils.

The astringent ingredient, when present, has a much more powerful interfering influence than the mere clay upon the fertilizing agency of the marl. If copious in quantity, it not only abates greatly, by its poisonous properties, the benefits that would naturally result from the green mineral with which it is associated, but it too often has arrested or destroyed entirely, the whole crop for one or several seasons. Certain marls, otherwise excellent, have grown into disrepute in consequence, and the indiscreet use of it and of the overlying astringent clay before mentioned, has had in several neighbourhoods a seriously mischievous effect in retarding the growing spirit of experiment and enterprise in regard to the use of marl, which is, nevertheless, fast effecting a happy change in the agriculture of all this region. A specific, and it is hoped, effectual antidote will be suggested, which will render marls thus contaminated nearly equal in efficacy to the purest.

Besides the foreign matters here specified as often present with the green granular substance, there are other materials now and then associated with it whose agency is highly beneficial, co-operating to the same fertilizing purposes with the other portion.

These substances are the *carbonate of lime* and the sulphate of lime (*gypsum*) derived directly and indirectly from the numerous beds of fossil shells and other organic remains which largely abound in certain portions of the stratum. Various fossil shells and other marine remains, to the number of considerably more than one hundred species, are scattered through the marl bed. They do not occur everywhere, but are collected together in groups or *colonies*, extending in layers of a few feet thickness over pretty extensive areas. It is an error, and a prevailing one, that supposes these organic relics to be the essential cause of the highly fertilizing powers of the marl. Their presence or absence seems to have *little or no effect* upon the efficacious action of that

material upon the soil, for the marl pits containing few or no shells far exceed in number the localities where they abound, and the farmers have failed to notice any superiority in the latter. As the shells consist chiefly of carbonate of lime, a substance of well known efficiency as an improver of soils, the misconception is natural enough, where minute attention has not been given to the facts of the case. Abundant proof will be brought forward presently to show that the true fertilizing principle in the marl is *not lime* but *potash.* The analyses which have been made give us in several cases no lime at all, and where a small proportion of lime is present in the green granular mineral it is in a combined state, chemically, or in other words *originally*, united with the other ingredients, and not traceable to the organic remains which are in many of these instances not present. Besides this the quantity of shelly matter, even where the shells are plentiful, is so disproportionately small, and moreover, the matter of the shell so firm and unsusceptible of that easy disintegration and decay necessary to form a calcareous marl or to act speedily upon a crop, that the striking effects witnessed from the action of marl can in nowise be attributed to the trivial amount of lime which the shells may at times furnish to the land. Nevertheless, as some feebly beneficial effects may possibly accrue from this source, it may be of service to the agriculturist, in choosing between different fossiliferous marls, to attend to the nature of the particular fossils, and the state of more or less decomposition or change in which they are to be found. It must be borne in mind, that a large portion of the visible marl stratum is immediately overspread by a very porous layer of sand, either the superficial bed (A), or more frequently the yellow ferruginous stratum (D 2), and that this introduces to it a graduated, diffused, but perpetual supply of water, furnished to it with great regularity as from an *immense filter*. The water descends with facility through the arenacious beds above, but is immediately arrested and thrown out along the upper surface of the more tenacious marl stratum, which is, therefore, wet, and is to be regarded as the *water bearing* stratum of the region. The water percolating through the upper and more porous sandy marl, has, in many places, effected a change upon the fossils in this bed, either leaving them in the shape of mere casts, or almost entirely obliterating them. In its

descent it becomes charged with ferruginous matter, staining the shells near the upper surface of the green marl, of a deep brown colour, and coating whatever it overflows with a ferruginous incrustation. I have nowhere seen a better example of the changes which the infiltration of water can effect upon strata than may be witnessed in these marl deposits of New Jersey, where every variety of dissolving and cementing agency is in hourly operation upon an extensive scale. From the upper or *ferruginous* sand it must descend charged often with a considerable amount of the oxide of iron, as may be seen in the abundant ochreous sediment which it almost always deposits as it issues from the surface or upper part of the marl bed. It is ready, therefore, to precipitate this oxide of iron upon any substance capable of displacing it from the water, and meeting with the more soluble carbonate of lime of the shells, an interchange of materials, so to speak, arises, and the calcareous matter of the shells is dissolved and carried away, while the oxide of iron takes its place. Hence we often see the shells of a deep yellow or brown colour, and upon inspection they are found to consist less of carbonate of lime than of oxide of iron. In such case they are to be regarded as wholly inert upon the soil, as in fact so much useless matter, usurping the place of a far more serviceable substance, the green marl itself. But this is not the only change which seems to have been effected in the foreign materials of the marl bed by this unceasing infiltration of water. I have before alluded to the peculiar composition of the overlying dark blue astringent clay; to the fact that it frequently contains a sensible quantity of the sulphate of iron or copperas, and that both this clay and its astringent impregnations are very often present in a greater or less degree, intermingled with the granular marl itself. Now the water from either of these sources must dissolve in its passage a considerable quantity of the copperas (an easily soluble substance), and where there are shells or other calcareous fossils, it must carry with it a portion of the carbonate of lime derived from them. These two substances coming together in a state of solution, a chemical reaction, of course, ensues, both the sulphate of iron and carbonate of lime are decomposed by the mutual affinities of their ingredients, and the result is a precipitation of the oxide of iron of the former, and a combination of the sulphuric acid and the lime to form sulphate of lime or *gyp-*

*sum* (plaster of Paris). That such is the *modus operandi* is apparent from our finding, in so many cases, a sensible amount of gypsum, either in the earthy state or in minute crystals intermixed with the marl; and besides from our observing that when the gypsum is in greatest plenty, we can most generally discover a strong sulphurous odour coming from the marl, an evidence, upon grounds before explained, of the existence of sulphuret of iron undergoing a conversion into the *sulphate* of the same, (copperas). It will suggest itself at once to every one, that the existence, even in small quantity, of so potent a stimulant to vegetation as gypsum or plaster, must have a powerful influence in adding to and modifying the useful properties of the marl containing it. It is of some consequence, therefore, to the farmer that we request his attention to the facts and explanations here stated, so as to assure himself of the probability of finding this valuable material in the marls of his vicinity. When the traces of shells are very numerous in the bed, and their conversion into the sulphate of lime has happened on the large scale, I have seen the gypsum forming a conspicuous part of the soft white clayey matter derived from the shells and interspersed among the green grains. The mixed mass of carbonate and sulphate of lime is then usually in a yellowish white *chalky* condition. Sometimes we may detect the gypsum in the marl in the shape of small regular crystals of transparent selenite, at times so minute as only to be detected by the magnifier. Where a heap of the purer variety of the marl, or that consisting of little else than the green granular mineral, has been exposed for sometime to the air until it has become partially dry, it acquires externally a lighter grayish hue, caused *sometimes* by the exterior grains becoming incrusted with an efflorescence which, from several examinations and anylyses that I have undertaken, I conclude to be also sulphate of lime (gypsum). This will serve to explain why the preference is so usually given to that marl which contracts this chalky coating. Yet it must not be inferred from this, that the sole efficacy in the marl is owing, as some persons suggest, to the gypsum which I have shown to be so frequently present. The comparative inertness of plaster upon the sandy soils of parts of the region where the marl has never been applied, as in several places near Salem, is a fact in itself sufficient to overthrow this notion, even if it were not true that

very many marls are endowed with the highest capacity to fertilize the soil which do not contain gypsum in any one of the above several shapes.

The oxide of iron, the source of which I have endeavoured to explain, is frequently so abundantly introduced into the marl stratum, as to play the part which it so extensively performs in nature, of a *cement*, binding firmly together into a semi-rocky mass, the particles with which it is in contact. When this occurs, the marl is often rendered too hard to be excavated by the ordinary implements. The marl, indurated or solidified from this cause, is most commonly in the form of large round concretions, from the size of a bushel to that of a barrel, lying in horizontal layers, generally near the top of the stratum, with the masses at various distances asunder. These masses thrown out and exposed to the frosts of a winter, most usually crumble down into the friable state so essential to form a useful marl; and the material seems to be not in any way impaired in its virtues, from having been united in such firm cohesion. When the cementing action has proceeded farther, a regular stratum of indurated marl-rock exhibits itself. Such may be seen in some portions of the cliffs on the bay side, in the Nevesink hills; large blocks of it strew the beach, and offer some beautiful specimens of a fine brownish green rock, in which the green granules are dispersed through a cement (or paste,) deeply coloured by oxide of iron, the whole exhibiting a very pleasant contrast of tints.

Such seem to be the more important changes which the materials of the marl stratum have undergone, subsequently to their original deposition, and they are dwelt upon in this place the more especially, as a correct knowledge of their nature is fraught with applications all important to those who are interested in the use of marl as a manure.

What the total thickness of this widely diffused bed of green mineral is, it is by no means easy to ascertain; as, from the large supply of water which it holds, the pits that are sunk into it in search of the marl, become so wet by the time a depth of twenty feet is reached, that they are scarcely in any instance carried below that limit. From one or two instances which have come to my knowledge, where the bottom of it has been reached, in wells for example, it will be safe to fix its probable depth, at least for

certain neighbourhoods, at thirty feet; but I am far from supposing that its thickness is uniform. A natural and important question here suggests itself: Is this bed, which is penetrated for marl in numberless places, over almost every square mile of the "marl tract," to be viewed as a single and uninterrupted stratum, extending beneath the whole area; or may we suppose that the layer of green mineral may disappear and re-appear irregularly, and constitute several beds occupying nearly the same horizontal plane, but lost in intermediate places by tapering away in thickness, or by becoming so far deteriorated from a superabundance of foreign matter, as to preclude our recognizing it as a portion of one continuous deposit? My present conviction is, that the former conjecture is the correct one; and that let us sink a well wherever we may in the region, if we but go deep enough, we shall encounter the marl under all its ordinary characteristics. To this however, I venture to enter one exception, which relates to the outskirts of the tract, especially upon its North-western side. Here, as previously intimated, the *lower part* of the dark astringent clay where it has been reached, is found to be replete to a certain moderate extent with the green grains; and whether such portion of the stratum may be considered as an extension of the lower marl, under a deteriorated form, or merely a layer of the upper clay shading into the other, which must then lie still lower down; are points which, though admitted to be of extreme consequence to that belt of country, I have not yet succeeded in determining positively, simply through want of time, and the means for making the requisite borings. My impression and belief is, that outside of the "marl tract," the true green sand stratum occurs at no great depth below the surface of the blue clay or spurious marl, in which the diggings all at present terminate.

It will be seen from the details which are to appear presently, that over a pretty extensive area throughout the eastern part of the marl tract in Monmouth, Burlington and Gloucester, the stratum comprises very generally two varieties of the green sand, distinct as to colour, and holding invariably the same relative position to each other. The uppermost layer, where it appears (for it is not always present,) is of a light glowing green, very nearly of the hue of the green paint called *verditer*; while that beneath it, is the common dark variety, of a dull bluish green, or sometimes of a dull blue itself.

I have here described the green sand stratum in nearly all its essential and distinctive features, leaving the local and rarer circumstances which attend it, to be noticed when I detail, as I shall do presently, the nature of the deposits in a number of places which have been visited by me throughout the region. But in giving a large space in this report to the bed in question, in consequence of the high importance which attaches to it as a source of fruitfulness to a wide neighbouring territory, it must not be forgotten, that there are in immediate connexion with it, several other strata, which, both by their positions and their fossil organic remains, prove themselves to be all closely related deposits, belonging to the same group, with the green sand or marl bed.

The first of these is the yellowish sandy stratum marked (D 2) in the summary, and seen to constitute a very general capping to the marl, through a great extent of its range. It is always more or less ferruginous, is invariably very sandy, but occasionally contains a small admixture of a yellowish mottled clay, visible in several districts in Monmouth, more especially in the township of Middletown. Upon Crosswick's creek, the bed is sometimes slightly calcareous, and may be seen to abound in organic remains, always in the form of solid casts, composed chiefly of carbonate of lime. It here suggests itself, that lime enough may possibly exist in the lower portion of this mass in certain localities, to give it an additional claim upon our attention; especially as I shall show, in speaking of marling, of how much importance even a small quantity of that earth may be in many portions of the "marl tract." In some sections, the stratum contains a rather copious share of the *green grains* mixed through the other sand. When this is the case, and as often happens, the true marl beneath it is not readily accessible; I recommend it as a substitute, in the anticipation that it will be found by no means inert as to fertilizing properties. But it should be applied only to lands so stiff from an excess of clay, or so sandy, naturally, as not to be deteriorated by the addition. In Burlington county more especially, the colour of the roads is in many places of a decidedly greenish olive hue, in consequence of the presence of the green mineral in this overlying sand.

LIMESTONE OF SALEM, GLOUCESTER AND BURLINGTON COUNTIES.

Another stratum connected with the great deposit of green sand, is a narrow and very thin calcareous formation reposing immediately above and in contact with it, and traced by me, at regular intervals, from near Salem to the banks of Crosswick's creek. This rock is usually a soft coarse-grained yellowish or straw-coloured limestone, with a structure varying from sub-crystalline to coarsely granular, often replete with organic remains, the disintegrated shells and corals and other fossils, composing a considerable portion of the mass of the rock. Much of the rock contains impurities in the shape of sand, clay, and oxide of iron; and its value as a limestone is therefore very variable. At times it is little else than a sandstone, in which the sand is cemented together by a trace of lime. A good deal of it occurs of this character in loose rounded masses, resting above the marl, at Woodstown. Again it occurs as a pretty firm calcareous rock. This is its state in some places near Salem, in Mannington township. In the table of analyses, the composition of the leading varieties of the rock may be accurately seen. This limestone is no where to be seen in thick massive strata; on the other hand, it occurs only in thin horizontal beds, or irregular layers, not often more than six or eight inches thick, and commonly separated by a thin parting composed of sand and carbonate of lime in small grains, to all appearance an incohering mixture of the same materials that form the rock itself. The more calcareous beds have not unfrequently a pretty close resemblance to some of the thin oolitic strata of England, in consequence chiefly of the *granular form*, in which much of the carbonate of lime is present in the rock, together with the innumerable fragments of fossils which sometimes assist in forming almost half the mass. Persons inattentively looking at this rock will be apt to pronounce it much more sandy than it actually is, owing to some of the carbonate of lime being in the shape of small round yellow grains, like those of sand. Occasionally, especially near the bottom of the stratum where it adjoins the marl, it contains a greater or less proportion of the green grains of that bed, and in such abundance as to unfit it for being burnt into lime, the potash and other fluxing ingredients of the green mineral, appearing to vitrify it and form a kind of slag.

The general range of the stratum extends from a little north-east of Salem, past Woodstown, the White-horse, Vincentown, and New Egypt to Prospertown; beyond which I have been as yet unable to recover a trace of it. But it is not to be inferred that it exists as a stratum of any conspicuous extent or importance throughout all of this long line. It has hitherto been detected at distant points only, and nowhere but in Mannington, Salem county, does it cover any wide area, or possess more than a very insignificant thickness. It lies along the south-eastern verge of the visible marl tract, and if it dips* at all, it is towards the south-east, to underlie the ferruginous sandstone. At its greatest width, about four miles north-cast of Salem, it can be recognized over a breadth of three-fourths of a mile. Its thickness in the same neighbourhood, as proved by a well sunk through it, is as great in one spot as twenty feet; though elsewhere in the vicinity it is not more than six or eight. Near Vincentown it seems to be still less, and upon the branches of Crosswick's creek, it is reduced to less than one foot, though still preserving its prevailing structure and position so plainly, that no uncertainty can prevail as to its identity throughout.

In point of relative age to the lower fossiliferous portion of the sandy stratum previously described, I conceive the two deposits to have been formed *contemporaneously*, and to differ in no respect but in the relatively greater or less share of calcareous matter and sand, which the waters precipitated immediately after the deposition of the underlying green marl, had ceased. I am led to this conviction by finding the north-eastern termination of the limestone to be the quarter where the calcareous or lower layer of the sandy bed (D 1) most prevails; and by perceiving that both masses abound in fossils closely analogous, that they both hold the same position directly upon the top of the green marl, and that they are both mixtures of the same elements, sand and carbonate of lime; the only difference being a larger share of the latter in the one case, and a consequent solidification of all the component substances into solid rock. Upon this view, all that we have to consider in regard to the difference in the origin of the deposit

* *Dip,* when a stratum does not lie horizontally, but is inclined; the point of the compass towards which it sinks, is called the *dip* of the stratum, and the angle which it makes with the horizon, is called the angle of dip or inclination.

in the two districts, is a progressively increasing deposition or precipitation of the carbonate of lime towards the south-west portion of the marl tract. This rock is destined to prove of signal service to the soil, and to the agriculture of all the region adjacent to it; for lime is particularly precious upon lands so entirely destitute of calcareous matter, as are those of the more sandy tracts of New Jersey. The lime from this rock in Salem, is growing rapidly into use. I would also recommend—as promising to prove highly beneficial—the soft, friable, unconcreted parts of the stratum which lie between the solid layers, especially that next the bottom. Being already in a pulverulent state, and composed chiefly of carbonate of lime, with occasionally some of the highly active grains of the green marl, the whole must constitute a *calcareous marl*, admirably adapted to ameliorate permanently the land of the surrounding country.

Were I willing to generalize from so small an assemblage of observations, as a single season has furnished, it might not be difficult to establish the existence of another deposit containing fossils of the marl stratum, and to show it to be a subordinate member of the general group. I allude to a series of siliceous sands, both loose and in the form of rock, which there seems some evidence to suppose lies *yet lower* than the true marl. The principal exposures of this are upon Crosswick's creek, near Varmintown, and also between Arneystown and Hornerstown. The most remarkable portion of the mass is the rocky stratum, which seems to be an almost purely siliceous sand, loosely aggregated, either by oxide of iron, in which case the mass is stained brownish or yellow, or by a minute portion of carbonate of lime, when its colour is a light gray. It is very fossiliferous, but possesses but little variety in the species of the fossils, almost the only shell being the *ostrea falcata.* This may sometimes be found very perfect, but more commonly exists in the state of an impression on the rock, the calcareous matter having long since been dissolved away by the filterings of the highly porous stratum. There is also a thin bed of the dark astringent clay between these sands. The reason that I am still dubious respecting the position of these arenaceous (sandy) layers to the green marl, is partly owing to the strong resemblance between the above fossiliferous sandstone, and the fossiliferous ferruginous

sandstone, which lies near the top of the overlying sandy stratum in the Nevesink hills; and which it will be remembered, is characterized by containing a profusion of the *ostrea falcata* in the form of casts, with little else in the nature of organic remains. The few data which 1 gathered upon the subject, will appear presently in discussing the several marl localities; but I view them as too imperfect to qualify me to form a decided opinion regarding this question of age or relative position. Several minor variations in the stratification of the whole fossiliferous group, embracing the marl or green sand bed, prevail over areas more circumscribed than the range of the great strata above specified; and it will be sufficient to mention them when speaking of the respective neighbourhoods where they occur.

It is of little importance to the practical purposes of the present report, to enter upon any details respecting the numerous highly curious fossils which abound in the formation, of which I have here given a general description. The most fossiliferous beds are the green sand or marl stratum itself; and the limestone, and marly, and calcareous sand which so generally repose immediately upon it. The fossils from these deposits, together with others from some equivalent formations in the Southern states, are described with the requisite details in an interesting work devoted expressly to the object, by Dr. Morton of Philadelphia. This highly esteemed contribution to our Geology, is entitled "Synopsis of the organic remains of the cretaceous group of the United States."—1834.

To that source I must refer for much specific information respecting the individual fossils of the marl group, which it would not be in place to offer here. I may be allowed however, to indulge in a few generalizations calculated to be useful, by imparting more just notions than commonly prevail, touching the nature of the fossils, and the relative age and origin of the strata in which they are imbedded.

There have been found up to the present time, in the marl and the deposits connected with it, relics of from seventy-five to eighty races of animated creatures; of these at least seven are of the class of large reptiles, including three species of crocodile; two belong to fishes, one to a tortoise, and one to a wading bird; while of the other fossils, upwards of sixty-five are remains of

shell-fish, corals, and other marine tribes low on the scale of beings. Now it is a curious, and to science an important fact, that *not one* of the fossils of this catalogue can be traced to belong to anything living in the present day; and it is scarcely less interesting to know, that comparing the fossils here found with the organic remains of the most nearly related strata of Europe, we discover but one of these lost species, the *Pecten Quinquecostatus* to be common to the deposits of both continents.

The first fact determines the place of the marl group to be somewhere among the secondary rocks, and the generic relationship of the fossils to well known fossils of the green sand and chalk formations of Europe, makes us naturally look at that part of the secondary series of formations as the most probable place to which we should refer them. The striking want of identity between the species, as shown by the second statement, renders it, however, a question of much uncertainty, to what precise part of the secondary series of Europe these deposits most nearly conform.

To refer the production of the marl strata of New Jersey to the same period which produced the green sand rocks of Europe, merely in consequence of their both containing the green granular mineral, and to their having, moreover, a general resemblance in their fossils, is to commit the decision of the question to far too loose a mode of reasoning. Received principles of geological investigation requires us rather to consider our own deposits as having originated during a somewhat different epoch from that which produced the green sand formation of Europe.

As therefore the title *green sand formation* is pre-occupied by a group of strata in Europe, between which and those of New Jersey, I am far from foreseeing that we shall be able to establish any close identity of period, either by their mineral structure or their fossils, I deem it unwise to confer upon this formation that name which otherwise from the prevalence of the characteristic green sand throughout its strata, it might seem so fairly to claim.

The term *cretaceous* (containing chalk) applied to this group of beds in this country, is objectionable upon the same grounds, and for another reason no less cogent, that thus far no true chalk has been discovered in the United States.

I prefer for present purposes the simple title of *secondary* "*green sand marl*" stratum. These deposits of secondary green sand marl have all the aspect, both from the unequivocal indications given us by the nature of their fossils, and the character of their mineral contents, of having been deposited upon the bed of the ocean in places where the sea encompassing the coast was *shallow*, like that which now exists over the wide belt of shoals and soundings in front of our Atlantic coast. The habits of the animals whose remains are found, and the tokens of land derived from the coarseness of the sands, and the remains of terrestrial vegetation, are proofs of the correctness of this idea. The green granular mineral or marl must be regarded as a *chemical precipitate* thrown down from solution in the waters of that ancient sea, and not a sediment of sand mechanically carried out from land, as must have been the case with the silicious sands adjacent to it. But what may have been the condition of the waters, holding in a dissolved state so singular a mineral, and what the unexplained action which in a seemingly brief time precipitated so thick a stratum, are questions which must be left for perhaps a more advanced state of chemical science to elucidate. Some further views and reasonings respecting the condition of things attending the origin of these deposits, with a few comparisons between them and the strata of a nearly corresponding age in the southern part of the United States, will be found in a report on the geology of North America which I communicated, by request, to the British Association for the advancement of science. The report, as far as completed, will be found in the fourth general report of that body, published in 1835, London.

## DETAILS RESPECTING THE PRINCIPAL EXPOSURES OF MARL EXAMINED DURING THIS SURVEY.

For the sake of affording as much local and detailed information as possible of the several neighbourhoods which it was in my power to explore, and for the purpose of exhibiting the numberless varieties of aspect under which the marl and its subordinate beds display themselves, I shall in this place bring forward from my journal a number of concise descriptions of some of the more important localities which I have visited. After the gene-

ral account of the marl above given, the particulars about to be stated will serve both to confirm what has been advanced, and to show several minor and local peculiarities in the strata, calculated ultimately, if not at present, to be of essential importance to the agriculture of their respective districts. I offer these details as showing only some out of many spots explored, and though a very large number of marl pits and natural exposures of the strata remain to be studied before a thorough report upon the "marl tract" can be furnished, yet the various descriptions about to be given will suffice for all the purposes of the general survey which has been authorized.

I shall follow pretty much the systematic order in which I traversed the marl region, which was from its north-eastern extremity upon the coast of the Raritan bay towards the south-west to Salem. Many sections of the tract were necessarily omitted, but the places not explored were more frequently in the interior of the region, where fewer new and important facts of a general kind were to be ascertained, than adjoining the limits or outskirts of the marl to which my more especial attention was directed, for the purpose of ascertaining its true boundaries and discovering its relations to the other strata.

## DETAILS OF THE MARL TRACT.

We commence with the township of Middletown in Monmouth county. The north-eastern corner of the marl bed, or rather the portion thus far traceable, seems to be somewhere near Middletown Point. On the borders of the Matavan creek, near Middletown Point, there is to be seen beneath the sands a dark clayey stratum, much resembling that above the clay at Morgan's, but containing a small portion of the green sand grains, and in places much mica. This is very like the clay at the base of Nevesinks, on the west side going from the little place called Chapel.

It is not to be regarded, however, as the most western edge hitherto seen of the strata in immediate connexion with the marl, for a similar bed occurs on the Manalopan near Mounts. No marl is known near Middletown Point; but I think it probable that sinking a trifling depth would bring one to it. This is the many variety of the astringent clay. It appears in several

places on the borders of the creek. The overlying bed is often quite clayey of a buff hue and solid texture when dry, which is so frequently the character of the upper stratum of the marl region. South of Middletown Point there is a range of hills of considerable size omitted entirely upon the map. They are distant about three miles.

These hills are within the marl limit. Their general direction is north-east by north and south-west by south, and they extend from opposite Middletown Point to Conovan's near Buck's. Opposite Middletown Point, and about three or four miles from Middletown, they make an elbow to the east stretching away to the head waters of the Nevesink river, and they are in no way connected with the Nevesinks, being separated from them several miles by a wide plain or valley and one or two outlying knolls.

They are rather irregular and seem to be hills formed by extensive denudation. A low outlyer or spur crosses the road south of Mount Pleasant. The termination of the hills is on Conovan's farm within half a mile of the Dutch church. The most northern point where the marl is opened in this vicinity is at J. Morgan's, near Mount Pleasant. Marl occurs near the Matchaponix, not far from the *rail-road*, on land of a Mr. Johnson. This is even more to the north-west or west.

There is marl not far from J. Morgan's, at Mr. Castlereagh's on the north base of the above-mentioned hills. At Conovan's, we are in the midst of a highly fertile marl tract. The country is rather plain, or gently undulating and extensively intersected by low flat valleys of denudation, or by meadows which are furrowed out down to the marl stratum, and in some cases twelve feet into it.

The soil is mostly a loamy clay sometimes sandy, and not often more than thirty feet higher than the top of the marl. The top of the marl is a sandy stratum, containing a trifling share of the green particles and much ferruginous matter which, in some cases, by filtering down, has produced a change on the upper part of the marl bed to the depth of a few feet, dissolving out the shells and replacing them by oxide of iron. The thickness of the marl bed is not known, but perforations twenty feet deep have not penetrated through it. Its general aspect when moist

is a deep blue, or black; when dug a light blue, or gray. The lighter kind contains more clay, which is of a dove colour, and sometimes a light gray, or white. The tint of the grains is a dark olive green, almost black, and in this quarter rarely a light green. Sometimes the clay exceeds in quantity the green grains, and this in marls which are regarded as being very active. Those varieties which hold the lowest reputation I find invariably to contain either a quantity of silicious (flinty) sand, or mica (isinglass).

The fossils are Exogyra costata, Gryphea convexa, G. Mutabilis, Ostrea falcata, Belemnites Americanus, Terebratula, Spine of Cidaris, Teeth of Shark, and Vertebra; of Crocodile.

When the marl dries the surface is sometimes covered with a white or gray incrustation. When moist, the black marl often exhales a sulphureous odour, and in one case the white efflorescence had an astringent sweetish taste, indicating it to be in part a *sulphate of alumina.*

The marl in this quarter, has been known and used as a fertilizer for forty years. It is applied very profusely; one hundred loads to the acre, or even more, being no unusual application. The improvement is very permanent, changing the natural growth from *Indian grass* and *five finger,* (or cinquefoil,) to fine white clover. White alder, and other plants of rich soils, abound in the marl meadows.

The natural *timber* of this, like most other parts of the marl tract, consists of several varieties of Oak, Chestnut, Locust, Beech, Maple, Dogwood, Hickory, Liriodendron or Tulip Poplar, &c.

The ferruginous conglomerate, strews the surface of the hills which bound the tract in question, on the northwest, but it does not seem to exist in this vicinity. I have little doubt that it is *in place* on the tops of the hills between Middletown Point and Middletown. In this township of Freehold, no calcareous stratum, like that near Vincentown, seems to exist. The following results of analysis, exhibit the composition of the marl in this vicinity.

Analysis of a Green Sand Marl, from the farm of John Smock, Freehold township, Monmouth county. One hundred grains yielded:

| | |
|---|---|
| Green Sand, | 90.00 |
| Coarse Siliceous sand, | 2.00 |
| Ash coloured clay, | 3.00 |
| Water, | 5.00 |
| | 100.00 |

One hundred grains of Green Sand afford:

| | |
|---|---|
| Silica, | 51.00 |
| Protox. Iron, | 25.10 |
| Alumina, | 7.50 |
| Potash, | 9.30 |
| Lime, | *a trace.* |
| Water, | 6.50 |
| | 99.40 |

The marl is known as far to the west, towards Englishtown, as one and a quarter miles east of the Presbyterian meeting house.

At Ely's mill the marl is very impure, being almost entirely composed of silicious sand, and doubts exist with me whether it belongs to the marl bed, or the overlying clay.

At Mr. John Johnson's Nut swamp, the marl consists towards the top, of the usual ferruginous yellow clayey bed, containing a small portion of the dark grains. This is not used, but is pared off to a depth of two or three feet. Next to this comes the dark marl, nearly black when wet, and rather hard in the bed, from the quantity of ferruginous matter which cements it. It crumbles on exposure, and becomes gray or even white, from the efflorescence which collects upon it. In it are large roundish masses of the marl cemented into firm stone by the oxide of iron. These, however, crumble down in time by exposure. In these beds the siliceous sand is very little in quantity. The top of the bed is the richest in green sand; lower down there is more of the dove-coloured clay resembling precisely the clayey marl at Conovan's. (The vertebræ of a species of reptile have been found here.)

On Porricy brook, upon the road to Middletown, there occurs a fine exposure of the marl. It seems to be very thick and is covered by the yellow ferruginous sandy marl, which is seen again half a mile south of Middletown, in the meadows. The black marl lies beneath.

At Middletown, only the upper yellowish, or ferruginous bed is seen, the black, or more correctly the green sand marl, not having been reached, though there can be no doubt of its existing at a small depth every where in this vicinity. This upper portion of the marl stratum contains a considerable share of the green grains, but mixed with much ferruginous clay and sand of an orange or variegated yellow hue. This orange and many-

coloured clay is distributed in streaks and blotches, giving to the smoothly cut surfaces of the bank an aspect somewhat like that of a decomposed granite or conglomerate. It is a curious question how the ferruginous clay could thus arrange itself. This upper stratum is inferior to the dark green marl, in fertilizing effects, though it is used with excellent results in many places near Middletown.

Mr. Johnson stated to me some interesting facts, proving the utility of the marl. Land which bad been sold at two and a half dollars per acre, in consequence of the permanent increase in its fertility from the marl, is now worth thirty seven dollars the acre.

Between Middletown and Chapel, Jonathan Tunis has penetrated into the lower green sand marl, and uses it in preference to the yellow top bed, and with great advantages to the crop.

Chapel, is upon a flat hill or table land; and a well near this place dug seventy-four feet through the upper strata, did not reach the marl, though it shows itself, near the surface, in all the surrounding low grounds, and is of very good quality.

The hills are sandy and strewed with fragments of the conglomerate, which is also in place and quarried, half a mile south of Chapel.

The timber growth on the hills contains a pretty large mixture of cedar.

The marl extends from Chapel north towards the Bay shore. almost as far as the permanent land itself extends. Richard Wallin has reached it in digging a well; it was seven feet below the surface, and was penetrated fourteen feet. Mr. Anderson, within half a mile of the shore, also has a marl pit. The dark green grains abound in the sands of the beach, and every where as we pass along the road from Chapel to the Bay shore, towards the east.

Mr. Loughborough's stone quarry, half a mile south of Chapel, shows a good exposure of the upper conglomerate in a solid stratum. It is on the north-west slope of a hill, and the rock dips west-north-west, at an angle of fifteen degrees. It is a hard conglomerate, with a prodigious quantity of the oxide of iron as the cement. The pebbles consist of transparent quartz, from the size of a pea or hazel-nut down to coarse sand. There is another quarry in the same vicinity, owned by Mr. Corman. The height

of the table on which Chapel stands is probably two hundred feet, the surface declining on all sides.

*Bay shore and cliffs of the Nevesinks*.—The marl appears to extend to within a short distance of the Bay shore near Compton creek. The first cliffs which we meet with on going along the shore to the east, exhibit a dark stratum, chiefly clay and silicious sand, with mica, containing very little of the marl, and often a considerable share of the copperas, showing itself upon the surface, in the state of a yellow efflorescence. Tracing the base of the cliffs, as they swell in height we see this stratum slowly rising and forming the lower stratum along the beach, nearly the whole way to the termination of the highlands at the Telegraph hill.

In some places the cliffs have a height of fifty or sixty feet, composed of several different beds, all containing more or less of the marl; but some of the layers are chiefly made up of silicious sand, and clay, and ferruginous matter. Over the dark lead-coloured silicious clay, a stratum of the sand is seen, often green, though for the most part silicious or flinty. High above this the true marl is seen in many places, and may be known by its *white* efflorescence. Above the marl, the dark silicious clay or copperas-bearing stratum is again *repeated*, and on the top of this, there is sometimes a bed of consolidated ferruginous sandstone, frequently so full of oxide of iron, as to be in fact a poor iron ore.

Analysis of the Arenaceous (sandy) Hermatic Iron Ore, from the cliffs of the Nevesink hills.

| | |
|---|---|
| Peroxide of Iron, | 70.10 |
| Silica, | 11.25 |
| Alumina, | 4.05 |
| Water, | 13.55 |
| | 98.95 |
| Loss, | 1.05 |
| | 100.00 grains. |

It is either compact, or has the honeycomb or cellular structure, upon a most prodigious scale; great tubes run through these masses almost of the dimensions of a cannon, and what strikes one particularly, is the horizontal position of the pipes and plates

of the ferruginous stratum, showing that mere infiltration downwards, did not produce them, but that they have arisen from some other peculiar mode of concretion. This bed rests near the top of a stratum of ferruginous sand, which indeed sometimes replaces the ferruginous rock, the thickness of which may be ten feet; that of the whole stratum, of which it is a part, is perhaps thirty feet. Where the cliffs are high, the conglomerate is seen in its natural place, over the top of all. Near the top of the marl bed may be seen the large globular masses of indurated and cemented marl, like that found before at Nut Swamp. They here possess the hardness of a true rock and do not crumble. The freshly fractured surface is often very beautiful, showing the green grains of marl distributed through a cement of argillaceous red oxide of iron. The globular masses are seen in horizontal layers in the marl, and they strew the beach pretty thickly. The blocks of the horizontal iron stone are often of several feet diameter. Sometimes the consolidated ferruginous masses of the cemented sand are the size of a small apartment.

In several places beneath these cliffs of the highlands, vast masses of the strata have subsided by the undermining action of the water passing through the lower beds, and they form an *undercliff* or landslip with a steep pitch towards the land, bringing down into nearer view the top strata, the upper ferruginous sands of which, owing to the condition of their oxide of iron, are of a most beautiful reddish colour.

At the shore beneath the Telegraph hill on the ocean side, the lower dark astringent stratum is seen at the water's edge, the piles in the foundation of the wharf, in front of the Telegraph tavern being driven into it. Some portion of this bed is said to be marl, and the green grains abound every where *among the sands of the beach*, as they do at Long Branch, a few miles more to the south, and indeed the whole way from the commencement of the Nevesinks along the bay shore, and thence along the sea-shore to Deal, and even beyond.

Tracing the cliffs round the Telegraph point to the mouth of the Nevesink river; the lower or marl-bearing strata are covered up by a steep talus or inclined bank of fallen matter at the base of the cliff, reaching thirty or forty feet up. Above, are the yellow

sands, covered by a layer of the cellular iron stone several feet in thickness, being beautifully seen at the Devil's chimney. Above this there is a very ferruginous, brownish consolidated sandstone, full of impressions or casts of shells, especially *ostrea falcata.* It seems to be a more ferruginous portion of the stratum (D 2). A little above this at the height of eighty or ninety feet, is a bed a few feet thick, of a bright *green clay*, apparently the same material as the light green variety of the marl, in a massive and not granular condition; it includes a few indistinct light green grains. Over this again and towards the top of the hill, the fragments of the conglomerate abound, and there is every reason to believe that all the hills near Mr. Hartshorn's, at the mouth of Nevesink river, are capped by the conglomerate in place.

Along the North bank of the Nevesink river, at Mr. Hartshorn's, the stratum which is on a level with the beach is the copperas-bearing dark clay and sand. It has been found by him to be hurtful to the soil when applied thick, still as it contains a very considerable share of the green grains, it is probable that applied in a lighter dressing, it might prove somewhat beneficial. Exporting this marl from the Nevesinks, has tended to injure the credit of the true marl for agricultural purposes.

There is no good marl from the mouth of Nevesink river up as high as Claypit creek, above which as far as its head, the marl extends on the north side and is generally very good. The other or astringent stratum beneath the marl, sometimes takes its place in the banks on the water's edge.

It should here be mentioned that in the bed of ferruginous sand, in the cliffs at the mouth of the Nevesink river, there are numerous hollow concretions, being the brown ferruginous sand, cemented by the oxide of iron. Some have the shape of bottles, gourds, flasks, and hollow balls or bombs; and what is curious, all are full of white sand, the ferruginous particles seeming to have been withdrawn from the sand within, during the formation of the concretion. Ascending the Nevesink river, no good marl occurs below the west side of Burge's or Claypit creek, where it is of excellent quality; from thence to the next or Redneck creek, the impure astringent kind prevails; on the west of the creek, the bed at the water's edge, is again the true marl, being like Burge's. The deleterious variety abounds in ordinary sand and mica, and

has an excess of oxide of iron and the copperas efflorescence, and seems to be in fact the same stratum as that upon the bay shore under the Greenland banks, in the Nevesinks.

We may trace the marl to Crow's creek; approaching which it becomes very green and good. Here and farther east it lies below the layer of nodular indurated marl before seen on the bay shore, on top of which is the micaceous sandy bed containing copperas. In one place on the very beach, the marl has been dug and exported to Barnagat, for sixty-eight cents the load of twenty bushels.

On drying this marl, it assumes a light green colour. The spurious bed almost invariably presents the yellow astringent efflorescence, and is evidently a different layer from the good marl, and there seems to be no good reason to doubt that this shore if examined, would every where display *both* beds; the bad marl above, the nodules next, and below all, the pure green sand marl.

The reason that the stratum at the water's edge in the banks of the Nevesink river is sometimes the true marl, and at others the dark astringent clay and sand bed, seems to be, that there occurs a slight undulation of these beds, which sometimes exposes only the upper or clay bed above the beach, while in many other places, the true marl lying beneath it also appears above the water. Some have thought them portions of the same stratum, shading into each other upon the same level. The above view is correct, however, and is important, as indicating the possibility of reaching marl almost *any where* by sinking to a very small depth.

At Pintard's point on the opposite or Shrewsbury side, the marl is dug on the beach, none appearing much above the water level. There are good reasons for believing that on this side of the river, marl exists the whole way down to the termination of the peninsula, dividing the two rivers. That at Pintard's is of a lighter green than any seen in this immediate quarter; it contains some clay mixed with the green grains. Very few fossils are seen in the marl, either in the Nevesink hills or upon the river.

Marl of very good quality occurs in several places between Redbank and Shrewsbury, also around Eatontown.

Between Eatontown and Long Branch, and about three miles from the sea-shore and two from Eatontown, at a mill called Turtle mill, there occurs a variety of marl, very different from

any hitherto seen. It consists of hardly anything but shells in a fragmentary condition, very friable and purely calcareous, and contains but a very small share of the green particles; its colour is yellowish owing to a small portion of sand. The shells are in a very broken condition, but we may recognize them to belong to the well known secondary fossils of the marl. The large shell called *Terebratula Harlani* seems to constitute a large portion of the mass. Something similar is seen farther to the south, on the farm of Mr. Field, about one and a half miles from Eatontown. This deposit deserves to be traced more minutely, as it is probably a new variety of marl fit for the agriculture of the neighbourhood, containing much more lime than the green sand of the same formation elsewhere.

*Red Bank.*—Here the dark green sand marl has a top layer of the large round consolidated masses, an indication of a superabundance of oxide of iron. The marl itself is rather copiously charged with the sulphate of iron or copperas. The predominant portion of the material is the green sand.

At Judge Paterson's we have a convincing proof of the hurtful influence of the copperas, in a marl otherwise excellent; his being extremely rich in the fertilizing green grains. The bank from the level of the water for a few feet up, is composed of the marl stratum, but abounding in the yellow astringent efflorescence. Tried upon the land it has been found injurious to the crops for at least the first year or two, unless when applied in great moderation.

Where the poisonous impurity is abundant, it is not safe to employ more than five loads of the marl upon an acre; nor do I see any good reason why five loads of a rich marl is not enough in nearly all cases for a single dressing.

The entire material of the beach beneath the bank, consists of the dark green sand or marl grains, from which nearly the whole of the astringent matter appears to be removed by the washing of the waves, as the caving of the bank from time to time, brings down the matter upon the beach, and within the dissolving action of the water.

This washed marl is pure, and may be used, as some experiments made by Judge Paterson have fairly proved, in any degree of abundance, even at the rate of one or two hundred loads to the acre, without showing any caustic effects upon the vegetation.

This among other facts induces me to recommend to the farmers, to expose their *caustic* or astringent marls to the rain for a season, before attempting to employ them.

*Long Branch*.—Along the low sea-cliff facing the ocean in front of the boarding-houses at Long Branch, appearances in several places show that the true marl stratum meets the sea-coast in this quarter, and that it cannot lie at any considerable depth below the beach. About half a mile north of Renshaw's, at apparently the highest point in the cliff, the astringent clay bed which so generally accompanies the marl as an overlying stratum is exposed, rising four or five feet above the average level of the beach. This itself is strongly indicative of the existence of the marl bed at no great distance beneath. The probability of the fact is manifested however in another way. The sand of the beach contains a very notable proportion, often *five per cent.* or more, of the green granules of the marl, which examination assures me cannot be derived from any of the strata in this part of the bank, and which therefore can only come from a bed extending into the sea below the ocean level, or at least lying as low as the base of the cliff. This mixture of the green granules among the sand of the beach is observable along the whole bay shore, from near *Chapel* to the Telegraph hill, and thence along the ocean side from the mouth of the Shrewsbury river past Long Branch to Deal, and somewhat further. It has been discovered somewhat recently that the beach sand throughout this line where it has been tried, is endowed with active fertilizing powers, attributed heretofore to salt and other supposed ingredients in the beach. But the well known properties of the marl grains, coupled with the fact that in every place along the shore further south than Deal, at which place the marl region departs from the coast, the sand of the beach contains none of the dark granules, is a sufficiently convincing proof that the benefits so distinctly perceived, are attributable to the source which I suppose. The good effects of the beach sand are strikingly exhibited upon Wardell's farm, a little north of Long Branch. Surprising results are also witnessed on the farm of Jacob Curlis, at Deal. The most sterile patches of sandy soil are made to sustain very admirable crops of corn by the use of this powerful agent. The quantity of the beach sand applied is often as great

as two hundred loads to the acre, but the facilities for procuring and spreading it are very great. It is obviously a point of importance to find out those portions of the beach where the proportion of green matter is largest, for there are spots much darker than the rest from this cause. Experience has already taught that the sand gathered after the heavy storms of the winter is the most efficient, a fact giving countenance to the notion that the marl grains are cast up by the beating of the surf. The high degree of activity in fertilizing both the clayey and dry sandy soils of this portion of the sea-board, possessed by the green sand, goes far towards establishing several very essential points in the doctrines previously advanced, concerning the cause of the enriching qualities of the green sand. It clearly demonstrates, in the first place, that the efficacy of the marl stratum lies mainly in these green granules, and not, as many imagine, in the shells and other foreign substances discovered occasionally in the bed. It moreover decides the point, that the more essential and permanent properties of this mineral are in no way connected with the gypsum, or with the carbonate of lime, which so frequently form a coating upon the green grains. Both of these incrusting matters, should they have previously existed in the stratum from which the granules are derived, must be considered as being too easily dissolved by the waters which incessantly wash the shore to remain in the sand in the smallest appreciable quantity.

We are forced, therefore, to ascribe the usefulness of the green mineral to its *potash*, the only ingredient of an alkaline reaction, which is always present and essential to its composition.

Another all-important consideration is, that the marl or green mineral loses nothing of its potency by a long exposure, even of years, to water and the atmosphere; in other words, that it is not dissolved, or decomposed, or changed, by the ordinary atmospheric agents which react so powerfully upon many other minerals, and consequently that we are to regard it as nearly unchangeable until the roots of the plants come in contact with it, effect its decomposition, by the *vital* power of their organs, and imbibe a portion of some of its constituents.

When we behold a luxuriant harvest, gathered from fields in which the original soil is of a kind least of all congenial to vegetation; when we find that all this fertility, contrasting so strikingly

with the barrenness around it, proceeds from a few granules of a substance sparsely distributed through the enormous and counteracting excess of sea-beach sand itself, still more arid than the soil to which it is applied, are we not led to look with admiration at the potent nature of this unique and curiously constituted mineral. The developments of Geology are full of instances like this, showing in how many unlooked for ways, the mineral world has been made subservient to the good of mankind.

So striking a display of the powers of the marl ought to hold out an encouraging picture of the future, to those districts not directly within the limits of the marl tract, but where some of the strata possess the green fertilizing substance in a sensible proportion. It expands most materially the limits of the territory where marling may be introduced, and points us to many beds as fertilizing, which otherwise would be deemed to be wholly inefficacious.

There can be no doubt that the agriculture of our sea-board states is destined to derive essential benefit from the remarkably wide distribution of this green granular mineral under different geological relationships, to those in which it presents itself in New Jersey.

Thus the Tertiary shell marls of Delaware, Maryland, and Virginia, and I might add of other states still farther south, contain not unfrequently as high a percentage of the green sand as does the sea-beach upon the coast of Monmouth county in New Jersey, and I may mention that my brother, Professor Wm. B. Rogers, of the University of Virginia, charged with the geological survey of that state, has already done important service to the agriculture of some districts, by discovering, and subsequently calling attention extensively to the existence of the green sand in Virginia.

Between Long Branch and Deal, the marl stratum has been penetrated thirty feet. The upper two feet consist of a green clay, seemingly derived from the disintegration of the green grains, intermixed with a large proportion of yellowish white clay. The main marl bed having a thickness of about twenty-six feet, contains several subordinate layers, but all contain a large share of the green granules. Beneath the whole is a grey yellowish clay, in which the grains abound, but they are remarkably large, and are associated with numerous casts of shells. A

similar layer is seen in Jacob Curlis's pits, where it contains beautiful casts of the *nautilus* and several univalve shells, and also shark's teeth. The marl stratum, composed of nearly the same layers, is exposed again between Jacob Curlis's and the Whale Pond-mill, at John Curlis's. At all these points, the bed contains a considerable share of the astringent matter or sulphate of iron, which, whenever it shows itself in excess, must be counteracted by following the suggestions proposed in this report.

*Elisha West's, near Long Branch*.—A very interesting and rather extensive exposure of the marl stratum is to be seen on the farm of Elisha West, about one mile south of the boarding-houses at Long Branch, and in a direct line not more than a fourth of a mile from the sea. The pit is dry, a rather unusual circumstance, and occurs near the head of a gently sloping hollow or small valley, which fact, taken in connexion with the obvious outline of the ground between it and the shore, leads the observer to believe that the top of the stratum is not as low, by several feet, as the sea-beach. It follows, if this be correct, either that the marl bed runs horizontally to meet the cliffs at the sea-side, at a point above their base, where the inclined pile of fallen matter may conceal it, or else that it descends with a gentle eastward dip until it merges beneath the ocean at a lower level than the tide. The question as to which of these is the fact, is of some consequence to the neighbourhood, for a good marl bank opened directly on the shore would be a benefit conferred upon no inconsiderable line of coast.

The section in the pit is about twenty feet deep, being almost entirely in the marl stratum. The top layer, one foot thick, consists of an indurated marl, somewhat similar to that at the top of the marl at Ely's, on Shark river. It contains but a trivial proportion of the granules of marl, which are imbedded in a paste of a grayish white calcareous clay, identical in aspect and composition with certain waterworn rocky masses which strew the beach in front of the boarding-houses. This apparent identity in all respects except hardness, furnishes a farther proof that the marl stratum is prolonged to the sea-side, and rests either at the level of the beach or at so small a depth beneath the surface, as to be at all events, within the action of the surf, which I con-

ceive to disturb and bring to shore not only portions of this upper bed, but likewise of the softer marl straturn below.

Beneath this upper bed in the pit, there occurs a hard, somewhat firmly cemented mass, consisting of light green grains and a little ordinary sand, the whole eight feet thick. In it is a very thin layer of white clay. Lower down we meet a gray and afterwards a yellowish ferruginous marl both rather sandy, and in aggregate thickness about three feet.

Still lower and throughout the rest of the vertical section we find a layer of yellowish ferruginous sand, containing a very moderate proportion of the green grains. Few or no shells are visible in the perpendicular wall or section disclosed in this pit, but numerous traces of casts occur to show that they once have been there, and to intimate the nature of the change which they have undergone, and the possibility that they have furnished to parts of the stratum a small amount of diffused carbonate of lime and perhaps of gypsum.

*Tinton Falls*.—The stratum here is a dark brown and greenish friable sandstone rock, forming a horizontal ledge across the creek, in which it occasions, by its abrupt termination, a sudden fall of about sixteen feet. It seems to be nothing more than a very sandy and highly ferruginous marl, consolidated by the cementing action of the oxide of iron into a moderately compact sandstone. It abounds in the usual characteristic shells of the marl series, but they are almost invariably in the state of casts. The amount of the green grains in the rock is not very considerable, though sufficient, in some of the layers, to impart a decidedly green or dark olive hue to the otherwise brown mass. Three layers of nearly similar aspect, all differing somewhat in their hardness and proportion of oxide of iron and of the green granules, are to be observed here.

Whether this rocky stratum at Tinton Falls may not be the equivalent of the brownish ferruginous sandstone with casts, which overlies the friable marl stratum in the Nevesinks, near the mouth of Shrewsbury river, or whether it may not possibly be the true marl stratum rather more than usually cemented, and ferruginous, are questions which it is of some importance to determine, in order to form a just opinion as to the proba-

bility of meeting, at a moderate depth, the valuable loose green sand stratum itself.

Nearly upon the same horizontal line with the top of this rock, and at a distance less than a fourth of a mile, a bed of sandy green marl, not consolidated, shows itself very near the surface of the fields upon the Monmouth road. The somewhat clayey texture and greenish hue of the road itself between this point and Eatontown, is strongly indicative of the proximity of the top of the marl stratum to the soil.

*Poplar Swamp*.—At Jacob Woolley's, Poplar Swamp, the section of the marl stratum which is exposed exhibits three separate layers. The top bed is about three feet thick, the marl granules are of a light green, and mixed with them is a small quantity of common silicious sand. The next, or middle layer, is four feet thick, of a much darker green, and the bottom bed of a dull greenish ash colour, and contains rather less than fifty per cent. of the green granules, the residue being clay and ordinary sand. Very few shells occur at this locality, though bones of the fossil crocodile and shark's teeth are occasionally met with.

The middle stratum gives indications, from its darker green colour and greater freedom from foreign intermixtures of being the most efficacious of the three as a marl. Astonishing results are produced from it when applied in the proportion of from seven to ten loads to the acre.

This marl tract lies on Poplar Brook, the source of which is about a mile west of Mr. Woolley's, its entrance to the ocean being at Deal. There is marl in the banks of its meadows and adjacent ravines throughout nearly its whole length.

Mr. Woolley manured a piece of land in the proportion of two hundred loads of good stable manure to the acre, applying upon an adjacent tract of the same soil his marl in the ratio of about twenty loads per acre. The crops, which were timothy and clover, were much the heaviest upon the section which had received the marl, and there was this additional fact greatly in favour of the fossil manure over the putrescent one, that the soil enriched by it was also entirely *free of weeds*, while the stable manure had rendered its own crop very foul.

This green sand stratum at Poplar Swamp seems to be almost

entirely free from any sulphate of iron or other astringent material, and, as a consequence, the crops seem not to be scorched by an extra dose, however lavishly applied.

There can be no doubt that twenty loads of marl per acre must be regarded as an unnecessarily bountiful dressing, but computing the relative cost of the two manures, when employed in the ratio above stated, we find a considerable disparity of expense in favour of the green sand. Placing the home value of farm-yard manure at ten cents for each two-horse load, and that of the marl at twenty-five cents per load, we have the expense of manuring one acre, *twenty dollars*, of marling the same *five dollars.*

This being an *experiment*, an extravagantly large dressing of manure was employed, but not exceeding the usual average application more than the twenty loads of marl surpassed what was necessary of it.

Experience has already shown that land once amply marled retains its fertility with little diminution for at least ten or twelve years, if care be had not to crop it too severely, while with all practicable precautions, the stable manure must be renewed at least three times in that interval to maintain in the soil a corresponding degree of vigour.

The following are the results of an analysis of the marl from Mr. Woolley's middle bed:

| | |
|---|---|
| Silica, - - - - | 51.40 |
| Protoxide of iron, - - | 24.68 |
| Alumina, - - - - | 8.30 |
| Lime, - - - - | 1.20 |
| Potash, - - - - | 10.00 |
| Water, - - - - | 4.00 |
| | 99.58 in 100 grains. |

*Shark River*.—Ely's marl pits on the Shark river present the following order of layers in the descending series:

1st. A dark brown or amber-coloured mixture of sand, clay and mica, reminding one strongly, both from smell and aspect, of an ooze of the ocean. It sometimes contains thin seams of very coarse sand, completely water-worn and rounded. This bed is between seven and eight feet in thickness, and is seen resting in immediate contact, on an indurated or cemented marl.

It is also visible elsewhere in the neighbourhood, and always shows the astringent character of the corresponding bluish sandy clay already so often mentioned, with which, in fact, I hold it to be identical as a stratum.

2nd. A hard cemented marl, being a paste of a yellowish white clay, perhaps containing gypsum with a moderate sprinkling of the marl grains. Except in its being a cemented mass it differs but little from the bed of friable marl which underlies it. It is two feet thick.

3rd. This lower stratum yields the well known marl so much in request in this part of Monmouth. When moist the mass possesses a dark, dull, grayish hue, from the colour of the clay which coats the granules. When dry the colour is a very dark plumbago (black-lead) tint, having also a deep olive-green tinge. It consists of little else than the dark granules, the small quantity of clay present being only as a thin coating upon the grains. The lower part of this layer has a more yellowish hue from a greater excess of the clay, which is here rather ferruginous. The thickness of the bed is not known, though it has been penetrated sixteen or seventeen feet.

I have witnessed its action on some very poor light soils, rendered highly fertile from the use of this marl in a first dressing of five loads to the acre, and an equal quantity at a second rotation of the crops.

The best part of Ely's marl bed exhibits by analysis the composition which I here annex:

| | |
|---|---|
| Silica, - - - | 45.60 |
| Protoxide of iron, - - | 26.10 |
| Alumina, - - - | 7.40 |
| Potash, - - - - | 12.08 |
| Water, - - - - | 8.32 |
| Lime, | *a trace.* |
| | 99.50 in 100 grains. |

*Squankum*.—Thorp's marl, near Squankum, presents the following varieties:

1st. On the top, a bed of diluvial sand and gravel, and in certain places a coarse ferruginous sandstone, sometimes two feet thick.

2nd. A light greenish-blue clay, the upper part of which some-

times shades into a brown sandy clay, like the corresponding bed at Shark river, and a portion of which contains a small mixture of the green granules. This portion appears, in fact, to graduate into the upper part of the marl bed, in which there is not unfrequently as much as fifty per cent. of the clay itself.

3rd. The inferior layer is the true marl stratum, consisting of little else than the green granules. When dry, the colour of the mass is a tolerably light grayish green, not uniform, but having lighter specks throughout it.

When the heaps have dried, the external grains are coated, in some degree, with a white efflorescence. The upper portion of the bed, in consequence of containing so much of the astringent clay, presents a good deal of the yellowish efflorescence ascribed to copperas. The depth which has been reached in the pits is about twenty feet, and hitherto the bottom of the marl has not been struck. The lower portion of the stratum is conceived to contain the best marl. It is not free from decomposing sulphuret of iron, judging from the strong odour of sulphur which every pile of it exhales, and which it does not lose even after being conveyed to a distance, and long exposed to the weather. It probably, therefore, contains a slight impregnation of sulphate of iron or copperas, but not enough to injure it, if we are to infer from the extraordinary reputation as a fertilizer which this marl possesses.

At the pits, which are very extensive, the marl is sold at the rate of 37½ cents the load, the purchasers having to dig it. It is transported by wagons to a distance, in some directions, of twenty miles, and retailed, when hauled that far, at the rate of ten or even twelve and a half cents per bushel, being very profitably spread upon the soil in the small proportion of twenty-five or even twenty bushels to the acre. The fact that so small an amount of this marl is found efficacious to the soil, which, after two or three dressings, is permanently improved and to a high pitch by it, furnishes me one consideration for supposing that too generally the marl is spread with a prodigality surpassing all the necessities of the land.

The high and deservedly high name, which the Squankum marl now boasts, was an inducement to me to subject it to

chemical examination, with especial care and rigour. In external aspect it differs in no respect from many other marls of the state, and, chemically studied, I do not find it to depart very materially from several others in the proportions of its constituents, though it does most certainly possess an amount of potash in its composition not a little astonishing. Others, however, seem to have nearly as much. After all, therefore, I am not by any means convinced that the marl of Squankum is *peculiar* in having a very high degree of activity, and I conceive were other marls once applied in equally small proportions, and with as much care to make them go a great length, and to diffuse the substance intimately through the soil, they would yield results equally surprising when estimated by the small amount of material employed. "Enough is as good as a feast," for vegetation no less than for man.

Like many other marls, that of Squankum is apt to become coated, as it dries, with a white tasteless efflorescence, which analysis convinces me is principally gypsum. The mass, in general, appears to be a pretty pure green sand. The same deposit of marl shows itself, in places, for several miles down the Manasquan river, appearing as near to its mouth as the old Manasquan bridge, about four miles from the sea.

A specimen of the marl from Thorp's lowest layer yielded me, after reiterated trials, uniformly about the following, for its composition.

| | |
|---|---|
| Silica | 43.40 |
| Protoxide of iron | 21.60 |
| Alumina | 6.40 |
| Lime | 10.40 |
| Potash | 14.48 |
| Water | 4.40 |
| | 99.68 in 100 grains. |

The quantity of the potash is so remarkably great, that I have been led to assure myself of the true proportion by several analyses, proving the results by adopting different modes of separating the potash.

In the neighbourhood of Mount's mills or Berkelue's, at a Mr. Rue's, half a mile south of Spotswood, there is a black clay like that of Middletown Point, containing a considerable quantity of

the marl. It has been thought to be somewhat beneficial to the land. It is near Mr. Berkelue's mill-pond, and not in the lowest ground. There is a considerable undulation of the surface in this quarter, though the denudation would seem not to have reached a low level. The superficial stratum is sandy, containing also some of the loose materials characteristic of the marl region.

At the pits of William Johnson, one mile east of the former, the supposed marl stratum exhibits a small proportion of the green sand with much silicious sand, some clay and mica, and has a decidedly sulphurous odour; it also tastes of copperas, and has a yellow crust. These pits lie in the side of a hill, on the road from the mills to Johnson's house. Around this neighbourhood the land is rather high, and hence perhaps the true marl has not been yet reached. The proximity of this impure marl to the rail-road, makes it desirable, if possible, to learn whether the true green sand bed does not lie below it at an accessible depth.

Three miles from Englishtown, on the Matchaponix creek, at John Perrine's saw-mill, the same stratum is seen as at Rue's. It is not so destitute of the grains of marl as to be entirely unfit for use. It occupies the bed of the creek for some distance below the saw-mill. It is sandy and micaceous, with small irregular concretions of clay cemented by oxide of iron, and a few grains of marl.

In many parts of this section there is a stratum of a mottled bluish clay with blotches of yellow ferruginous clay. This lies over the spurious marl stratum, and looks not unlike the upper marl bed at Middletown and its vicinity.

Around the parsonage, two and a half miles from Englishtown, on the road to Freehold, the marl is pretty good, though a little impure from containing some sand and clay. At no great depth it contains shells and other fossils. The soil is sandy, but grows better to the northwest. All the indications of the marl region are present here.

In and around the farm of Mr. Hunt, one mile from Bloomsburg tavern, the marl lies extensively denuded in the meadows. It is pretty good, consisting mainly of greenish grains, with a

good deal of clay. These meadows are very ferruginous, and contain bog iron ore.

The marl seems not to be known much farther to the north-west, in which direction there is a low range of hills of denudation.

Below the dam at Bargain's mill, on the Millstone creek, the spurious marl stratum is visible again. At Lewis Perrine's, half way between this and the Presbyterian church, the marl is found, but not very good; it lies rather high in the fields. The true marl is known here as far west as Mr. Van's, two miles farther towards the rail-road on Rocky brook, one mile below Imley's mills. The quality is not known, but it is supposed to be the inferior sort.

At Willow Tavern or Clarksburg, a thin layer occurs in the road-side, being a light green marl with yellow specks. Beneath this there is a whitish bed of silicious sand with white clay and containing a very few yellow and green specks.

The ochrey olive hue, so common in the clay of the marl region further to the south-west, is seen here upon the road, and though no marl has been dug, I do not doubt its existing in this quarter. I was told that marl, declared to be good, has been found two miles to the north-west of Willow Tavern.

The country between this and Allentown is, for a certain distance, somewhat hilly, then flat and very sandy. Hills occur of some magnitude near the head waters of Rocky brook; and range from east to west. The highest is called Pine Hill, and is the same which is seen so conspicuously from Hendrick Conover's insulated hill, as before noticed. We pass through a gap in this range, in coming from the north-east to the Willow Tavern.

Two ranges of high grounds seem to extend in parallel directions to the south-west, one on each side of the road going to Wrightsville, before reaching which place, however, the western one is crossed. To the east is Cream Ridge.

At the head of Montgomery's mill-pond, near Allentown, Mr. Burdon has dug in search of marl. It is very poor (of the spurious kind), no green grains being visible, and it tastes strongly of copperas. At the rate of twenty loads to the acre it destroys the crop. A very light dressing, however, was thought to be

beneficial to potatoes. The stratum is the blue sandy clay usually so astringent.

At Crosswick's, Gideon Middleton has a marl pit near the mill, in which the layers are as follows:

1. A micaceous tough clay on top.
2. A rather greenish grey marl, somewhat micaceous, but pretty rich. Beneath this, one foot of ferruginous manly concretions, each about the size of a man's head.
3. A dark blue marl.
4. A black sand and marl.

In sinking a well at his house, many years ago, the beds traversed were ten feet of yellow sand, then twenty-seven feet of marl strata, and below all a white sand. Low down in the pit just spoken of, shells, belemnites, &c. occur. Fossil wood, with much pyrites attached, is sometimes seen in the marl pit near the bottom.

This marl is highly fertilizing, as Mr. Middleton's fields show. Mr. M. has *mixed it with lime with very beneficial results.* In the upper stratum, yellow incrustations of efflorescent sulphate of iron abound.

The marl is very good one mile lower down upon Crossrick's creek at David Killey's. It lies in a bank on the side of the meadows of the creek, and has a top layer of the black astringent clayey or spurious marl. There is good marl on Crosswick's creek, half a mile above Hogsback landing, and I am told it extends still lower down. This proximity to the railroad is a matter of deep importance to the state.

Near the Sand hills, and in places between these and Bordentown, the upper or spurious marl stratum is visible in the sections of the rail-road, and I am now firmly of the opinion, that the clay with lignite at Bordentown landing and below, is but the upper bed of the marl formation, and is identical with the astringent blue clay bed above the true marl or greensand bed on the Nevesink river and elsewhere in Monmouth county, and throughout a great portion of the whole marl region.

*Shelltown*.—Howard's marl is near this place on the south side of Crosswick's creek, and presents both the true marl stratum and the overlying astringent clay. The marl is dark, friable, smells of sulphur, and is found to be very efficacious. The overlying

lead-coloured clay is somewhat micaceous, and contains a trivial quantity of the greensand, being in all respects like the bed which shows itself at Wall's mill near Burlington. It resembles very much the character of the bed where it caps the marl at Crosswicks and in the neighbourhood.

On the road from Shelltown to James S. Lawrence's, which is one mile south-west from Varmintown, the same overlying bed is exposed in numerous places in the banks of the meadows.

All these cases are adduced to show the high degree of probability before expressed, that the true marl underlies the dark clay along nearly the whole north-western edge of the marl tract, as, for example, near Burlington and Camden.

Fine exposures of the marl deposit offer themselves to view in the vicinity of the residence of Mr. Lawrence. The soil itself is a brown ferruginous loam, being a portion of a narrow tract of red clayey soil, which extends a considerable distance north-east and south-west, passing by Arneystown, and exhibiting whenever it is seen, every evidence, from its texture and the minute waterworn grains of quartz in it, that it has resulted from the breaking up of a once overlying stratum of brown sandstone. In some of Mr. Lawrence's fields, it contains a very sensible quantity of the green granules. The upper part of the marl stratum here differs materially in aspect from the lower. For a thickness of several feet, it is little else than a mass of decomposed shells almost invariably in the state of casts, or replaced by oxide of iron. An inconsiderable proportion of the green grains is mingled with a yellowish white pasty matter, which is a mixture principally of sulphate and carbonate of lime, derived no doubt from the shells, and tending to impart many valuable qualities to the marl.

The lower stratum is a mass of dark greensand in which we witness few traces of the changes noticed in the materials of the mass above. The quantity of oxide of iron in the free state mixed with the marl causes it to be rather hard in the digging; this is the case with nearly all the more ferruginous kinds, but a short exposure to the air renders it friable, when it is found to be a very powerfully fertilizing marl. Striking benefits result from the use of this stratum when it is applied in the ratio of about ten loads to the acre. In this bed have been found teeth

of the *mososaurus* and several bones apparently of the fossil crocodile. Mr. Lawrence states that his lower or dark green marl, which is very full of the astringent matter or sulphate of iron, will not admit of being lavishly employed, for it then invariably *poisons the crop*. If as much as twenty-five loads be used, the growth of the corn is seriously checked; nor does it recruit until late in the season, after which the vegetation is wonderfully quickened. The upper stratum, on the other hand, will admit of being applied in any excess, one hundred loads or even more, manifesting no deleterious effects upon the crop. Where the banks of the meadows are high, a different stratum from either of the previous two is seen, and to all appearance occupying a higher place in the series. This is the calcareous sandy stratum which in another part of this report I alluded to as being in all probability a deposit of the same date with the limestone of Vincentown and Mannington. It is here a yellow calcareous sand with scattered grains of marl in it and with a multitude of solid casts of various fossils, some of which do not show themselves in the green marl beneath. Out of this bed I have procured *coprolites*,* the first time they have been found in this country. All the casts in question consist chiefly of carbonate of lime in an earthy state mixed with a little clay and sand.

The stratum in some places is more than twenty feet in thickness. Being the upper bed, it is in some instances the only accessible one, in which case I think it deserves to be employed as a substitute for marl, not merely for the amount of calcareous matter in it, but for the quantity of the greensand grains distributed throughout it. Bones of some reptile, the *crocodile* apparently, are found in this stratum, and we may hence form a conjecture of the source to which the coprolites belong. From the same bed we may procure solid internal casts of *claws* of a *fossil crab*, two species of *baculites*, teeth of the crocodile, and many interesting species of bivalve and univalve shells.

In a deep ravine on the opposite or west side of Crosswick's creek, and a little lower down than where the previous beds are seen, and very near the line of an ancient Indian path, we have

* *Coprolites*, are the fossilized dung of extinct animals.

an exhibition of a very different group of beds, the relative position of which to the former, whether above or below them, it seems not in the present stage of inquiry easy to ascertain.

The probability is that the beds in question are a part of the overlying ferruginous marly series, such as caps the marl in the cliffs on the Raritan bay.

The upper layer is a yellow sand. A little beneath this, there occurs a brownish, ferruginous, sandy rock, characterized by casts of the *Ostrea falcata*, identical in all its features with the stratum having ostrea falcata, and resting high up in the cliffs of the Nevesinks. Next beneath is a dark silicious sand, with casts of shells, and masses which appear to have been lignite or fossil-wood dissolved and replaced by a sandy clay. This bed is very astringent, the surface in many places being coated with the yellow efflorescence. Lower still there exists a mottled gray and yellow sand, and beneath all a gray sand with lumps of what was once lignite but is now clay, having all the markings and occupying the place of the woody matter now removed.

Mr. Lawrence entertains an opposite opinion to mine, concerning the relative position of the series here described, compared with the dark marl stratum in his meadows, thinking that the former have a slight dip which carries them to the east, under the valley of the creek, and therefore beneath the greensand beds on the other side. This *may* be the case, and I am anxious therefore to speak doubtingly, for the present, upon the main point.

At John Meirs, two miles south of the localities above described, excellent marl is seen in two layers, the top one being a light green, with little or no white incrustation upon the grains, and this graduating into the inferior, or dark green marl, which seems to be rather less friable and considerably more ferruginous. The grains in the lower part of the stratum acquire, when drying in the heap, the white tasteless incrustation or efflorescence so common to the marls of the region, and which chemical experiment establishes to be the sulphate of lime or gypsum.

It is an observation made in this neighbourhood, and one in complete accordance with my observations throughout the marl tract, in its range from hence through Burlington and Gloucester, and even Salem counties, that when the *light green* shows itself,

it is usually along the eastern side of the marl belt, and invariably occupying a position on the top of the dark greensand. The latter, I find in many districts to be esteemed the most efficient of the two varieties.

At *Snuff mill*, on a small tributary to Crosswick's creek, about one mile north of New Egypt, we witness the same limestone bed which appears lower down the state, at Vincentown, and in Salem county. It holds the same position on the top of the green marl, is a stratum of about a foot in thickness, and contains the same corals or zoophytes, for example, the same alcyonia, and the same shells seen in the districts where this stratum of rock is of more important thickness.

At *Fuller Horner's*, on Crosswick's creek, about a third of a mile below *New Egypt*, there is a bank exposing the strata, where, during the last twenty years, enormous quantities of marl have been procured for the use of the neighbourhood. The section is between twenty and twenty-five feet high. Near the top of the bank, the upper layer is a greenish silicious and slightly calcareous sand, and beneath this occurs the rubbly, straw-coloured, and somewhat sandy limestone, the frequent capping to the marl elsewhere. Both these layers are represented in precisely the same order near Vincentown. In the bank before us the limestone is rarely more than one foot thick, and reposes upon the greensand, or marl bed, in which a series of thin layers of different tints, and various degrees of purity, occupy an exposed depth of at least twenty feet. The uppermost part of the series belongs to the light coloured greensand stratum, while the lower portion shows a large predominance of the dark green variety.

This is a locality containing some very interesting fossils, but the present is not the place to treat of them. The marl has its very usual odour of sulphur, and exhibits, when dry, the gray or white efflorescence. It enjoys a high reputation for its powers as a manure. Most of the shells in it show that the carbonate of lime has been nearly all supplanted by oxide of iron, and here, as in the instance of many other marls, the virtues of the mass are not to be accredited to the lime, but to the specific power of the constituents of the dark granules chiefly to that of the Potash.

I have not succeeded in ascertaining whether any difference

in activity of fertilizing effect has been experienced in using the dark and the light green varieties, from which we may infer the improbability that any prevails.

Near *Arneystown*, the marl is to be met with in nearly all the meadows and low grounds. The soil is the red or brown loam, derived from the destruction of the brown ferruginous sandstone, one of the principal upper beds of the secondary strata of the region.

The underlying marl does not, to my knowledge, offer either the overlying light green layer, or the still superior seam of limestone, a fact corroborating what has been said, that these lie chiefly upon the eastern or ocean side of the marl tract. The dark marl here is highly effective upon the crops.

Between Arneystown and Hornerstown, we meet the same superior thick mass of calcareous sand full of organic remains which are usually in the state of solid casts of the *interior* of the shells. The whole corresponds to what we see nearer to Varmintown, at Mr. Lawrence's. The spot where this bed best shows itself is on the hill side overlooking the meadows at Crosswick's creek, and it is thought that we may behold here, as at Lawrence's, a slight dip of the strata, to the south-east. To establish the amount of this is of some importance, because upon the other side of the valley, on a level with the meadows, we meet with a gray loose sandstone full of *ostrea falcata*, in an undissolved and beautifully pearly condition. The question to be settled is, whether this rock lies over the calcareous sand before mentioned, corresponding with the conjectured place of the ostrea falcata rock at Mr. Lawrence's, or whether it may not be a local bed not hitherto discovered in any other spot. The thing demands investigation, as tending to remove uncertainty respecting the depth at which the greensand bed will be found to extend through the neighbourhood.

At *Cookestown*, a rock, equivalent to the Vincentown seam of limestone, is seen lying near the level of the stratum.

At *Imlay's*, where the Monmouth road crosses Crosswick's creek, and about a half a mile below Fuller Horner's beds, the marl series is exposed at a considerable elevation above the creek. Gray sand shows itself on the top, then follows a yellow sand, with ferruginous bands of cemented shells, and sand, and

marl grains, through a thickness of several feet, down to the top of the pure greensand marl stratum.

A light green marl, four feet thick, full of casts of shell succeeds; below which lies the dark green marl, rather cohering or slightly cemented by oxide of iron, and having a few shells.

The top of this is many feet above the meadows, and I can well comprehend how, by the descent of the meadows to Lawrence's, space enough may exist for the silicious group of beds, characterized by ostrea falcata, to occupy a yet lower place in the series.

*Burlington*.—The nearest place to the river where marl occurs in this vicinity, appears to be at the mill pond, near Wall's mill, one mile south of the town. The pit is not deep, owing to the stratum being wet. It is exposed in a spot where the dam sometime since gave way, and its top is very little below the level of the original water course. The top of the marl stratum is covered by a thin, hard, ferruginous crust. The marl is highly silicious and micaceous, yet contains a very sensible proportion of the green particles. No fossils appear in it. It has a strong sulphurous odour, and presents the yellow efflorescence and astringent taste of copperas, and resembles pretty closely that at Johnson's, near Mount's mills.

It very probably lies above the true marl, which, there is reason to infer, can be reached by digging or boring down a few feet.

At *Costill's mills* the marl is pretty much of the same character, containing perhaps rather more of the black clay and silicious sand. *Sulphuret of iron* also occurs in it, in little nodular lumps. It smells strongly of sulphur. When applied in light dressings to the land, it has been found useful. It is said to contain shells and shark's teeth. I have never seen these in a marl so poor as this, and were it not for this statement, I should judge it to be the top stratum. Possibly they come from a point very low down, as the nature of the astringent clay seems to have been inimical to the growth of shell-fish.

On the *Rancocas,* near Franklin Park, the good marl lies at the level of the tide, being covered by the yellow ferruginous sand, and has a good deal of clay mixed with it. It has been found very beneficial, but is regarded as inferior to that which

lies higher up the Rancocus. This certainly contains fossils. How far down the creek the good marl extends, I have not yet ascertained, but I fancy it does not extend much farther towards the Delaware.

Higher up the Rancocus, the marl extends to Pemberton and Vincentown, and, as it would appear, even to the vicinity of the Pine Cottage.

On the Assiscunk (Barker's branch) a little above Slabtown, marl has recently been opened. It is not good, owing to its containing too much of the ordinary impurities. The opening is on the side of the road. It is said to contain fossils.* This is a point of prime importance, and to determine it will require much research, aided by boring.

Higher up, on the same branch, the marl seems to be considerably better, yet it is still too silicious to be ranked as the best kind.

Arney's mount is a considerable hill at the Friends' meeting house, one and a half miles south-west from Juliustown. The sandy soil of the neighbourhood, even that of the road, is mixed with the greensand, so that its colour is sensibly influenced. Eastward from the meeting-house, a few hundred yards, there is a small opening on the road, where the ferruginous conglomerate has been quarried. Most of the cemented particles in this rock are grains of coarse silicious sand, but some of them are *felspar*. It is very hard and durable, and shows no departure from the horizontal position.

On the top of Arney's mount, there lies a pretty thick bed of this sandstone; it is largely quarried, dipping very gently to the east. This mount is distinctly visible from *Mount Holly*, and from it there is a rather extensive view. The whole surrounding landscape is extremely flat, the eastern horizon, more especially, being perfectly uniform. Marl occurs, near the surface of the fields, to the south-east; its existence being shown by the water oozing forth along the base of the hill or mount.

On the Haybridge run, and a mile and a half north of Pemberton, there is very good green marl which is dug near the

* Query.—Does the impure overlying bed ever contain fossils; or may not this, and even that of Costill's mill, belong to the true marl stratum, which, near its north-western edge, may be more impure ?

road. Over this is a thin layer, containing much of the copperas in a state of efflorescence.

At Forsyth's, north of the road between Pemberton and Lisbon, and one and a half miles from the former place, there is very good dark green marl, lying on the surface of the meadow. It encloses numerous fossils. On the edge of the meadow, and near the top of the marl, there were found, some years ago, the principal portions of the head of a mastodon, improperly called mammoth, and also a tusk, pieces of the tibia, ribs, &c. It would seem, from the state of the bones, and the unworn condition of the teeth, to have been a young one. The head was exposed to the air, lying only eighteen inches below the surface of the meadow, and was much decayed.

In a ravine, on the edge of the meadow, and lying in the yellow sand which covers the marl, there was found a large mass of what has, externally, very much the aspect of *bituminous coal*. It proves to be retinasphaltum, and not anthracite, as Dr. Morton considers it.*

Shark's teeth, phosphate of iron, &c. occur in the marl here. The marl in the meadow, midway between Eayrstown and Newbold's Corner, presents something unusual. The grains are generally coarse and dark green, while some are very light, almost white, and seem to be decomposing. These owe their whiteness to an incrustation of *carbonate of lime*, their interior being of a very light green. An analysis of this singular variety, presents us with *one per cent*. of carbonate of lime, derived wholly from the disintegrating *light-coloured* grains. The composition of the whole mass is as follows.

Analysis of the greensand marl, one mile from Eayrstown and Newbold's Corner:

| | |
|---|---|
| Silica, | 43.40 |
| Protoxide of iron, | 23.56 |
| Alumina, | 8.20 |
| Potash, | 12.15 |
| Lime, | 3.64 |
| Carbonate of lime, | 1.00 |
| Water, | 7.45 |
| | 99.40 in 100 grains. |

The thin limestone stratum of the vicinity of Vincentown,

* See Morton's Synopsis of Organic Remains.

extends to the north-east, as far as Benjamin Peacock's, on the road between Vincentown and Pemberton, and one mile from the limekiln, on the south branch of the Rancocus. To the south-west it extends, and is seen on the farm of James Lippincott, between Vincentown and Medford. It occurs at Hosea Moore's, on the Red Lion road, three and a half miles from Lamberton.

I do not think it at all established that Benjamin Peacock's is about the extreme north-east limit of this formation, for there is a thin band of calcareous rock (No. 2 in the descending order) in the marl bank at New Egypt, which is almost identical in character with the rock at the limekiln on the Rancocus; and what is remarkable, the top bed at Egypt is identical with the top or overlying bed at the limekiln, being a thin layer of a *brownish silicious sand*, tinged here and there with green. This would extend the limits of the bed much farther towards the north-east. On the Rancocus it is very thin, consisting of two layers, each only six or eight inches thick, and separated by eighteen inches of sand. If it be indeed an extension of that at Egypt, it is then proved to *overlie* the marl, as we know the corresponding stratum does in Mannington, Salem county.

Analysis of the yellow limestone, from the neighbourhood of Eayrstown:

| | |
|---|---|
| Lime, - - - - | 49.69 |
| Carbonic acid, - - - | 38.31 |
| Silica and other impurities, | 9.00 |
| Water, - - - - | 3.00 |
| | 100.00 |

It is in many places a very pure limestone, containing ninety per cent. of carbonate of lime. It has a structure somewhat resembling certain varieties of the *oolite* of Europe, which imparts to it a granular and sandy aspect, leading the careless observer to regard it as a more impure limestone than it is. Between Pemberton and Pine Cottage nothing of importance is exposed, this last point being the extreme edge of the marl region. The soil is very sandy on the verge of the Pines, the limit of which may be placed at the Cottage. The cedar swamp south of *Stop the Jade* creek, is four miles within the Pines. The road lies through white sand all the way. This sand is too coarse for glass-making; though white wherever washed by the rain, it is often

rather yellow and ferruginous below the surface. Some of the particles are of an *opake* white, and seem to be *felspar*.

*Points south of the Rancocus*.—On Haines's creek, or the main south branch of the Rancocus, one mile and a half below Haines's place, the banks exhibit a black micaceous and astringent clayey stratum, ascertained to rest throughout a considerable area *beneath* the true green marl. In a meadow half a mile to the north of Joseph Haines's, the two beds are seen in contact with the spurious stratum resting underneath.*

On the main Rancocus for several miles from its mouth up, the superior astringent clay occurs near the water's edge; the true greensand bed slowly rising from beneath it as we ascend, and appearing near the tide level a short distance below the Franklin Park Academy.

The spurious bed occurring more convenient to the Delaware than the true marl, has been resorted to under the impression, that it was the genuine kind, and the mischief arising has served to check the zeal at one time manifested by the agriculturists on the Pennsylvania shore, to enrich their country-seats by marl.

At Charles Haines's mill, two miles below Medford, on the creek, a section is seen exhibiting on the top, a greenish silicious sand; beneath this, a gray sand some feet thick, containing a small proportion of the green granules, and under this, again the straw-coloured limestone two feet thick.

These beds hold the same order, and are identical with those above the green marl at New Egypt and elsewhere, towards the eastern side of the "marl tract." One fourth of a mile from the mill, the beds have been cut through, in digging a well into the green sand stratum underneath. The limestone was reached, between seven and eight feet below the surface. It was in thin irregular beds, separated by incohering sand and calcareous grains, similar to the mixture which composes the rock; its total thickness is about six feet; the organic remains are the same which characterize the limestone at Vincentown. The marl stratum here possesses when dry, a dark slightly greenish gray hue, the granules being coated with a very copious efflorescence; it resembles the marl at Inskeep's. In the upper part of the bed

* It is obvious from this and what has been said of the strata in the Nevesinks, that there are more than one of these astringent clayey deposits.

there is a layer four feet thick, of decomposed shells, (Gryphea, &c.) mingled with marl grains, in a dark friable brownish mass, the efficacy of which upon the soil is found to be very great. Capping this top layer, the diluvium contains a bottom band of very ferruginous cemented sand and gravel, a foot and more in thickness.

The extensive range of meadows in which these exposures of the strata occur, meets the meadows of the Rancocus about two miles above the limit of the tide, at Joseph Haines's. They contain marl in their banks almost to the source of the stream. None of the overlying limestone seems to occur nearer the Delaware than this vicinity, for the marl here is the uppermost stratum.

The limestone belt measured from north-west to south-east, appears as far as exposed, to be about one mile wide, and there are pretty good reasons for concluding, that it expands still more to the south-east. In the marl at J. Haines's, shells, shark's teeth and bones are occasionally found.

The marl is traceable as far to the south-east as Pricket's, upon the edge of the sandy tract, denominated from the prevailing timber, *the Pines*. It is here very similar to the upper and moderately pure variety seen in the stratum at Medford.

Near Medford, which is about two miles from the edge of the pines, pretty good marl abounds in all the ravines or meadows adjacent to the town.

On the north branch of Cooper's creek, and about one and a half miles south by west from Swain's, the marl is very extensively laid bare in the banks skirting the meadows. The marl banks of Mr. Buck, J. P. Rogers and others, are very extensive. At the former, which are lower, the marl is of a pretty light bright green, which, when drying in the heaps, does not become covered with much efflorescence. The excavations penetrate the stratum about ten feet; no shells or other fossils are seen. The sand of the overlying diluvium contains some of the green granules, and a layer which has somewhat the aspect of a green clay, derived from the attrition of the granular marl below. That this overlying bed is certainly diluvium, is proved by the fact of its occasionally filling *troughs* or undulations in the top of the marl, which seems to have been furrowed at some time by rapid currents sweeping over its surface.

At J. P. Rogers', the colour of the marl is darker, being a deep dull bluish green. These diversities in colour, are due as often to small admixtures of differently coloured clays, as to an intrinsic difference in the tints of the granules themselves. The marl now before us exhibits a copious white efflorescence on drying. It is certainly a curious fact, but is true, as far as I have yet observed, that the darker marls should have more of this than the light ones. The dark and light green varieties in this quarter, seem not to be as in many places elsewhere, distinct beds. At the depth of about ten feet numerous fossils occur. Besides the ordinary shells, there have been found shark's teeth, and a portion of the jaw of a crocodile, containing three of the teeth in their sockets. A small mass of a black bituminous substance possessing all the characters which belong to *retinasphaltum*, was procured two feet beneath the top of the marl. It is identical in all respects with the mass found near the top of the marl at Forsyth's, and which was once conceived to be anthracite coal, brought hither by a wide sweeping diluvial current from the mountains of Pennsylvania. But nothing in the diluvial stratum of this district betokens an origin from that quarter.

At Cooperstown upon Cooper's creek, five miles from Camden, there is a marl much in use throughout the neighbourhood; it lies near the surface covered by a yellowish mottled bluish clay, apparently the same with the *brick earth* upon which Philadelphia stands.

It has been penetrated in pits which are dry, to the depth of twenty-four feet. It is a tough unctuous bluish clayey stratum, with only a moderate per tentage of the green granules, and a considerable amount of the astringent matters, (copperas, &c.) It contains numerous shells, some of enormous size, an *exogyra costata* weighing upwards of *nine pounds*. It is a question with me, whether another stratum of the usual character of the greensand bed does not underlie the pits in this quarter. The true marl stratum is so very generally *wet*, that a doubt is suggested whether this dry stratum, which in other respects also, differs from it, can be the same. A well was dug in this upper clayey marl bed without penetrating to the bottom of it.

The true greensand marl, brought from some distance, was

applied by the side of this material upon alternate rows of corn, and the result has been decidedly in favour of the former. Lime was spread over a portion of the crop which was marled in the spring, but I have not yet been able to learn the results of the union of the two fertilizing fossil manures. The lime seems especially appropriate as an admixture with this marl, which possesses a large portion of the sulphate of iron, the importance of neutralizing which by lime has already been fully insisted on.

Within one mile of the Delaware, to the north of Cooper's creek, a bed is reached having all the characteristics of that at Burlington and near Spotswood. It is highly astringent, though when used in moderation it has been found to be serviceable upon the potato crop. Shells and shark's teeth are said to have been found in it, though of this I have not been able to get distinct information. The fact would go far to determine whether these feeble and astringent marls along the Delaware are a portion of the true marl stratum deteriorated upon its western edge, or whether, as I am more disposed to believe, they are in reality a part of the overlying clay stratum; in which case it would be my duty to encourage the disposition to go down some yards deeper in quest of the genuine material.

*Localities between Camden and Salem.*—The upper blue micaceous clay has been dug in an experiment upon the Woodbury road, about six miles from Camden. It is highly astringent, having a whitish efflorescence which has a strong taste of *alum.* Five feet below the top there is a seam of white sand, and whether the greensand marl stratum lies still below, has not yet been ascertained.

The western edge of the marl stratum approaches to within about three miles of Woodbury and six miles east of the Delaware river.

Good marl is met with in various parts of the tract, as at two miles east of Dilke's mill, T. Bease's, Heritage's, and in the neighbourhood of Barnsborough.

At Carpenter's landing, about one hundred yards north of Mantua creek, the blue clay, containing a small proportion of the green granules and much silicious sand, displays itself upon

the road where the top of the stratum holds up and discharges the water. It is seen very generally upon the side of the marl tract next the river, and may, in nearly every instance, be known by the water which it throws out, and the astringent impregnations contained in it.

A pretty deep section of the beds belonging to this portion of the marl region, is beheld in Richard's hill, about two miles north of Mullica hill. A loose yellowish sand containing a few of the green grains, and having the depth of about five feet, occurs on top, being underlaid by about seven feet thick of ferruginous sand full of disintegrating shells, casts, and concretions, intermingled with a small amount of the greensand or marl grains. Below this there occurs a brown ferruginous sand, containing a few of the granules, indistinct casts, and cemented lumps or concretions of the same with the calcareous matter of the shells. Beneath all, and nearly at the base of the hill, is a bed of unmixed ochreous ferruginous sand, very yellow. It has been dug by the meadow side, and applied to the soil, but with what good results I know not. By adverting to the section at Mullica hill, to be given next, it will be seen, that this last bed is in all probability the same which lies at the base of the series there, and that to search, therefore, lower in the earth at this place for a purer marl than that half way up the hill, would be to experiment without hope of success, or at least any that could be justified by our present knowledge of the marl stratum in this quarter.

About four miles north-east of *Mullica hill*, a marl is dug in a ravine near the road which leads to Woodbury, which is of a dark green colour, and found to be extremely beneficial upon the land. Analysis shows it to possess the following composition:

| | |
|---|---|
| Silica, | 52.05 |
| Protoxide of Iron, | 23.20 |
| Alumina, | 7.50 |
| Potash, | 11.20 |
| Water, | 5.25 |
| Lime, | *a trace.* |
| | 99.20 in 100 grains. |

*Mullica Hill.*—At the village of this name a fine escarpment, formed by the valley of Racoon creek, exposes an interesting

series of beds through a height of about forty feet. The uppermost deposit of all, is about six or eight feet of diluvial sand and gravel. In the descending order the beds are:

1. A light-coloured bright *greensand*, very free from any foreign substance, if we except a moderate share of greenish clay. It has all the aspect of the light green or upper marl of many other localities, the efficacy of which has been proved in some cases to be equal to that of the darker stratum which lies beneath; notwithstanding which, the farmers of the vicinity deem it to be quite inert, and therefore erroneously call it a clay. It is admitted that very imperfect attempts have been made in using this material as a manure, and I cannot but believe that a too precipitate judgment has been passed upon it; for, as the following exhibition of its chemical constitution shows, it differs but little from many marls of long acknowledged efficacy. Its composition, it will be seen, does display a less than ordinary proportion of potash.

Analysis of Light-Green Sand of Mullica Hill:

| | |
|---|---|
| Silica, | 52.32 |
| Protoxide of Iron, | 27.56 |
| Alumina, | 8.94 |
| Potash, | 5.50 |
| Water, | 5.42 |
| | 99.74 in 100 grains. |

2. A chocolate-coloured bed, in which about one half is the green granular matter and one half a fine clay of a light purple or chocolate tint. This also has all the features of a good marl, though it is not reputed to have any power.

3. A thin seam, not more than a foot in thickness of a dark bluish green marl, *unquestionably* very good.

4. A bed consisting of dark greensand and shells in the state of casts, the shelly matter being all replaced by oxide of iron.

5. A dark yellow ferruginous sand with casts of shells and ferruginous concretions, and a small proportion of the green granules.

6. A dark yellow ferruginous sand, almost entirely free from the grains of marl, and containing no trace of organic remains.

Analysis of the dark greensand of bed No. 4.

| | |
|---|---|
| Silica, | 55.00 |
| Protoside of iron, | 25.60 |
| Alumina, | 7.50 |
| Potash, | 5.24 |
| Water, | 6.00 |
| | 99.34 in 100 grains. |

In the meadows east of Mullica Hill about half a mile, excellent marl is dug from a level many feet higher than the bed of the stream. As far as the general aspect of the surface enables us to judge, the position of this bed is lower than the green stratum in Mullica hill, but whether they are different horizontal beds, or one and the same stratum connected by a slight dip to the east, are points demanding additional research to settle.

The width of the visible marl tract in the neighbourhood of Mullica Hill, is about three miles, but this is a quarter where much more investigation is wanted to bring to light its real extent and the precise nature of the several subordinate beds.

The several beds seen at Mullica Hill are discernible in the same relative positions in various places more to the south-west. At Colston's, four and a half miles off, the marl is very good.

*Woodstown*.—The exposed portion of the marl tract opposite Woodstown is of inconsiderable width, extending from a little east of the village to about one mile north-west of Sharptown, beyond which the stratum no doubt exists, though more faintly visible. In this neighbourhood, as at Mullica Hill, the streams sink rather deep into the beds, and reveal very nearly the same varieties of the marl or greensand. Upon Old-Man's creek, the marl is found as far towards the Delaware as Skulltown, which indicates a wider expansion of the deposit than might be inferred from confining our observations to the exposures upon Salem creek. The marl of Skulltown however, is inferior, resembling closely that which is seen in so many other places as we approach the Delaware. Nothing has yet come to light to prove whether it belongs to the true marl stratum, or whether, as I rather believe, it is an upper bed closely contiguous to the great greensand deposit, but partaking of the composition of the overlying clay.

The excavations at Woodstown are very extensive in consequence of the excellent quality of the material and the circum-

stance that this is near the extreme south-western termination of the marl tract, or at least of that portion of it which lies at a sufficient elevation to be of ready access. The features of the stratum where it is opened in the eastern bank of Salem creek are simple, and such as we have seen to belong to a great number of other localities, more particularly within the southern half of the marl region.

The deposits in the descending series are as follows:

First, the usual covering of diluvium, in which there abounds a considerable quantity of white quartz gravel, and near to the top of the subjacent marl a number of large somewhat rounded blocks of a yellowish sandstone, scarcely to any extent calcareous. It is close grained, and often excessively tough. It has been derived most evidently from a stratum once in place upon the upper surface of the marl, a portion once, I have no doubt, of the bed which still occupies that position in many places not remote. I see every reason to consider it as belonging to the stratum which is known elsewhere as the silicious limestone of Mannington, Vincentown, and other points. It seems to differ from this rock only in the relative proportion of the sand and lime, containing but very little of the latter. At the bridge over Salem creek about a fourth of a mile to the west of the marl pits where these rounded blocks occur, there exists in an undisturbed condition a stratum of rock in the very position here assumed, and of a composition and aspect strictly intermediate between the almost pure limestone, and the above almost perfect sandstone. It lies close to the water's edge, and has therefore been little noticed. It effervesces pretty strongly when tested with an acid, and has in the small way been found to yield a lime when burned capable of slaking with considerable activity. It possesses a yellowish gray hue, showing the ordinary flinty sand which is its main ingredient, and in addition, a trivial percentage of the green granules, which for brevity sake in allusion to their fertilizing action, we call marl.

The next deposit is the light green marl, which however does not overlie the dark green in all parts of the bank, being absent in all the excavations nearest the town. In the banks lower down the creek, as at Mr. White's, the section exhibits a layer of the light green or upper marl four or five feet thick, resting upon

the dark green, here called *blue marl*, from which it is occasionally separated by a crust of cemented ferruginous matter an inch or two in thickness. Mr. White has applied the material of this upper stratum to a portion of his soil without any apparent benefit to the crops, and his sentiment is, that it is destitute of fertilizing powers. In the pits farther up the creek where a thin stratum of it occurs, it is dug, and use is made of it, though the farmers prefer the marl from the darker bed below. To ascertain whether any such difference really exists, and to what it is owing, is an inquiry of much importance to the agriculture of all this district, as the bed in question is the one most accessible for excavation. A comparative experiment should be carefully made between it and the dark marl upon the *same* soil, and care taken that neither marl should fail from the presence of any astringent matter or other known cause poisonous to vegetation. Connected with this should be some chemical analyses cautiously conducted to ascertain what real differences in their composition may prevail. Opportunity has not yet presented itself for these investigations which are necessarily slow. The light green variety shows none of the white efflorescence so common in the darker kind, and as this is usually gypsum, the fact may *help* to explain its supposed inferior activity. It is likewise almost free from the sulphurous odour, nor does it contain any fossil shells.

In the banks nearest the town, we behold only the lower marl penetrated in some places to the depth of fourteen feet, and resting under the gravelly diluvium, from which it is parted by a thin cemented ferruginous crust, a proof of the imperviousness of the stratum to water, and the facility with which the water penetrates the diluvium, and brings down the oxide of iron which it contains. As the covering of diluvial sand and gravel increases in thickness in receding from the creek, it is becoming a daily augmenting obstacle to the uncovering of the marl, rendered serous by the copious ingress of water from the marl itself. I take this place to recommend attention to the advantages to be derived from the application of some simple machinery as a *crane* placed upon the bank above, or a winding machine moved by a horse such as they employ at the mouths of coal pits, for the purpose of more effectually elevating the marl and draining the pit, that it may not be necessary to aban-

don each excavation at the usual trivial depth of ten or twelve feet, and to incur the labour of uncovering fresh surfaces of the marl bed.

In the vicinity of Sharptown, and in two places near Dr. Swing's, upon the road from thence to Salem, the marl stratum is pretty fully exposed, and seems to present almost precisely the same succession of beds as seen at Mullica Hill. The upper stratum invariably consists of little else than the green granules, their colour being a light verditer green, and on drying rarely presents the white crust upon the grains seen in the darker sort. The dark green bed possesses a larger share of dark clay intermingled with the grains; which, according to its hue, imparts different tints to the stratum. The grains themselves are not of a very deep green. In Dr. Swing's neighbourhood, the lower bed alone is used, under the impression, not based upon experience, however, that the other is inert. This lower marl has proved to be highly beneficial, the evidences of which may be seen upon Dr. Swing's farm. Yet this lower bed is apparently identical in all respects with the lower stratum at Mullica Hill, where it is pronounced equally inefficient with the upper. This fact ought to show us how many experiments remain to be made before we can pass a final judgment upon the non-existence of fertilizing properties in any of these marls. The lower bed here contains but few shells. At Woodstown there is one layer containing a prodigious abundance of the *Gryphea convexa*, and a less proportion of one or two other species. Shark's teeth, and the bones of the fossil crocodile are not uncommon. The shells possess but a small amount of lime in their composition, much of it having been dissolved away and its place supplied by oxide of iron, from which they derive their brown ferruginous colour. Their presence is therefore of little or no benefit to the marl.

Four miles to the south-west of Sharptown, the surface of the country suddenly drops twenty-five feet, or more, to a lower level which forms an extensive plain, characterized by a clayey soil, and noted in this section of the state for its greater relative fertility. The same tract borders in a belt of a few miles in width, the Delaware river and Bay, to Cape May. Throughout the whole of this area, in consequence of the very small elevation of its surface above the tide, the marl stratum is scarcely once intersected by ravines or streams; though I entertain but little

doubt that it spreads itself in the south-west direction to the Delaware. At Joseph Bassett's, about four miles from Salem, the marl may be seen at a small depth beneath the surface. It resembles in all respects that which is generally the lower stratum; containing the same mixture of clay, the same shells, and having the same white efflorescence. The principal fossils are *gryphea convexa*, *exogyra costata*, *ostrea falcata*, and several spiral univalves in the state of casts, finely preserved, from which we may justly infer that the stratum is not very wet. Teeth and bones also occur.

The marl stratum may be no doubt probed in places still nearer to Salem, for at the new dam across the creek, about one mile north of the town, the piles when driven down reached a stratum below the mud of the creek, which exactly corresponded, from the description I received, with the marl. The creek here is twenty-five feet deep, so that the marl stratum must lie at a depth of at least thirty feet below the surface of the country.

I have thus brought my observations as far to the south-west as any traces of the marl stratum show themselves. The chief object of the numerous details here given is to furnish hints, possibly of some future advantage to the several neighbourhoods specified, and moreover to awaken in each district a spirit of *inquiry* and *experiment*, which, should it ever be aroused to a vigorous activity, must sooner or later be productive of the greatest benefits to the whole marl region and to the state at large.

### On the proper mode of correcting the noxious effects of the spurious marl, or astringent clay, and of employing it as a substitute for the true marl.

From the descriptions of this stratum already presented, it appears that the action of this astringent mass upon the crop is decidedly pernicious, when the material is employed in any amount beyond the most stinted doses; and the cause of its poisonous property would seem, judging from the chemical analyses made, and from other evidence, to be attributable to the acid reaction of the astringent ingredients which it possesses, namely, the *copperas* and *alum earth.*

Copperas, though a neutral salt, is well known to chemists to exert an *acid reaction*, and hence we are not to be amazed that

a clay having it in such obvious quantities, should act in a way to burn, or more strictly, to *poison* the vegetation. Knowing, as we now do, the source of the deleterious properties of the clay, a few simple correctives suggest themselves, and such as any one wishing to use this substance as a substitute for marl may adopt.

My first recommendation to the farmer who is about to make use of this clay upon his soil, is, that he be careful to select, when he has the choice, that variety which contains the green granular material of the true marl, and to avoid altogether, unless indeed good marl be very remote from him, the kind which is wholly destitute of this substance. When the green grains are numerous enough in the mass, as they are near Spotswood, Burlington, Camden, and generally upon the north-west side of the marl tract, I would then advise its use, but guarded by the following precautions. Let the clay be dug several months before it is to be scattered on the land, and let it be spread out in broad, *shallow*, flat heaps, where the rains may soak through it and carry away the copperas and alum earth, which it is presumed from their well known solubility will be easily dissolved and washed off. The green mineral does not dissolve in water, and hence, while the rains will purify the mass, no loss of its more active portions can happen. Numerous attempts at using this clay as a marl have shown, that though noxious at first, it is often permanently beneficial to the land, after the second, third, or fourth year; a fact which I attribute to the gradual escape of the astringent matter by the rain. Though I do not think that the exposure of even an entire winter will always suffice to rob the clay of all the sulphates (copperas, &c.) which it may contain, yet it bids fair to do much good and therefore deserves a careful trial.

I have to offer another, and I think, far more promising suggestion, for making the better portions of this stratum beneficial in their effects upon the soil. Chemists are aware that both the sulphate of iron and the sulphate of alumine, are decomposed by *caustic lime*; and the antidote I propose is founded upon this fact. My recommendation is, to add to every heap of this spurious astringent marl, a small quantity of *freshly burnt lime*, and to mingle

them thoroughly together. The sulphuric acid of the copperas or alum earth, or of both if present, will pass over to the lime and form sulphate of lime, (*gypsum* or *plaster*,) the value of which, as a stimulant to vegetation, is well understood; the other ingredients, the oxide of iron and clay, will on being liberated contribute also towards improving the texture of the soil should it be sandy. A bushel of lime to every hundred bushels or five tons of the mass, will in most cases be sufficient to neutralize all the astringent matter present, and to convert it into, or rather replace it by, *gypsum*. The dressing of an acre of such a mixture will contain of the green marl, of gypsum, and of uncombined lime, or more truly lime now in a state of carbonate, in all probability fully enough to impart to the soil a most decided improvement in its fertility.

Lastly, I would recommend, for this astringent marly clay, the same course so long pursued in Europe in regard to lime; I mean the practice of making *a compost* of the substance with the common *manure of the farm.*

It would be justified, like the former suggestion, by good chemical reasons. In the fermentation of animal manure, *ammonia* always escapes in greater or less quantity, and ammonia, like lime, has the power of decomposing the sulphates of iron and alumina. In this case, however, gypsum is not a product.

From what I have here said, it will be obvious, that when a field has been made *sterile* by the indiscreet use of this caustic clay, a ready and certain remedy will be found by spreading upon every acre a few bushels of newly made lime.

Should these hints, which are designed to bring into use, as a marl, certain portions of this upper stratum, receive their final corroboration from experience, we may consider that the area of the region susceptible of improvement by marling without the expense of hauling the material from a distance, has been in many districts doubled or tripled in extent. To ascertain whether the clay possesses a sufficient share of the green granules to warrant a trial of it upon the land, it may be necessary to employ the aid of a small *magnifying-glass*, which will be found by every farmer to be of indispensable use in the discrimination of all greensand marls.

DIRECTIONS FOR TIME SELECTION AND PROPER MODE OF APPLYING THE GREENSAND MARL.

In seeking for the marl stratum in neighbourhoods where it is supposed to occur, but where a covering of any of the superficial deposits obscures it, the primary point to be remembered is, that the true marl is the lowest deposit of the region. We should find out, therefore, the *deepest depressions* of the land, as the meadows and natural ravines, and by the use of an auger or other instrument for probing the ground, several feet in length, we may very frequently ascertain whether the stratum lies sufficiently near the surface to be easily and economically uncovered. A pretty sure guide to the marl may be found in some places from the aspect and composition of the earth upon and near the surface. Should it be at all *greenish*, or contain, on close inspection, any of the green granules, the probability is pretty strong that the marl lies beneath, at a very moderate depth, and the likelihood of this is augmented when we find our borings bring up an increasing proportion of this mineral as we descend deeper. I have repeatedly found the position of the marl stratum indicated by the trickling forth of the water from the foot of a bank, for the water is almost invariably seen to issue along the top of either the dark clay or the true marl.

For judging of the quality of a marl by observation, some familiarity with the multiform aspects which it puts on is indispensable. The leading rule, however, is, to bear in mind that the fertilizing efficacy of the compound, resides in the minute round greenish grains which compose more or less of it, or sometimes all of it, and that it seems, moreover, to be dependant upon the proportion which these green grains contain of those powerful alkaline stimulants to vegetation, *potash* and *lime*, but more especially potash. The first thing then, is to approximate to the relative quantity of the green grains in the whole mass, and this may be effected, to a greater or less degree of accuracy, in several ways. The simplest and surest method is to employ a small pocket magnifying-glass (a common burning-glass will answer), and to make the eye familiar as soon as possible with the dark green grains, so as to distinguish them at

once from other dark varieties of sand which sometimes occur associated with them. A little practice will very soon enable one to use the glass expertly, and to arrive at a pretty true estimate of the probable percentage in which the green grains may exist. But as these granules cannot sometimes be distinguished from the grains of ordinary white flinty sand, or from other kinds, in consequence of the particles being *all alike coated* with a thin film of the dark cementing clay, it will be useful to devise some method of bringing out under the magnifier their different characteristic traits of colour and form. Let the mass be washed in a large glass tumbler, and repeatedly agitated with the water, until as much of the clay as possible has been detached from the grains. After pouring off the turbid water by repeated rinsings, and permitting it to settle until clear, we may estimate the comparative quantity of clay in different marls by the relative amount of sediment which subsides. If we wish to be more accurate, we can weigh out a given quantity of the marl, then pursue the above plan, and decant the clear water from the clay, and after thoroughly drying the clay, weigh it to ascertain its amount. Having got away most of the clay, we should spread out the granular matter upon a sheet of paper and dry it, when there will be no farther difficulty in distinguishing, by their colour and lustre, the foreign impurities, from the grains of the true marl, and also of estimating the relative abundance of each. When the marl to be examined contains much clay, I would recommend the experiments to be made upon a regularly weighed quantity, weighing both the clayey and the granular portions. A delicate apothecary's balance will commonly be found accurate enough. Another more expeditious, though less accurate method, is merely to dry the marl, and spread it extremely thin upon a sheet of white paper, and then to hold it near a window or in the light, and to examine it carefully by the magnifier. The flinty sand, though stained with clay, may then be clearly discerned, in consequence of its transparency, whereas when we inspect a solid lump, all the particles upon the surface are nearly alike dark.

A good suggestion is, to place a portion of the marl upon a hot shovel or on the top of a stove, when all the marl grains will change from their ordinary green to a light red or brick colour, while the other materials of the mass sustain little alteration. This

will often make it obvious to the naked eye in what proportion the green grains are present.

When there is a yellowish or whitish incrustation upon the marl in a bank, after the *moist* surface has remained for some time exposed to the weather, it is indicative of the existence of a portion of copperas or alum earth, the hurtful nature of which has already been explained.

An astringent inky *taste* will very often detect the presence of these noxious substances at times when no such efflorescence shows itself. If the quantity be too small to betray itself distinctly to the palate, and we are still in doubt as to their presence, other more rigorous tests are within our reach, and as these astringent matters are so unquestionably pernicious in their action, it must be of importance to have the means of determining in what proportions they abound in different marls. This can be effected with precision only by a systematic chemical analysis, but their existence can be made to appear by the following test. Put a small portion of the marl in a flask or other thin glass vessel, pour upon it some pure water, and heat it moderately. After causing the water to dissolve in this way as much as possible, remove the heat, and let it settle, then decant the *clear* fluid into some glass vessel, such as a wine-glass. If there has been any copperas present, it will be proved by adding to the fluid a little lime-water, which will produce a milky turbidness, that after a little while will become stained of a yellowish-brown colour. The milkiness is owing to the formation of gypsum, and the brown colour to oxide of iron from the copperas. Or in lieu of this, add a solution of oak bark, and if copperas be present, we shall have a dark inky colour at once produced.

A good marl will, upon being squeezed in the hand, fall asunder again rather than bake into a tough doughey mass, and upon being left in heaps to dry will retain a light grayish green colour and be extremely *crumbly*. It seems to be a very general characteristic of the better class of marls, that they throw out a white efflorescence or crust, upon those grains which are most exposed to the air. Hence the very light colour externally, which some heaps of marl possess. This crust I have already shown to consist of the sulphate of lime (gypsum) and carbonate of lime, but much more usually of the former. A drop or two of

strong vinegar or any strong acid will produce an efflorescence or *frothing* if it be the *carbonate* of lime, and should nothing of this kind take place, we may set it down to be *gypsum.* Of course, from the minuteness of the quantity of the white coating, much care and nicety of observation are demanded in doing this, in order to avoid erroneous conclusions.

I do not state that marls equally good with that kind having the efflorescence do not very frequently occur and exhibit none of this white incrustation.

It does not seem that any general rule can at present be safely given for distinguishing the fertilizing properties of a marl by its *colour.* The truth of this must appear from what has been said about the peculiar shade of colour being so frequently owing to the colour of the intermingled *clay.* When the mass, however, is comparatively free from clay or common sand, and consists of little else than the single material, the greensand, my observations go to establish that the rather dark green variety is more potent in its effects upon the land than the very light green which sometimes overlies it.

The presence or absence of shells I look upon to be a point of but little moment, for I find that several of the most active marls in the region, show no traces of fossils in them. The whole amount of carbonate of lime in the shape of fossils, and in that of the occasional white incrustation upon the grains, can in very few instances amount to *one per cent.*, while as my analyses show that the lime chemically combined with the other ingredients in the green grains, is sometimes as much as *ten per cent.*, and that the potash amounts almost to *fifteen per cent.*

There yet remains, however, the most important, and by far the most difficult inquiry; namely—into the *exact* constitution of the green grains, in order to determine the percentage of the several ingredients—or in other words, the richness of the marl in *potash* and *lime*. I had entertained hopes, that the external aspect of the grains might perhaps depend in part on the presence and proportion of these bodies, and that *mere inspection*, after multiplied analyses were made might enable any one with certain directions, to inform himself whether a marl abounded in these essentials or not. But, I find that so far from being a mineral of definite and constant proportions, as some mineralogists have regarded it; the greensand is in fact a compound, which fluctu-

ates widely in its external characters and in its chemical composition. The page of analytical results which I present, will serve abundantly to prove this. It is manifest therefore, that we possess no other shorter guide to discover the quantity of the potash and of the lime when this is present, than to subject the marl to a systematic chemical analysis. Very possibly when these experiments have been once sufficiently multiplied, we shall arrive at some connexion which has not yet suggested itself between the composition and the external appearance of the grains of marl. In the meanwhile, though both laborious and tedious, a separate investigation seems to be required for *each separate variety* of the substance, before we can be aware of the precise amount of its most efficient ingredient, the *potash.*

Though it is not presumed that among those engaged in agriculture, more than a very few persons possess the requisite chemical skill, or the facilities for this species of research; yet for the sake of enabling those to execute it, who may chance to be competent to this kind of analysis, I have thought it well to introduce a statement of my method of analyzing the mineral in question. Several plans, modifications of the same general method, have been tried for the purpose of arriving, if possible, at some mode sufficiently simple to make it practicable by those who possess but a limited knowledge of chemistry. But the nature of the compound seems not to admit of either a very direct or expeditious course of operation, and though practice has taught me the steps which are the most certain and least operose in the case; I can hardly hope, that the analysis of the green marl can at present be brought within the skill of such as are not already professionally familiar with this laborious and intricate art.

*Method of analyzing the greensand.*—(*a*) Digest the mass in a flask of pretty strong muriatic acid, by a sandbath heat for at least three days, or boil it actively for five or six hours. Everything is dissolved but the *silica* which must be filtered, ignited, and weighed. (*b*) Precipitate the *oxide of iron* and *alumina* by ammonia and estimate them together, or detach the alumina by *caustic potash.* (*c*) Evaporate the ammoniacal solution to total dryness and heat the mass to incipient redness, to expel the muriate of ammonia. There remain the chlorides of calcium, magnesium, and potassium, which redissolve in water, dividing the liquor. (*d*) To one half add oxalate of ammonia, and separate the lime, then by ammonia and phosphate of soda separate the *magnesia.* Subtract the combined weight of these two computed as chlorides, from the original triple chloride, and we have the *chloride of potassium.* (*e*) Now evaporate the other half again to dryness and dissolve up all the chlorides of calcium and magnesium by *alcohol,* and dry and weigh the residual chloride of potassium. If further cheek is necessary, convert this into chloroplatinate of potassium and estimate the potash from this.

# PART II.

GEOLOGY OF THE COUNTIES OF SUSSEX, WARREN, HUNTERDON, MORRIS, BERGEN, SOMERSET, ESSEX, AND PART OF MIDDLESEX.

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## PRELIMINARY REMARKS.

I PASS on now to the results which have been obtained from an examination of the stratification and the mineral deposits of the formations comprised in the northern section of the state. Since these refer themselves as before stated, to the primary rocks, and the lowest group of the secondary series, containing few organic remains, it is next to impossible to say confidently, with what rocks in the European scale, the mass of the strata in this region should be classed; though the few fossils that have been procured and studied, make it clear, that the most recent among them are of a date as ancient at least, as the upper beds of the Grauwacke formation. To attempt, however, to trace these affinities of age is, I conceive, in the present state of our knowledge, a premature and profitless task; and the allusions made in this report to supposed correspondence in period between our rocks and certain strata of received names in Europe, are rather to assist the reader in forming a general conception of the nature of our formations, than to discuss in this place the question of what are their *European equivalents.*

The older formations of the state occupy the whole of the counties of Warren, Sussex, Hunterdon, Morris, Bergen, Somerset, and Essex, with a small part of Middlesex.

This large area may be conveniently divided geologically into three distinct regions. The most northern is embraced between the New York boundary line, the Delaware river, and an irregular line tracing the northern base of the chain of hills, which in

Pennsylvania goes under the name of the South mountain, and in New York under that of the Highlands. The next or middle region, is meant to include the various ridges and spurs of this chain, some of which are, Scott's mountain, Musconnetcong mountain, Jenny Jump, Schooley's mountain, Trowbridge mountain, Walkill mountain, Green Pond mountain, and Ramapo mountain. I shall venture, for brevity sake, to call the whole district by the name of the Highlands of New Jersey.

The third, or southern region, comprises all the country between the last mentioned and the line before traced, as forming the limit of the more recent horizontal clays and sands. Limestone, slate, and white marl characterize the first; granitic rocks and magnetic iron ore, the second; and architectural sandstones, shales, and ores of copper, and trap rocks, the third.

These three geological regions will be described in the order here sketched. After stating how much has been ascertained, respecting the range and extent of each formation, and its relative position to the other strata; the more minute details regarding particular localities and such points of a practically useful nature as may have come to light, will be given.

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## CHAPTER I.

### *Northern or Blue Mountain region.*

### SECTION I.—*Of the Limestone and Calcareous Sandstone formation of the Delaware, in Sussex.*

It will be seen by reference to profiles No. 1 and 2, upon which I have represented the relations and positions of the strata in Sussex and Warren, that the rocks of the region adjoining the Blue Mountain, both upon its north-west and south-east, and in the mountain itself, all decline at pretty nearly the same angle or steepness to the *north-west.* It is believed that this is the prevailing direction of the dip throughout nearly the whole of that which I have called the Blue Mountain region. Pursuing the *descending order* in our description of the individual formations, we commence of course with the uppermost strata, or those lying

farthest to the north-west, that is, with the formations contiguous to the valley of the Delaware river.

*Description*.—This which is the most fossiliferous formation in the upper half of the state, may be described as a triple series, consisting of a dull bluish slaty limestone, abounding in organic remains; a bluish, sometimes reddish, calcareous slate or shale; and a gray and sometimes slaty sandstone.

It is probable that these several varieties of rock alternate variously with each other, though the limestone seems generally to occupy the uppermost place in the series.

*Range and relative position*.—The group of beds now before us, follows in a nearly north-east and south-west course, the valley of the Delaware river, keeping parallel to the Blue Mountain, and being distant from it between three and four miles. It may be traced in pretty nearly a straight line, from Carpenter's Point, to the Wallpack Bend, where the ridges consisting of these strata cross the river, and the whole formation is thrown upon the Pennsylvania side. In New Jersey, therefore, this formation is confined exclusively to Sussex county. Its greatest width, which is about four miles, is opposite to Milford. If we follow the stream called the Flatkill, from its mouth at Wallpack bend, to the source of one of its branches, the Little Flatkill, we shall trace very nearly the south-eastern edge of this formation. Low down on the Flatkill, and also on the river, from Dingman's ferry, to the bend, the stratification of these interesting rocks may be studied with great facility. Their prevailing dip is to the north-west, at an angle to the horizon of thirty degrees. The course or bearing of the strata is almost precisely north-cast and south-west.

The relations of these rocks to the strata of Pennsylvania, more particularly to the anthracite coal formation of that state, seem to establish the point that they occupy an *inferior position* to the series of the coal region. This I have been able to determine from some investigations made at a former time in that quarter; when I found a formation in all respects similar to this, holding a position underlying all the strata of the anthracite series. There would appear in fact to be but little doubt that the group of calcareous deposits, here described, is prolonged to the south-west, crossing the Lehigh five or six miles below

Mauch Chunk, and the valley of the Schuylkill, near Orwigsburg. In those districts we may see the same fossiliferous beds, having such a relative position to the red shale and siliceous conglomerate, of the anthracite formation, as to make it pretty evident that they pass beneath them. If such be the fact, it is then obvious that any formations equivalent in age to the anthracite coal must lie to the north-west of this group as it occurs in New Jersey; in other words, that the state possesses no rocks of a period so recent as to embrace the coal.

This conclusion, deduced partly from a comparison of the fossils which identify this series of rocks, in their range from the Delaware to the Schuylkill, but more especially from an inspection of the direction of dip in the several strata from the Blue Mountain to the Anthracite Coal itself, is a determination of some utility, as tending to dissuade those, who are misled by appearances, from renewing their fruitless search for coal in the formations of New Jersey.

Such seem to be the relations of these calcareous rocks to the overlying or newer deposits on the north-west. In regard to the strata upon the south-east, that is to the beds composing the Blue Mountain, there is every proof that those belonging to the formation in question, repose in parallel arrangement upon the red sandstone and coarse gray grit of that Mountain at its northern base. This is clearly recognized in the valley of the Flatkill near its mouth, where, along the northern bank, the limestone is seen in its usual dip to the north-west, and the red sandstone in a spur of the Blue Mountain, is seen dipping into the bed of the stream, to pass beneath the limestone. The same position of things may be discovered about a mile north of the Water Gap, where the red sandstone dips to the north-west, and descends beneath the gray sandstone of the other series.

There is one striking feature possessed in common by all the beds, either calcareous or not, of this formation. I allude to that remarkable oblique, or slaty cleavage, or false stratification, so common in most slate strata, and which sometimes throws considerable doubt in the way of ascertaining the true dip of the rock possessing it. It this instance the structure is well calculated to deceive one not upon his guard, but I am well satisfied that the direction of the dip exhibited in profiles No. 1 and 2, is correct,

from having verified it by examining the position in which the flat fossil shells lie in regard to the surfaces of the rock. All flat shaped bodies deposited by gravity upon a material obviously once a sediment from water, must lie with their surfaces conforming to the surface of the deposit, and to whatever inclination the whole may afterwards have been uptilted, the direction of the dip in the shells or fiat pebbles, if any, will denote the general dip of the mass. The oblique cleavage in all the beds of this formation, obeys one common rule, facing invariably to the same point, the south-west, and at an angle of about sixty degrees to the plane of true stratification. These facts are mentioned to put those who may at any day study these formations, on their guard, as the structure alluded to is very common, and as the erroneous inferences it might conduct us to, would inevitably falsify some of our more practical deductions.

*Fossils*.—The organic remains of this formation seem worthy of particular study by geologists, from the circumstance, more especially, that it is the oldest rock in New Jersey and Pennsylvania, in which any considerable catalogue of species is likely to be found. There are other fossil-bearing strata still lower in the series, but the organic remains seem few, and the individual specimens sparsely scattered. Being, moreover, the nearest formation of the kind to the Anthracite coal, the investigation of these fossils seems indispensable in determining the epoch of that formation, or in comparing any of our old rocks with the corresponding strata of Europe. Towards this point little or nothing has been done to promote so desirable an end in the geology of our Atlantic states.

The more abundant shells belong to the genera Productus, Spirifer, Unio, &c.; the zoophytes to cyathophyllum and several others, and I have found more than one undescribed species of trilobite. Upon the sandstone beds of the formation there is a fossil impression often very abundant, which I have hitherto seen nowhere but in New Jersey. It may be described as a circular disc, often a foot in diameter, of radiating arched fibres, curving outwards from the centre, always in the same direction, like the hair parting on the crown of a man's head. It suggests the idea of being of vegetable origin, though all is uncertainty about it.

Still it furnishes a mark to recognize this formation by, in its course through the states south-west and north-east of New Jersey.

*Mineral Contents*.—The limestone part of the formation is to be regarded as the most valuable of its materials in the economical way. Certain beds, especially in the district along the river, from opposite Milford to below Dingman's ferry, furnish a lime of very good quality. Much discrimination may be shown in selecting the most calcareous varieties of the rock. My present impression is, that the most calcareous beds are those having the largest number of coral-shaped fossils (zoophytes,) while the more slaty sort exhibit a greater proportion of *shells*. I do not lay this down as ascertained for the whole tract, but confine the observation rather to the country opposite Dingman's ferry, that is to the vicinity of Profile No. 1.

In the flat alluvial lands which lie along the river, or rather, just where these rest against the base of the limestone, where it bounds the valley, there occurs in one or two localities, a deposit of travertin, a material of much value to any neighbourhood requiring a superior lime. This excellent variety of limestone is a deposit from the waters of the limestone hills just above; the springs, as they traverse the rock, dissolve a portion of the carbonate of lime, and afterwards precipitate it, in coming into the open air. Little has been done, as yet, in tracing the extent of these deposits, but it may be a useful hint to those interested in discovering the travertin, that it is to be found only in the low grounds, receiving the springs which issue from the limestone part of the formation.

This travertin is a yellowish, somewhat porous, concretionary limestone, burning into lime with great facility, and yielding a material of great purity and beautiful whiteness.

The water deriving it from the limestone, dissolves of course only the carbonate of lime, and leaves behind the insoluble impurities of the rock; hence its superior value for making good lime. It usually lies in thin beds in moist meadows, covered by a few feet or inches of earth, is easily dug, hardens by exposure to the air, and makes oftentimes a very excellent building stone.

*Agriculture*.—*Applications*.—The soils of the entire belt of country embraced between the Delaware and the Blue Mountain, are destined to be extensively benefited by the introduction of lime from these two sources, the fossiliferous limestone rock and the travertin. The fertile alluvial plains, along the river, consist of a soil which experienc has shown to be every way susceptible of great improvement by lime.

The more gravelly soils in the valley of the Flatkill, and the poor uplands of the hilly part of the district, would derive essential benefit from the introduction of this lime, which, from the more arable portion of the region, is in hardly any place, more than three or four miles distant.

The corresponding part of Warren county, though it contains no limestone, is most easily within reach of benefit from the same source, as the calcareous rock lies directly opposite on the Pennsylvania side, the whole way along the river to the Water Gap.

Black oxide of manganese, a material used in the manufacture of bleaching salts, and in other chemical operations, also in glass-making, occurs near Milford in this region, though little information was collected regarding the deposits of this mineral.

*Desiderata*.—What is most wanted in regard to this formation, is a fuller study of its fossils, and a minuter delineation of the limestone strata, including the deposits of Travertin.

## SECTION II.—*Sandstone Rocks of the Blue Mountain.*

*Range and Extent*.—It is not practicable at present to designate precisely the area comprised by the Sandstone Group in question, farther than to specify that the Delaware river from the Water Gap to Walpack bend, and the valley of the Flatkill, from thence up to its source, indicate pretty nearly the division line between these rocks and the group last described, while upon the other side, the south-eastern base of the mountain, wherever I have yet explored it, makes the boundary between them and the slate and limestone formations of the valley.

The average width of this sandstone region is not considerable, and at the widest part, which is seemingly north of our profile No. 1, or near the line of the Turnpike to Milford, it proba-

bly does not exceed four miles. The main axis and secondary parallel ridges of the Blue Mountain, comprise nearly the whole of the area occupied by these rocks.

Their dip is commonly or almost universally to the north-west, though, as the mountain is double or triple, it is probable that local contortions of the dip may occur. The angle of inclination to the horizon may be stated at about 30°, but what the entire vertical thickness of the strata may be, has not been sufficiently determined.

The strata run very nearly north-east by north, and south-west by south.

*Description*.—The rocks of the Blue Mountain series, consist chiefly of two well-marked varieties of sandstone. One is a fine grained compact sandstone of a pretty bright red, being nearly all siliceous matter, with the exception of the colouring matter, (oxide of iron). The other is a gray, coarse grained, and extremely hard quartzose rock, the sand and small fragments composing it, consisting chiefly of semi-transparent vitreous quartz. Sometimes it has the character of a conglomerate. The materials seem rather united by firm and intimate adhesion, than by any interposed cement.

The red sandstone beds hold the uppermost position, and constitute therefore the rock of the north-western base and flank of the mountain. They, in fact, seem to be much the most extensive, stretching into the plain beyond the mountain, forming most of its spurs, and rising often high into the principal ridge itself. The other, or gray sandstone, forms, wherever I have witnessed a section through the mountain, the mass of the main ridge, from its eastern base to its summit. Dipping conformably beneath the red sandstone, the gray rock appears in a bold and steep escarpment in many places along the south-eastern side of the mountain, which, in consequence of the dip, is the steepest side of this range throughout nearly its whole course. The relative positions of these two rocks, their dip, and other features, are finely exhibited in that beautiful natural scene, the Water Gap of the Delaware. Here the gray sandstone attains, in the crest of the principal or eastern ridge, (for the mountain at this place is double,) the elevation of fourteen hundred feet, and continues

its truly striking levelness of top, for many miles to the north-east.

The straightness of the mountain top, the regularity of its grand eastern escarpment, the uniformity in the direction of the dips, all suggest to the beholder the wonderful equality in the intensity and direction of the mighty forces, which, exerting themselves from within the earth, uplifted this thick series of rocky strata.

The red sandstone beds may be seen to dip beneath the fossiliferous limestone formation, both at the Water Gap, and as before stated, near the mouth of the Flatkill at the Walpack bend.

An interesting feature in this red sandstone, is its retaining a decided tendency to the same oblique cleavage noticed in the rocks overlying it; and it seems somewhat the more remarkable, as the rock shows nothing of the composition of a slate or shale. The direction of these joints is the same, as in the limestone and slates above. A disposition to the same sort of cleavage, is observable in nearly all the other strata, as well the limestones as the slates; which, as older members of one extensive series of rocks, occupy the region between the blue mountains and the primary hills, ten or twelve miles to the south-east. This feature in common, together with their remarkable conformity of dip, are amongst the facts which induce me to regard the whole group spoken of, as belonging to *one* epoch, and as produced by one class of causes, continued with but little interruption.

The gray sandstone of the Blue mountain, is almost the only rock in the whole series, which displays none of this slaty subdivision; and this is perhaps mainly owing to its consisting so entirely of coarse quartzose particles, which would certainly be greatly in the way of its assuming this structure.

*Useful Materials*.—The most valuable use to which the sandstones may be put, would seem to be building. To this they are far from being ill adapted, both from their uniformity of texture and their regularity of stratification. In employing the red sandstone, care must of course be taken, to reject the beds abounding in the oblique cleavage above mentioned. For bridges, the gray kind would be well adapted, from its solidity and indestructability by frost or the elements.

The formation before us has furnished several localities, where

copper ores in small amount occur; but the anticipation of finding any useful quantity of copper in this region, must ever, I think, prove illusive. At an early period in the settlement of the country, two or three openings were made into the western base of the Blue mountain near Pahaquarry; but I cannot learn that anything was procured to repay the enterprise, or authorize its prosecution. The mine holes are now obstructed, but specimens of the ore which I have examined, presented nothing about them to warrant renewed exertions in developing the mine.

The copper ore, in the state of gray sulphuret and carbonate, occurs mingled rather promiscuously throughout the substance of the ordinary rock of the mountains, the gray sandstone.

Nothing upon the specimens seen denotes the presence of a vein of ore, as all the minerals which usually compose the gangue in a vein are absent, and the sandstone rock is hardly changed in feature. Symptoms of copper ore, likewise occur in the gorge of the mountain at the Water Gap, but they are much more insignificant than those mentioned above. These sandstones of the Blue mountain, in no respect bear the character of a metalliferous formation, being traversed by no veins of any kind yet discovered, and even showing little disturbance of dip.

In the valley which divides the mountain into two ridges at the water gap, and about two miles and a half from the river on the Jersey side, a spot has been found containing very excellent hematite iron ore. In what quantity the ore exists, has not yet been ascertained; though the impression prevails that the Blue mountain contains in many places, iron ore in sufficient quantity to justify a more minute examination.

There are current throughout this Blue mountain region, various stories of localities of silver and other precious minerals; but such tales will be listened to only by the over-credulous, as everything in the geological structure of the district must indicate to persons at all versed in mineralogy and mining, the very slender probability of there existing in this place, any mineral treasures of this nature.

## SECTION III.—*Lower Limestone and Slate Series of Warren and Sussex.*

*Range and Extent*.—The group of rocks which next presents itself in the descending order, or, which is the same thing, in our course across the strata to the south-east, comprehends several alternating strata of slate and limestone of great apparent thickness. The eastern base of the Blue Mountain seems to bound them on the north-west, while their south-eastern limit is the much more irregular line marked out by the range of primary hills commencing at Easton, on the Delaware, and embracing Marble Mountain, Scott's Mountain, Jenny Jump, Pimple Hill, and Pochuck Mountain, to the New York boundary line.

The average width across the strata, of the present group, is about eight miles, though This breadth is greater near the dividing line of Sussex and Warren, and considerably less between the Wallkill and the Blue Mountain, measured near the dividing line of New York and New Jersey.

The prevailing dip of the beds is towards the mountain, that is to the north-west by west, though there are occasional disturbances in the opposite direction. The general bearing of the strata is north-east and south-west.

*Description of the several Strata*.—The series consists of at least two slate and two limestone formations, in apparently regular alternation. Between Sparta and the Blue mountain at Culver's Gap, the alternations appear more numerous, there being at least three that are slate and slaty sandstone, and three limestone strata.

The line of contact of these several formations, I have found it somewhat difficult to trace, except in the neigbourhood of the profiles No. 1 and 2, and not even there with invariable success, in consequence of the want of sufficient time for researches of this minute nature.

For the present I must speak hesitatingly, therefore, in regard to the relative position of these beds in two or three cases. I look upon it, however, as pretty nearly ascertained, that the newest or uppermost of these strata are those adjacent to the Blue

Mountain, and that as we advance to the south-east, we pass into others which will be found to rise from beneath those which we have left. Taking this view of their order of stratification, the first stratum to be examined, is the *slate*, which lies immediately adjacent and parallel to the eastern base of the mountain.

*First Slate of the Great Valley*.—This rock, where it crosses the valley of the Delaware river, below the Water Gap, is about two miles wide, being traceable from the foot of the Blue Mountain, to within about a mile of Columbia. In its course to the north-east, it seems to expand in width, entering further into the valley, on the boundary line of Warren, and on the Hamburg and Milford road, occupying a belt of between four and five miles wide from the mountain to Deckerstown. As far as the practical uses of the rock are concerned, it varies materially in its composition. In several parts of Sussex it is almost too arenaceous to go under the name of slate, and would be called a slaty or argillaceous sandstone. Throughout much of its course it is the ordinary dark blue argillaceous slate, with little or no firmness of texture or regularity of structure.

Adjacent to the Delaware, however, it possesses both the coinposition and the cleavage of the best roofing and writing slates. As mentioned before, the dip at this place is to the north-west, or into the base of the mountain.

The oblique cleavages, or in other words, the surfaces, by which the rock is split into slates in manufacturing, are at an angle to the dip, and are directed always to the south-west. Quarries have been opened in this formation, for the manufacture of slates, both upon the New Jersey and the Pennsylvania sides of the river, and in both places the texture of the material fits it admirably for making both superior writing and roofing slates. When the quarry on the Jersey side shall have been more extensively wrought, there is little doubt that it will exhibit an inexhaustible deposit of this substance. It possesses a closeness and evenness of grain which adapts it well to the production of the finer sort of slates. Nothing is wanted in the way of precaution but more attention to the mode of opening new quarries, as there frequently occur (as at the Water Gap) *faults* or interruptions in the regular stratification, which, if not studied upon a

right theory of their nature, may militate seriously against the success of the quarry.

I see no reason why the formation before us may not contain, in other sections of its course along the base of the Blue Mountain, subordinate strata, having the compactness, uniform grain, and regular cleavage, essential to give value to the rock, as a slate. This is a point, in reference to the group of rocks before us, in which, for the economical results of the survey, a much more minute examination of the district is greatly wanted.—Tolerably good slate does occur, it is believed, in Pennsylvania, in the same formation.

### FIRST LIMESTONE FORMATION OF THE VALLEY.

*Range*.—Immediately adjacent to the band of slate just described, we find a limestone of considerable width, being in some places a mile and a half or more across its outcrop. Its exact course, from the Delaware river, near Columbia, towards the north-east, has not yet been satisfactorily traced, though a limestone possessing its supposed geographical position, has been crossed in several places, both in Warren and Sussex. It may be stated, however, without much risk of error, to range from the river, where it occupies about the breadth of a mile, above the village of Columbia, in a direction nearly parallel with the general course of the Paulinskill, keeping chiefly on the north-west side of the stream, and extending to the source of the Papakating creek, north-east of Augusta, in Sussex. This limestone belt shows itself at Stillwater, in Warren, and from thence is traced past Swartwout's pond, to Augusta; but beyond this, further towards the north-east, it soon becomes lost, either thinning out entirely between the two adjoining states, or merely disappearing, for a certain space, beneath the meadows of the Papakating. The limestone which shows itself east of Deckerstown, in Sussex, though not out of the range of this stratum, seems to belong to another rather wider band, which passes by Lafayette and Newton, and which is separated from the first by a tract of slate at Newton, nearly two miles wide, referable, I believe, to the second slate of the valley, or that which extends

in breadth down the Delaware, from Columbia to the vicinity of Belvidere. In the neighbourhood of Swartwout's pond, it is embraced in width between the north-west side of the pond and the valley of the Paulinskill, on the Sparta and Milford road; its width at Augusta is nearly two miles, extending from one and a half miles below Branchville, to one mile below Augusta. In the vicinity of the pond, and from thence nearly the whole way to Augusta, it forms a number of low parallel ridges, trending north-east and south-west. Its more usual dip, in this quarter, is towards the north-west, but this direction is by no means constant, and as the rock is traced still further to the north-east, it is there seen to be somewhat disturbed, and north of Augusta, on the lands of William Gustin, its dip is to the east-south-east. Over the last few miles of its length here traced, the north-western edge of the stratum seems to be along the base of a rather bold cultivated ridge, which is interrupted at Branchville. The same ridge, to the north-east of that village, exhibits the limestone at its base and for some distance up its eastern side. Beyond this place it has not, as before said, been traced, and though it may possibly even cross the line of Profile No. 1, it certainly does not display itself north-west of Deckerstown. Its position at the base of this ridge, which passes Branchville, and the fact that it here dips, as it generally does, to the north-west, or towards the slaty sandstone, which composes the main mass of that ridge, are among the inducements I have to regard this limestone as underlying the other rock, which has been already described, as the first slate of the valley.

*Description*.—The rock is a rather light blue limestone, of variable purity, in which as yet no fossils have, to my knowledge, been detected. It has a tendency, like nearly all the strata above it, to the slaty cleavage, which, however, is by no means an universal feature in it. This point, together with the details about its dip, are mentioned for the assistance of all those who may undertake to quarry the rock for useful purposes, as inattention to these matters proves a fertile source of disappointment in the opening of stratified formations.

*Useful Materials*.—Besides the limestone itself, the purer kinds of which are burned into lime at Columbia and other places

along the range of the formation, there occurs near Augusta a variety of the rock, having all the character of a very handsome ornamental marble. The locality alluded to is on the farm of William A. Gustin. The limestone is penetrated in every direction by injections of light and dark green serpentine, often intimately mingled with the original rock so as to impart a great variety of beautiful and delicate shadings; very minute cubical crystals of bright yellow sulphuret of iron, lie dispersed here and there through the dark patches, and rather heighten than impair its beauty. A change seems to have been effected in the grain or texture of the rock, by the injection of the serpentine, which, as often arises in such cases, has nearly effaced the original regular stratification of the rock. As a consequence of the latter circumstance, the rock presents some little difficulty in quarrying, but if it were wrought for the sake of furnishing marble in sufficiently large quantities for the stone-cutters, I hardly doubt but that such might readily be procured. It does not show more liability to fracture, than such heterogeneous rocks usually exhibit.

There is every probability that more such localities of serpentine and other analogous materials in veins may be discovered, distributed occasionally through the series of rocks which I am describing. A sufficient number of such instances is known to warrant further search, and some might be found, no doubt, to hold out, as in the instance before us, a reasonable anticipation of profit.

### MINOR BANDS OF SLATE AND LIMESTONE ADJACENT TO THE FIRST LIMESTONE.

Between Swartwout's pond and Newton, and immediately adjoining the Paulinskill, there occur directly on the south-eastern edge of the limestone above described, first a narrow stratum of slate, and beyond it a similar one of limestone. The actual direction of the planes of stratification in the slate, was not clearly ascertained, though its dip is believed to be to the south-east. That of the neighbouring narrow belt of limestone is unequivocally towards the south-east at an angle, where it was witnessed, of forty degrees. The width of the slate upon the surface is not more than one hundred yards; the limestone

rock seems not to exceed in width a few hundred feet. It is a light blue rather argillaceous limestone, abounding in some of its layers with sulphuret of iron, both in cubes, and in several of the prettier secondary forms. This stratum is however more especially interesting, as being the depository of a quantity, it is not known how much, of white massive *sulphate of barytes* very pure. This occurs in two localities, about two and a half miles west of Newton, near the Paulinskill.

Upon the site of one of the excavations made some years since to explore this mineral, a very absurd mining project has been undertaken, not to procure the sulphate of barytes, which if abundant might in part repay the miner, but in the unfounded and futile hope of revealing a mine of *silver*. Every informed geologist or scientific miner would pronounce at once, from all the mineral symptoms there present, and from the structure of this and the other rocks at hand, that all such attempts at mining for the precious metals in these strata are likely to prove most abortive; nevertheless a shaft sixty feet deep and at a cost of two thousand dollars has already been dug. I deem it my duty to state, that I could discover in this mine nothing that seemed to contain a trace of silver, or anything to justify the anticipation of finding it.

How far these two inconsiderable strata are prolonged, I have not been able to determine, but it seems probable that they cease as distinct belts before they extend many miles to the south-east. One or both may coalesce with the thicker adjacent stratum of rock of its own kind, but much yet remains to be explored in everything that belongs to the stratification of the whole of this group of alternating slates and limestones. A more accurate developement, especially of the limestones, is a desideratum to the agriculture of the whole district.

There are useful marl deposits subordinate to the principal range of limestone above discussed, but their nature and location will be mentioned further on, when the rest of the limestone strata shall have been treated of.

SECOND SLATE OF THE VALLEY.

Near the Delaware, and the line of our Profile No. 2, this rock shows itself over the wide space included between the Paulinskill and a line half a mile north of Beaver brook. Its lower limit crosses the river into Pennsylvania, a quarter of a mile north of Belvidere, and is traceable to the north-east, through the village of Hope, and thence by Johnsonburg, through the centre of the town of Newton, and still further, in all probability, to Deckerstown, where it is also the lower boundary of the *first* slate. These two slates, from the thinning out of the intervening limestone, as here described, are supposed to come together. Its upper or north-western edge, for a considerable distance, observes a course not far from the valley of the Paulinskill. Upon the line of our Profile No. 2, its width probably exceeds six miles. At Newton it is about two, and below Augusta, on the Sparta road, not more than one mile. This reduction of width to the north-east, does, in part at least, arise from an increase of steepness in the dip, which is almost every where to the north-west. Of the manner in which this thick belt of slate rock is connected with the limestone north-west of it, I could not assure myself with certainty, though I incline to the impression that it underlies all the strata previously described. Several clearly ascertained cases of contact with the other limestone which skirts it, on the south-east, have satisfied me that it overlies this latter. This limestone is seen dipping towards it at Belvidere, and directly beneath it at Hope, Newton and elsewhere. In the Manunka Chunk and other elevated portions of the formation along the Delaware, the stratification of this rock is well revealed. It offers to our view, in a striking degree, all the characteristic features of structure belonging to the older slates. The cleavage planes, as in the strata near the Blue Mountain, are not in the direction of the stratification, but dip at a large angle *obliquely* to it.* This, as was alluded to before, is fitted to deceive us at first, regarding its true dip and relative position to the other strata. Its average inclination is about 30° to the north-west, though below the Paulinskill it presents one or two

*That is to a different quarter of the compass.

departures from this direction. Near Newton its angle of dip is much steeper, being at least 70° to the north-west.

*Description*.—The rock is a dark-brown, very argillaceous slate, not compact or regular enough in structure for a roofing slate, but yet approaching it. Some layers are much more arenaceous, and might almost be called sandstone. The soil over this rock is rather sterile, and would be benefited materially by a more general application to it of lime or marl.

If this formation contains any mineral matters of direct utility, they have not thus far been brought to light, though it does not therefore follow that none exist.

### SECOND LIMESTONE OF THE VALLEY.

*Range*.—The north-west boundary of this stratum has already been given as far as determined, in sketching the south-eastern edge of the slate last described. The two rocks have been seen in several places, in immediate contact, and little or no doubt exists that the limestone is the oldest or lowest stratum. Its dip in the districts adjoining both of the sections or profiles, is towards the north-west. Such is its inclination near Belvidere, Hope, Newton, Lafayette, Franklin, and various other intermediate points, where it has been examined, though occasionally there is a displacement of the dip to the north-east. The south-east limit of the formation, it is impossible at present to define, further than in the manner already attempted in delineating the general course of the primary ridges of the Highlands, against the western bases of which, the limestone usually terminates; this boundary, however, I do not consider as embracing by any means the whole of this widely distributed limestone, for I look upon the several calcareous strata which occur enclosed in many of the valleys, between the numerous spurs or ridges of the Highlands, to belong to the same formation, adopting the view that they have been originally united portions of one stratum, thrown asunder and insulated by the uplifting of the primary strata between them. These may be seen rising at a very steep inclination from beneath the also highly inclined beds of this rock. In strictness, no line of division can be traced, or ought to be at-

tempted, between the two districts here described as the northern and middle regions of this upper portion of the state, but convenience dictates that the limestone beds included between the primary hills of the Highlands or middle region, be discussed at the same time with the other rocks of that district, and not in this section, to the formations of which I consider them as properly belonging.

A narrow belt of slate separates this limestone formation into two ranges in that part of its course which lies between Deckertown and Newton. It appears in considerable width on the road between Hamburg and Deckertown, and may be traced with a diminishing width to the south-east until it finally disappears about two miles south of Newton. Its average width is less than half a mile, and its dip, wherever discovered, is to the north-west, at a high angle, not far from the vertical. Whether it thins out entirely or is prolonged on to the south-west was not ascertained.

The limestone formation to which we are now directing our attention, is traversed, it may be seen, by each of the three geological sections or profiles Nos. 1, 2, and 3. In the immediate vicinity of Franklin Furnace, in Sussex, where profile No. 1 crosses the formation, the order of its included beds is nearly thus: On the north-west, beds of blue limestone, of various degrees of purity, sometimes slaty, and like the rest of the blue limestone, very often arenaceous or sandy. This is about two miles wide near the little place called Harmony Vale. To it succeeds the narrow dividing stratum of dark blue argillaceous slate, beyond which occurs a repetition of the blue limestone, agreeing to the same description and having about the same dimensions as the first. This brings us to the Wallkill. All these three strata appear to conform to each other in their dip, which is to the north-west. Beneath the lower limestone there is a very narrow gray sandstone, to appearance not more than a few yards thick, having a south-western dip. Below this, however, there occurs a sudden change in the dip, accompanied by a very remarkable group of beds and veins containing some highly interesting minerals.

This part of the section is across the Mine Hill, at Franklin

Forge: First upon the north-west, the dips now being to the *south-east*, there is a narrow stratum of gneiss of the variety most common in the ridges of the Highlands, to be described by and by. To this succeeds a vein, several feet thick, resting next the gneiss, but not traversing it, composed of several ores and interesting minerals, to be enumerated presently. Overlying the vein, there is a mass of white crystalline rhomboidal limestone, between three and four hundred feet wide. The traces of dip in this rock are rather obscure, though its inclination seems to be parallel with the beds beneath it.

On the south-east of this limestone, two narrow veins or beds, one of quartz rock, the other of sienitic granite, of the usual composition of the gneiss of this region, present themselves, dipping with the previous beds to the eastward. A few hundred feet still further to the south-east, the blue limestone, in its ordinary characters, is beheld, occupying the valley to the width of a mile, dipping, like the higher first-mentioned beds of the formation to the north-west, and reposing, in all probability, upon the upturned primary rocks of the Wallkill Mountain, which possess the same inclination. A section made through Sparta, across these beds, would present a series in some respects strikingly analogous to that above: first would appear the two upper limestones with their interposed belt of slate, and beneath the lowest of these, the primary strata of Pimple Hill, or the ridge of which it is a portion: beyond this again, about a quarter of a mile west of Sparta, the white rhombic limestone, distinguished by the same minerals, and exhibiting in another place, a mile from Sparta, the same kind of metallic vein which separates it from the gneiss in the Mine Hill, at Franklin.

In the neighbourhood of Hope, or bordering upon the second profile, the structure of things is of the very simplest sort, there being no interposed slate, and the limestone resting without disturbance of dip against the primary strata at the base of Jenny Jump. It is true, that near the north-western termination of this mountain, there appears the rhombic white limestone rock, accompanied by a vein of iron ore, and including minerals similar to some of those found at Franklin and Sparta.

*Description*.—The ordinary external and chemical characters

of this important rock, are those of a moderately dark blue limestone, sometimes argillaceous and rather slaty, but more often compact and containing a considerable trace of silicious matter and a little oxide of iron. It is not uncommon to find in the strata of this rock, seams from one to several inches wide of hornstone or flint, usually black, though not invariably so, and differing from the tabular flint of the chalk formation, chiefly in its having greater hardness and occurring in a more massive form. It points plainly to the same origin as that ascribed to ordinary flint, namely, to chemical precipitation. It occurs always in hands, and never in layers of nodules, so that it appears more probably to have been deposited as it exists, than to have come together subsequently by concreting from the materials of the rock, during or after their solidification. Almost the only traces of organic remains which I have discovered as belonging to the formation, I have found in this silicious part of it. They are one or two varieties of madrepores. Being the least destructible portion of the materials of these strata, the flinty masses occur in the diluvium when none of the limestone itself is present, and at great distances from the original place of the formation. These flinty bands are characteristic of the limestone throughout its whole enormous extent across Pennsylvania, Maryland, and Virginia.

This limestone, like most of the other rocks of the extensive group to which it belongs, displays a great tendency to the oblique or slaty cleavage, which is a very usual source of perplexity in determining its true direction of dip.

### USEFUL MATERIALS, ORES AND RARE MINERALS OF THE FORMATION.

Besides the lime itself, which is to be ranked first, and the importance of which to the agriculture of the district, cannot be too often pressed ; there are several substances of value and some of curiosity, which occur within the range of this rock in New Jersey. Hydraulic cement-stone, a material of extensive application, from its property of making a mortar which hardens rapidly under water, occurs plentifully in this limestone near its upper limit, or where it approaches the overlying slate stratum.

The cement has been found in this relative position in the limestone upon the Jersey shore of the Delaware, about three miles below Belvidere. It is likewise met with, though under less conspicuous circumstances in two or three other places in the same range.

In Pennsylvania and Virginia likewise, the contact of a similar, probably the same limestone belt with the adjoining slate, presents several localities of the same hydraulic limestone. This is only in fact, a more argillaceous and ferruginous *impure* variety of the limestone rock. Near the junction of the two rocks, the limestone seems to have received, as is often the case, a larger share of the argillaceous matter, which explains the position of the cement layer, and suggests a general rule as to where this material may in other regions be most likely to occur. It varies much in colour, being sometimes dark blue, and often a light buff or yellow; nor is it much more constant in the proportions of the elements which compose it. Chemical analysis of that below Belvidere, presents the following as the prevailing composition of the cement-stone.

| | |
|---|---|
| Lime | 41.45 |
| Carbonic Acid | 32.00 |
| Alumina | 18.50 |
| Silica | 3.05 |
| Oxide of Iron | 1.75 |
| Water | 3.00 |
| Magnesia | *a trace* |
| | 99.65 in 100 grains. |

*Hematitic Iron Ore*.—Concerning the position of the hematitic iron ore, of the older formations of New Jersey and Pennsylvania, it may be given as a general rule, admitting of but few exceptions, that this valuable material is to be found in connexion only with the tracts of limestone; that is to say, that the earth containing these ferruginous deposits, is to be found only over limestone, or has been immediately derived from the disintegration of that rock. If this be a fact, and my observations upon the strata of New Jersey and Pennsylvania, particularly along the great valley, afford me some confidence in its truth, then it becomes of some importance, not merely to the Geologist, but to all who are interested in procuring supplies of the material, to

to explain this singular connexion. Two views suggest themselves; first, that part of the substance of this uniform blue limestone being itself ferruginous, and the rock having clearly furnished much of the soil which lies upon it, there may occasionally exist in this soil, a sufficient supply of oxide of iron, to yield the ore by those natural concreting tendencies peculiar to many substances thus disseminated.

The second notion is, that the ore lies already formed within cavities or nests, filled with yellow ferruginous earth and hematite in the limestone. It has been procured under these circumstances, in several places in the neighbourhood of Belvidere, the ore being of the usual quality of the kind called columnar or pipe ore. It occurs mixed with ferruginous loam, just such as imbeds the ore most commonly found in the overlying earth; and the cavities in the rock which contain the mass, are several feet in diameter. We may suppose that many such exist, and that the reduction or breaking up of the strata, by slow or violent agencies, has scattered the hematite through the superficial soil. Thus far, no large body of hematite ore has been found in this limestone range, or any of the other strata of the group, if we except the newly developed locality, near the southern termination of the Pochuck mountain, about two miles north of Hamburg in Sussex. Here the promise of a rich mine is at present flattering, and the ore has been pronounced extremely pure. Though the mass of the Pochuck mountain is primary rock, (gneiss), yet the ore, as is general elsewhere, lies in a stratum of clayey ferruginous loam, contiguous to the limestone. More minute researches throughout the limestone territories of this section of the State, would in all probability, bring to light more such valuable deposits, and perhaps furnish some general facts connected with the distribution of iron ore, which might be of much practical importance.

### MARL SUBORDINATE TO THIS LIMESTONE, AND TO THE OTHER LIMESTONE TRACTS OF THE VALLEY GENERALLY.

This is a deposit of chalky white pulverulent carbonate of lime, occurring upon the shores and in the beds of several small

lakes, and in many of the low grounds in Sussex and Warren. It is obviously a precipitation from the limestone waters of the place where the accumulation exists, and, as might be inferred, never occurs but within, or immediately adjacent to, an extensive limestone stratum. The ponds where this deposit is seen, present a singular aspect, being fringed with a broad white beach, as white as if the whole had been covered with lime, and exhibiting the same beneath the surface of the water. The white marl contains a profusion of very minute univalve shells of the species which occur in calcareous fresh waters almost everywhere. They belong to the genera Paludina, &c.

Analysis furnishes the following as the average composition of the Freshwater marl of Sussex and Warren:

| | |
|---|---|
| Lime, - - - - - | 50.52 |
| Carbonic acid, - - - - - | 39.00 |
| Water and earthy impurities, chiefly sand and clay, | 10.48 |
| | 100.00 |

In consequence of the peculiar appearance derived from this deposit, two or three of the ponds containing it are called on the map White Ponds, for instance, two ponds west of Pimple Hill, in Sussex; the more northern one being, however, incorrectly so termed, as the marl is confined to the other. There is also another pond about one mile north of Marksboro' in Warren. These, however, are not the only depositories of this useful substance: I enumerate the following as its localities already ascertained, and do not doubt, but that the list might be sensibly augmented, were the investigation followed up with sufficient minuteness. White Pond, near Pimple Hill, a pond near Brighton, Stickles Pond two miles south of Newton, a pond a mile and a half north-west of Andover, the White Pond near Marksboro' and a pond at Stillwater.

The marl likewise occurs in a marshy meadow to the northeast of La Fayette, and again near Peter Merkel's, in the same range. Considering the well tried value of this material in Europe, the benefit to the agriculture of the districts which possess it, and its abundance in the two upper counties of the state, it seems truly strange that its application to the soils adjoining it, should hitherto have been almost entirely overlooked by the farmers.

A material so ready of access, demanding no preparation to fit it for the land, and unquestionably so efficient when judiciously applied, ought to have been, we should suppose, ere now, an article of extensive use. One or two insulated trials which I have heard of, have been undertaken with the material, but with a precaution and attention no way commensurate to its importance. They proved decidedly successful, but one dose of it being incautiously applied, a check to the crop arose, and the prosecution of the marling was abandoned.

## OF THE WHITE CRYSTALLINE LIMESTONE AND THE MINERALS AND ORES CONNECTED WITH IT.

As a sketch of this remarkable rock, the repository of some of the most valuable and curious ores and minerals of the state, I cannot do better than present the following portion of a brief paper on the subject, by Dr. Fowler, who has long resided in the midst of the formation at Franklin, and whose liberal labours in developing the mineralogy of his neighbourhood, have rendered his name familiar to the cultivators of the science. The account is to be found in Gordon's Gazetteer of New Jersey.

"Perhaps in no quarter of the globe is there so much found to interest the mineralogist, as in the white crystalline calcareous valley, commencing at Mounts Adam and Eve in the county of Orange and state of New York, about three miles from the line of the state of New Jersey, and continuing thence through Vernon, Hamburg, Franklin, Sparta, and Byramy, a distance of about twenty-five miles in the county of Sussex and state of New Jersey. This limestone is highly crystalline, containing no organic remains, and is the great imbedding matrix of all the curious and interesting minerals found in this valley. When burned, it produces lime of a superior quality. A considerable quantity of this stone is burned into lime near Hamburg, and when carted to the towns below, as Patterson, Newark, &c. is sold for one dollar per bushel. It is principally used in masonry, for whitewashing, cornice-work and wall of a fine hard finish, and is considered superior to the best Rhode Island lime. Some varieties, particularly the granular, furnish a beautiful marble; it is often white, with a slight tinge of yellow, resembling the Parian marble from the island of Paros; at other times, clouded black, sometimes veined black, and at other times arborescent.

"*Franklinite*.—A new metalliferous combination, containing, according to Berthier, of oxide of zinc 17, of iron 66, and manganese 16, is very abundant, indeed it appears inexhaustible. It commences about half a mile north-east of Franklin furnace, and extends two miles southwest of Sparta, a distance of nine miles. It is accompanied in this whole distance by the red oxide of zinc, mutually enveloping each other. The greatest quantity appears to be at Franklin furnace. The bed here is about one hundred feet high above the adjoining land, on the west side of it, and from ten to forty feet wide. Various attempts have been made to work this ore in a blast furnace, but without success. It frequently congeals in the hearth, before time is allowed to get it out in a liquid state, in consequence of a combination of

the iron with manganese. All this difficulty I apprehend might be overcome, if a method could be discovered of smelting iron ore in a blast furnace with anthracite coal; as the Franklinite requires a greater degree of heat to cause it to retain its liquid state, than can be obtained by the use of charcoal. It occurs in grains imbedded in the white carbonate of lime, and detached in concretions of various sizes, from that of a pin's head to a hickory nut; also, in regular octohedral crystals emarginated on the angles, small at Franklin, but very perfect, with brilliant faces. At Sterling, the crystals are large and perfect. I have one from that place that measures sixteen inches around the base.

"*Red Oxide of Zinc*.—At Sterling, three miles from Franklin, a mountain mass of this formation presents itself about two hundred feet high. Here, as Mr. Nuttall truly observes, the red oxide of zinc, forms as it were a paste, in which the crystals of Franklinite are thickly imbedded; in fact a metalliferous porphyry. This appears to be best adapted for manufacturing purposes. The Franklinite imbedded in the zinc ore here, is highly magnetic, and may be all separated by magnetic cylinders, recently brought into use to separate the earthy portion of magnetic iron ore. It was long since observed, that this ore is well adapted for the manufacture of the best brass, and may be employed without any previous preparation. It is reduced without any difficulty to a metallic state, and may be made to furnish the sulphate of zinc (white vitriol). Berthier found it to contain oxide of zinc 88, red oxide of manganese 12.

"*Magnetic Iron Ore*.—On the west side of the Franklinite, and often within a few feet of it, appears an abundance of magnetic iron ore, usually accompanied by hornblende rock. In some places it soon runs into the Franklinite, which destroys its usefulness; and the largest beds are combined with plumbago, which renders it unprofitable to work in a blooming forge, but valuable in a blast furnace.

"The other minerals found in this district are numerous, rare, interesting, and several of them new, and not found in any other place, but better calculated to instruct the naturalist and adorn his cabinet, than for any particular uses to which they have as yet been applied. A catalogue of which I have subjoined, designating the minerals as they occur in each township.

"In Byram township, considered the south-western extremity of the white carbonate of lime.

"1. Spinnelle, colour reddish brown, green and black, in octohedral crystals, associated with orange-coloured brucite.

"2. Brucite of various shades, from that of a straw colour, to dark orange, and nearly black.

"3. Gray hornblende in six-sided prisms with diedral summits.

"In the township of Hurdiston,—

AT SPARTA.

"1. Brucite of a beautiful honey-colour, the finest we have is found here.

"2. Augite in six-sided prisms, colour brownish green.

AT STERLING.

"1. Spinelle, black, green and gray, in octohedral crystals.

"2. Brucite of various shades.

"3. Brutile, colour steel gray; lustre metallic, in acicular prisms, with longitudinal striad.

"4. Blende, black and white; the white sometimes in octohedral crystals, the lustre brilliant.

"5. Dysluite, in octohedral crystals, colour brown externally; internally yellowish brown; lustre metallic (a new mineral).

"6. Ferruginous silicate of manganese in six-sided prisms, colour pale yellow, associated with franklinite.

"7. Tourmaline, imbedded in white feldspar, in six-sided prisms; longitudinally striated, colour reddish brown.

"Green and blue carbonate of copper. A number of large excavations were made at the Sterling mine for copper, during the revolutionary war, under an erroneous impression, that the red oxide of zinc was the red copper ore. It was the property of Lord Sterling; hence the name of the Sterling mine. Of copper, we only find there a trace of the green and blue carbonate.

AT FRANKLIN.

"1. Spinelle, black and red crystallized.

"2. Ceylonite, green and bluish green, in perfect oetohedrons, truncated on the angles; lustre of the brilliance of polished steel.

"Garnets, black, brown, yellow, red, and green, crystallized in dodecahedrons.

"6. Silicate of manganese, light brownish-red.

"7. Ferro-silicate of Manganese, of Professor Thomson, and the Fowlerite of Nuttall, light red or pink, foliated and splendent, has much the appearance of feldspar, is also in rectangular prisms.

"8. Sesqui-silicate of manganese, lamellar in scales or small plates; colour brownish-black.

"9. Hornblende, crystallized.

"10. Actynolite, do.

"11. Tremolite, do.

"12. Augite, common variety, do.

"13. Jeffersonite, common variety, crystallized.

"14. Plumbago, foliated and crystallized in six-sided halls.

"15. Brucite of various shades.

"16. Scapolite, white, crystallized.

"17. Wernerite, yellow, do.

"18. Tourmaline, black, do.

"19. Fluate of lime, earthy and do.

"20. Galena.

"21. Oolite, in small grains about the size of a mustard-seed, disseminated in blue secondary carbonate of lime.

"22. Asbestus, connected with Hornblende rock.

"23. Green beryl.

"24. Feldspar, green and white, crystallized.

"25. Epidote and pink carbonate of lime.

"26. Arsenical Pyrites.

"27. Serpentine.

"28. Sahlite.

"29. Cocolite, green and black.

"30. Sphenc, honey-colour, crystallizcd.

"31. Quartz.

"32. Jasper.

"33. Chalcedony.

"34. Amethyst crystallized.

"35. Agate.

"36. Mica, black and orange-coloured, crystallized.

"37. Zircon, crystallized.

"38. Sulphate of Molybdena.

"39. Phosphate of iron.

"40. Carbonate of iron.

"41. Steatite, foliated, with yellow garnet.

"42. Phosphate of lime, crystallized.

"43. Pale yellow blende, of a foliated structure, lustre, vitreous.

NEAR HAMBURGH.

"1. An ore of manganese, and iron of a light reddish brown, very compact and heavy.

"2. Augite and brucite.

IN THE TOWNSHIP OF VERNON.

"1. Green spinelle and brucite, in octohedral crystals.

IN NEWTON TOWNSHIP.

"1. Sulphate of barytes in lamellar masses, and tabular crystals, in a vein traversing secondary limestone.

"2. Sapphire, blue and white, in rhombs and six-sided prisms.

"3. Iced oxide of Titanium.

"4. Gray Spindle in large octohedral crystals.

"5. Mica, copper-coloured, in hexahedral crystals.

"6. Idocrase, crystallized, yellowish brown.

"7. Steatite, presenting the pseudomorphous form of quartz, scapolite, and spinelle.

"8. Scapolite, in four-sided prisms. For a more particular account of the Newton minerals, see Silliman's Journal, vol. xxi. page 319.

IN FRANKFORD TOWNSHIP.

"Serpentine, of a light yellowish green, bears a fine polish, has a glistening lustre, and is quite abundant."

Upon the practicability of working the Franklinite as an iron ore, it may be observed, that perhaps the requisite increase of intensity in the heat of the blast furnace, would be afforded by the use of the hot air blast, which bids fair, soon to become generally adopted in this country. An enterprising experiment with it is now on foot at Oxford Furnace, near Belvidere.

The application of this new blast to the reduction of the Franklinite, seems at least well deserving of a careful trial.

We may be allowed to hope that the zinc of Sterling and other parts of the range, may not be left to lie always unproductive. The enormous quantities of it, and the facility it would present to mining, are calculated to invite to it attention and enterprise, so soon as its existence and value become more generally known. The association of the Franklinite with it, ought not to prove a serious obstacle, amid the improvements daily in making practical metallurgy.

The localities and the value of the sulphate of barytes and the serpentine mentioned in the catalogue, have been already described.

To give a more specific description of the altered white limestone, it may be defined as a coarsely crystalline rock, always of the rhombic structure, the smaller rhombs, when separated, being often semitransparent, though more generally a pure opaque white. The variety which is found in boulders, near Danville, has sometimes the crystals of carbonate of lime, of a reddish-yellow colour, not unlike the felspar in certain granites, and contains, moreover, both augite and mica in scattered crystals. The whole mass has, at a little distance, more the aspect of a sienite than a calcareous rock. It seems to expand in breadth in its course to the north-east, being only a few yards in visible width at Sparta, at Franklin forming a belt of several hundred feet, and near Amity, beyond the New York line, it is supposed to be expanded over at least two miles.

Both at Franklin and near the same vein at Sterling it exhibits a distinct dip to east-south-east, at a steep angle, about seventy degrees. A more detailed examination of this altered rock would, if the notion of its origin be correct, lead possibly to the developement of other valuable veins, especially in the northern part of the section.

It was stated, in another place, that the position of the great metalliferous vein or veins of zinc ore and Franklinite is directly at the junction of the crystalline limestone, with the primary strata. The vicinity not only of this vein, but of others of sienite and quartz, combined with other facts, as the highly crystalline structure of the rock, its unusual dip, and the peculiar minerals which it contains, are all circumstances tending to elucidate the

mode of origin of this uncommon variety of limestone. I regard it as having been originally the blue limestone of the district, invaded, at some period subsequent to its formation, by these veins of mineral matter, in a highly heated or molten state, effecting a series of changes similar to those known to have been caused by injections of trap into limestone strata under pretty nearly analogous conditions.

The vein or series of veins containing the Franklinite iron ore, and the zinc, I look upon as belonging, most probably, to that great system of parallel veins of magnetic oxide of iron, known to occur so extensively in the same primary strata, with which this white limestone is in contact. According to this view, where the veins have burst up adjoining the common boundary of the primary region and the blue limestone they have altered the structure of the latter rock, and imparted to it those minerals which never show themselves in limestone but where it evinces that it has sustained a great elevation of temperature and a partial fusion. Other cases of a like nature with that at Franklin Furnace, occur along the limit which separates the secondary from the primary strata; one has been specified as existing near the north-east foot of Jenny Jump, and I have encountered indications of more in boulders of .the crystalline limestone, holding crystals of various minerals, in the manner visible at Sparta and Franklin. These boulders are numerous near the eastern corner of Oxford township, in Warren. All these facts are invested with much scientific interest, as the changes supposed to be superinduced upon stratified rocks by *igneous causes*, are connected with discussions involving some of the most fundamental doctrines of modern geology.

# CHAPTER II.

## *Primary region of the State.*

### GENERAL VIEW.

The next district upon the Geology and Mineralogy of which I have to report, is distinguished by its hilly or mountainous features, by the small variety of its formations, and the great abundance of valuable ore which these contain.

It forms a wide zone of many nearly parallel ridges, with steep sides and very undulating outline, or low mountain ranges of moderate elevation, which rarely exceeds six hundred feet. These ridges are a portion of the system of hills which cross the Hudson between Peekskill and Newburg, under the name of the Highlands. This term, convenience would suggest, might be applied with propriety to the whole chain in their prolongation across New Jersey.

Upon the New York state line, where this belt of hills is widest, they are limited for several miles on the south-east by the valley of the Ramapo, and on the north-west by that of the Wallkill, pursuing them in their south-west course across to the Delaware river, their south-eastern ridges are Pompton, Stony-brook, and Trowbridge mountains, Foxhill east of German valley, and Musconetcong mountain; while on the north-west the extreme ridges are Pochuck mountain, Pimple hill, Furnace mountain, Jenny Jump, Scott's mountain, and Marble mountain, near Easton. The breadth of this zone of hills, diminishes therefore pretty regularly and rapidly in its extension towards the Delaware, occupying about twenty-three miles upon the New York line, and scarcely eight upon the third profile or that near the Delaware. The prevailing direction of the strata throughout the region is north-east by north and south-west by south, and it may be laid down as expressing in a general way, the character of the district, that nearly all the ridges consist of primary strata, while most of the principal valleys are composed of blue limestone.

A singular and striking feature in the surface of this region, is

the perfectly level outline of the bottoms of some of its valleys, which have hence procured the name of plains, as Pompton plains, Succasunny plains, and others. These present some strong contrasts of scenery, when viewed in connexion with the bold and often precipitous hills which encompass them. The whole area is abundantly irrigated, feeding innumerable rivulets, and furnishing to a considerable section of the state, a vast manufacturing power. The rocks which compose the district, belong so far as they have been studied, to three distinct formations. That is to say, there occurs first, in most of the valleys, at least of the southern half of this region, a formation of blue limestone, identical in external character, and I believe in origin, with the lower limestone of the slate and limestone group of the great valley. Next, there is a series of thick red silicious conglomerates, composing the Long-pond, Raffenberg and Green-pond mountains, in Bergen county. Finally there exists an assemblage of rocks of the stratified primary class, composing it is supposed, by far the greatest portion of the whole area. We proceed now to treat of these separately, in the order in which they are now before us.

## SECTION I.—*Blue Limestone formation.*

*Range and Extent*.—Regarding this rock of the valleys of the Highlands or primary region, as a portion of the limestone formation treated of before, nothing more in the way of description is necessary in this place. Its distribution as far as traced, its connexion with the belt of limestone to which it belongs, and its mode of superposition to the primary strata beneath it, deserve however to be touched upon.

Commencing at and below Easton on the Delaware, this limestone, after crossing the river, is seen to stretch up along the valley of the three streams which enter the river between Scott's mountain and Musconetcong mountain. That is to say, it follows the valley of the Musconetcong creek, almost to its source. It pursues in like manner the Pohatcong, underlying the Mansfield valley, while a portion from the same mass branches off and follows the Sopatcong for some distance between the spurs of

Scott's mountain. The same limestone rises upon the side of Marble mountain, between which and Scott's mountain, near Harmony church, it may blend with the limestone of the valley of the Delaware below Belvidere, which I consider to be a portion of the same rock.

In illustration of this, we may trace it passing to both sides of the mountain called Jenny Jump, one portion keeping the valley of Beaver brook, and another following the depression of the Pequest. A limestone of a description nearly analogous, is traceable at points along the south-eastern base of Musconetcong mountain, commencing at the Delaware, where it is seen on both sides below Johnson's ferry. To all appearance, the same shows itself in German valley, which it occupies for at least nine miles of its length, and half a mile of its width. Some of this range is an argillaceous limestone, and better adapted for furnishing hydraulic cement than pure strong lime. Another small range of the limestone, as yet imperfectly traced, lies in the valley of Indian brook, west of Mendham. The north-east limit of this is about a mile west of Mendham; its south-west course has not been followed accurately, more than two miles, though it is known to extend in that direction considerably farther. It is very analogous to the German valley rock and may possibly have been once a united part of that portion of the formation; its direction however, is towards the limestone of Pepack and New Germantown.

I think it very probable that further examination will make it appear that a limestone exists in many places, though buried up in diluvium from the mountain, along a great part of the Musconetcong and Schooley's mountains, and that a portion of this is the stratum which occupies nearly the whole of the valley of the south branch, between Clinton and German-valley village, while another portion, separated from this by the gneiss hills of Tewksbury township, will be traced from Clinton past New Germantown and Pepack to Mendham. I am induced to think so, from the seeming identity in the composition of this limestone in various parts of the tracts here mentioned, together with the confusion of the dip, and its unusual direction to the *south-west*, in the neighbourhood of Clinton, where the separation of the

stratum into two ranges must take place. The limestone is argillaceous, or of the kind furnishing the hydraulic cement, in certain seams. But little difference can be seen in it in respect to this character, either near the Delaware, or in German Valley, or at Mendham. Its dip is always from the nearest primary hills, and most usually to the south-east. At Mendham, the mass of the rock is a pretty pure blue or sometimes reddish limestone of very regular stratification and a steep dip of seventy or seventy-five degrees to the south-east by east. North of Mendham, a spur from the Trowbridge Mountain intersects the line of bearing of the strata, which has probably produced, the disappearance or concealment of the formation further to the north-east. The hydraulic cement from the stratum near Mendham was much employed upon some parts of the Morris canal, and was found of good quality.

Analysis of the Mendham Limestone of moderate Purity:

| | |
|---|---|
| Lime, | 52.65 |
| Carbonic acid, | 40.10 |
| Silica, | 3.05 |
| Alumina, | 1.30 |
| Oxide of Iron, | 0.75 |
| Water and loss, | 2.15 |
| Magnesia, | *a trace.* |
| | 100.00 grains. |

Analysis of the Mendham Hydraulic Limestone or Cement-stone:

| | |
|---|---|
| Lime, | 39.05 |
| Carbonic acid, | 30.10 |
| Alumina, | 22.00 |
| Oxide of iron, | 1.05 |
| Magnesia, | 1.35 |
| Water and loss, | 6.45 |
| | 100.00 grains. |

These eastern ranges of the great limestone formation, seem to present an especial claim to a more thorough investigation. Being the nearest sources of limestone to the middle counties of the state, every fact serving to extend the limits of this stratum is to be received with interest as proving useful to the agriculture of a large and important region.

There is an obscure belt of limestone running apparently along the Burnt Meadow valley, at the base of the Green Pond

mountain, and we may conjecture that this is in connexion with that which occurs near the Maukapin Pond. The whole may possibly underlie the Green-pond-mountain conglomerate. The range and relationship of this last limestone are, for the present, however, all uncertainty. It is believed that a few other more obscure belts of limestone, occupy valleys between the hills of this region, though in the general survey made, it was quite impossible to expend time enough in the search to bring them properly to light.

It is obvious, from what has been here delineated, that all or nearly all of these detached strata of limestone refer themselves to one formation, and it is also made very probable from what has been shown of Marble mountain, of the vicinity of Jenny Jump, and it might be added, of that of the Pochuck Valley, that the formation is the same with that described in another chapter as the lowermost rock of the slate and limestone series. By attending, in the next place, to the positions of these limestone strata upon the primary rocks which in so many places rise up among them, the identity of these limestones will be rendered yet more apparent. We shall be led, at the same time, it is hoped, to a just view of the causes which have influenced the irregular distribution of the limestone and other formations of the region.

By inspecting the three profiles or sections which traverse the strata of this portion of the state, it will be seen at once that the several beds of limestone enclosed between the primary ridges, invariably dip away from the centres or axes of those upheaved masses. The inclination, moreover, is generally great, approaching that of the beds in the primary hills upon the sides and at the feet of which, the limestone, therefore, reposes in a position parallel, or nearly so, with the dip of the rocks beneath. This we may see in the manner in which the limestone rests upon the two sides of Schooley's mountain, dipping in the Musconetcong valley to the north-west, and in German Valley declining away from the mountain to the south-east.

The same thing may be witnessed upon the two sides of Marble mountain, about three miles to the north-east of Easton. Nothing could bespeak more clearly the fact that these several

limestone deposits once formed a single, continuous and wide formation, resting horizontally upon the strata of gneiss or primary rocks as a basis. Conceiving this, and admitting that a force operating from below, and exerting its energy along a number of parallel lines, running north-east and south-west, has upheaved together the primary strata and the overlying limestone, we possess a ready explanation of the manner in which this region has acquired its principal features and its present structure. In most cases, the disturbing causes have operated to throw the strata away in both directions from the centre of the ridges, that is, to form a series of anticlinal axes. This disposition of things is, however, by no means universal, for by observing our Profile No. 3, we perceive that between Marble mountain and Musconetcong mountain, there are three repetitions of the gneiss, and three of the limestone, all dipping to the same quarter, or to the south-east. We are not to be led to infer from this, that the two classes of strata were formed alternately, but may account for it more naturally by assuming several parallel dislocations or faults, tilting off the strata in one direction only. It is admitted, however, that more research is necessary to establish fully this last point, as it is possible, though *hardly likely*, that a series of contrary dips to the westward may have eluded observation.

Whether or not the numerous mineral veins which penetrate the primary strata of the ridges, may have been connected with their original upheave, or whether their production belongs to a subsequent period, are points which, though curious to science, and upon which some feeble light might be cast, we feel it proper to refrain from discussing in this place. What has been said touching the geological structure of the region, was indispensable to the purposes of this report, and is, moreover, all-important in guiding future investigations, which would have in view to develope the truly valuable belts of limestone that lie distributed between the sterile hills of this region, and offer to our contemplation, a beautiful provision for ameliorating its agriculture.

Hematite iron ore occurs in the ferruginous loam which in many places covers the limestone valleys of this region. The

ore, and the earth containing it, are in all respects similar to such as may be found subordinate to the limestone which ranges along the north-west side of the primary hills. There are indications of hematite in several places near the eastern base of Scott's mountain. It has been dug and is very pure between Mansfield and Anderson's, near the Morris canal, in Warren. The valuable deposit upon the Pochuck mountain is to be considered as subordinate to the same formation. Detached masses have been found among the older strata, remote from any belt of the blue limestone, and may have reached their localities in the same manner as the scattered and rolled fragments of the black flint or hornstone, which lie strewed pretty abundantly in the diluvium of this region. That is to say, they may have resulted from the breaking up and destruction of portions of the limestone formation once overlying the primary rocks in which these fragments are found. Or it is possible that the hematite has been derived from the particles of the magnetic iron ore which fill the soil adjacent to the numerous veins of that mineral. A more full understanding of the origin of our hematite would be of great utility in directing the search of those interested in discovering mines of this valuable variety of iron ore.

## SECT. II.—*Red Conglomerate of the Primary Region.*

Respecting the geology of this formation, I have at present but little information to communicate, more than to give a description of the rock, and to trace its observed range through the state. It constitutes the Long Pond, Raffenberg and Green Pond mountains, crossing Bergen county, to the New York line. The average width of the belt is perhaps not over two miles, and whether it is prolonged to the south-west of the Green Pond mountain, to any distance, is not known, though there seems no doubt that the formation shows itself near Drakesville, or to the north-west of Succasunny Plains. Its strata range through the mountains above mentioned in bold mural escarpments or precipices, which invariably face the south-east, the uniform dip of the beds being towards the opposite point. Their inclination to the north-west is at an angle of about 30°.

What may be the relative position of this rock to the limestone which shows itself in two or three places upon the south-east of the formation, as west of Mount Hope, and near Maukapin Pond, it would be premature at present to assert, though the probability is rather, that the limestone underlies the conglomerate, whether conformally or not we do not pretend to conjecture. This limestone resembles somewhat the Mendham range.

*Description*.—The conglomerate before us possesses a pretty uniforrn external character, by which it may readily be distinguished from any of the other conglomerates of New Jersey. Its usual aspect is that of a bright red sandstone, rather fine-grained, imbedding large water-worn pebbles, most commonly of white quartz. Sometimes the paste is more argillaceous, and when the pebbles are large, several inches in diameter and of heterogeneous composition and colour, as they occasionally are, then it becomes a little difficult to know it at first sight, from the less calcareous varieties of the Potomac marble conglomerate. In fact, it is possible that the two may be of coeval formation. Its dip and features are finely seen in the mountain north and south of the Milford turnpike, between the Green and Mackepin Ponds. It is a rock that would be ornamental and well adapted to several purposes of architecture.

The geological relations of the rock and its range through the state merit further study. The boulders of this conglomerate may be traced in augmenting numbers and size from the Hudson, the whole way across the country, to the mountain range from which they have been torn.

## SECTION III.—*Primary Rocks of the Region, and its metalliferous Veins.*

In the general view already presented of the physical features and stratification of this region, all that was appropriate has been stated respecting its geological structure. It remains to describe more minutely the character of its small catalogue of rocks, to elucidate some particulars of their range and dip, and to offer such details as have been collected in regard to their metallic veins, their ores and minerals. The primary rocks of the district belong, I believe, to the stratified class *exclusively*, for I am not

aware of having met with any true unstratified igneous rocks, unless in the shape of occasional dikes of sienite or greenstone, traversing the strata. The greatly predominant rock is a mixture of felspar, quartz, and hornblende, united into a compact massive compound, never, or hardly ever, possessing any trace of the schistose structure, though always exhibiting on the large scale a true stratification.

Mica rarely enters as a constituent of the mass, or in very small proportions, and never prevails to any considerable extent in the stratum. Talc and chlorite, other laminated minerals of schistose formations are scarcely seen here. Very often the rock consists of little else than felspar and quartz, while a variety with great abundance of hornblende and but little quartz or felspar, is in other places predominant.

An association by no means unfrequent in some portions of the mass, is one of felspar, quartz, hornblende, and *magnetic oxide of iron*. Protoxide of iron seems in fact, an abundant, we might say, a *characteristic constituent* of the region.

A marked feature in the arrangement of the minerals in this rock, is a tendency, more especially of the hornblende, to assume an arrangement parallel to the external planes of stratification. It is in consequence more particularly of this character, that I consider the rock of these hills to be a true gneiss, though of the *granitic* kind. It more usually passes for a *sienite* on account, I presume, of the absence of mica, and partly perhaps from the occurrence in it of veins or dikes of true sienite and granite, which, lying like nearly *all* the veins of the formation in planes parallel to the strata, appear to be themselves portions of the rock and not veins.

Concerning the manner in which these primary strata dip, the three profiles which cross them will serve to explain pretty accurately their customary attitudes. Their inclination is generally steep, between forty and seventy degrees, and they are liable to few of those minor contortions and flexures so common in the micaceous varieties of gneiss and in mica slate. The almost universal bearing or range of the beds is between north-east by north, and south-west by south, and as the direction of the dip is transverse to this line, their common inclination is either to

the south-east by east or north-west by west, and they are not often disturbed or thrown into any other directions.

### OF THE METALLIFEROUS AND OTHER VEINS OF THE FORMATION.

These are various, but as those containing iron ore are at once the most useful and the best explored, all that I have to say of veins in detail will principally concern that class. It is impossible to treat of every known vein in the region, and therefore a review of the facts collected in the more important districts, will alone be offered in the present general report.

A general description of the iron veins of the primary region of New Jersey may be given in the following terms. They are true *lodes* or veins of vast longitudinal extent *always in the direction of the strata including them.* They occur in the granitic gneiss rock *ranging* and *dipping* with it. Their irregularities are extremely few, being liable only to occasional swells, insignificant slides, and trivial disturbances of pitch and direction; while they are never to my knowledge pinched out or cut across and dislocated by great faults, as are the metalliferous veins of many of the mining districts of Europe and other parts of the world. When several occur together their course is parallel. Their usual thickness is between six and twelve feet, though short veins art seen of all smaller dimensions, while the larger ones are seen here and there to swell by an occasional undulation to even much greater thickness. Some of these veins dip as little as fifteen degrees, while others have an inclination approaching to verticality. Though excavated here and there in small mines, they have nowhere been followed to a greater depth below the surface than about two hundred and twelve feet, the depth of the workings in the Mount Pleasant mine. In nearly all the shallower mines, the veins are worked open to the air.

The ore belongs to the species denominated oxydulated iron, or magnetic iron ore, and is of two varieties, compact and earthy. It consists, when pure, of per-oxyde of iron, seventy-two per cent., and protoxide of iron twenty-eight per cent., or in all of about sixty-seven and a half per cent. of metallic iron. It is magnetic, attracting the needle, and is often endowed with

magnetic *polarity* attracting soft iron, in which case it is the loadstone. It is often massive, associated with no foreign minerals, though the variety most desirable for making iron is granular, composed of imperfect crystals which are often mingled with small crystals of other minerals, sometimes green hornblende or quartz. It is possible that portions of this ore may contain titanium, though such facts, however important to the manufacturer, can only be ascertained by elaborate and multiplied analysis, a few of which I have made upon this point. The disposition of the ore in the vein is that of a solid mass, invested by no gangue, but sometimes containing dispersed through it small granules and crystals of other minerals. It often exhibits a tendency to cleave, by natural joints running from one wall of the vein to the opposite, a structure which suggests in appearance a strong analogy to the *horizontal columnar arrangement* seen in some vertical dikes of lava and basalt. This, if other proof were wanting, I should regard as a strong argument for maintaining that these veins of ore have been injected in a fused or molten state into the strata after they have appeared, and are not *beds* in the true sense, or layers formed contemporaneously with the surrounding rock. This point, though seemingly one of theory alone, is of much practical moment, as acquainting the miner with the nature of the veins he has to deal with.

The walls of the veins are usually smooth, compact, and regular, consisting not unusually of some of the less common varieties of the adjacent gneiss—being sometimes very micaceous, and at others, constituted almost solely of hornblende or red felspar.

To begin with the veins towards the north-east, our attention shall be first directed to those of Pompton township, in Bergen. The principal veins of this district occur in the continuation of the Sterling mountain, of New York. In the ridges immediately west of the Ringwood valley, there are known to be at least two extensive veins. That upon the east has been explored for much the greatest distance, mining excavations having been made in it throughout a length of nearly three miles. The other upon the west is distant from the first about two hundred feet, and where it has been mined or traced, it has been found to keep a

parallel direction. The more eastern of these veins extends north to within a quarter of a mile of the New York line. Their bearing or direction is north-north-east and south-south-west. The rock of the region in which these veins occur, is the granitic gneiss before described, abounding in hornblende and almost destitute of mica. It dips at a high angle to the south-east.

Pursuing the eastern vein from the most southern openings upon it towards the north, the first considerable excavation which exposes its structure is an old mine, wrought open to the day, to a depth of perhaps forty feet, and along the vein about three hundred and fifty feet. The position of the vein here is nearly vertical. It is somewhat disturbed from perfect regularity by trivial slides and changes of pitch, and occasionally divided by pretty large wedge-shaped masses (or horses) of the gneiss rock of the wall intruded into the middle of it, subdividing the vein into two or more branches that send off parallel filaments, that either dwindle out or re-unite with the main body of the vein.

Exclusive of these dividing masses of rock, the mean thickness of the vein in this mine is about ten or twelve feet. The rock forming the outer walls here, is a variety redundant in red felspar. The quality of the ore is good.

About one hundred feet to the north-east of this is the mine now worked. From the bluish hue of the ore, it goes under the name of the *Blue Mine*. The space out of which ore has been removed is about one hundred feet long, the depth fifty feet, and the width of the vein from fifteen to six feet. In this place the vein is also divided by a horse or vertical wedge of rock in the middle of the ore. It increases from one to five feet in thickness, and consists on one side of red felspar, like the adjacent wall, and on the other of compact green sahlite. In this part of the vein, there are slight oblique dislocations or slides, always declining to the south-east. Rather less than half a mile to the north-east of this last opening there is another, believed to be upon the very same vein, being directly in the proper bearing. The distance is such, however, as to cause doubts whether the first vein may not fine out, and its line be occupied by another having no connexion with it. The great length attributed to these veins,

though possibly a fact, may be an illusion caused by several lying nearly in the same line. From what we see of them, however, I must confess my belief, that some at least are very long. In this last mine, called the Mule Mine, the thickness of the vein is seven or eight feet, and the dip which is parallel to that of the gneiss rock sixty degrees to the south-east. Further on is a mine called Peter's Mine, formerly worked in part by a shaft, in part open to the day. The dip here, both of the vein and rock, is also sixty degrees to the south-east. The adjoining rock is a mixture of felspar and hornblende in a state of disintegration, to the depth of several feet, leaving in some places the less destructible ore projecting up like a wall. This mine is in a low spur to the south-east of the main ridge, in which the previously mentioned mines occur. The next opening, called the Hope Mine, is at the south-western extremity of another hill, north-east of the former, and a spur of the main mountain. The vein may be traced in numerous openings which go under the name of the Spanish Hope Mine. The general width is eight feet, and the dip to the south-east at an average of seventy degrees. The ore contains a considerable quantity of foreign crystalline matter. The furthest north of these openings is the old Hope Mine, where the vein is very regular and entire, dipping to the south-east at eighty degrees to the horizon, and having a pretty invariable width of twelve feet. Depth of the excavation sixty feet. The ore here is very excellent. This mine is not more than one-third of a mile from the New York line.

In the same direction with this vein, that is, toward the north-north-east, there occur in New York a series of mines extending for several miles, but whether upon the same vein or not, seems questionable.

It appears from what has been detailed, that the ore in its course to the north, grows more uniform and undisturbed. The general quality of the ore along much of the line here traced is excellent, answering well for the bloomery or the furnace. Much of it is coarsely granular, which is a good feature; a portion, however, is too compact, being somewhat refractory and red short—especially a particular band or subdivision of the vein.

Near the openings first mentioned, the second or western vein

has been penetrated throughout a length of about one hundred feet, and to a depth not exceeding thirty. Its ore makes an iron highly cold short, a circumstance which has caused the vein to be less explored than the other, though it is probable that it ranges over a considerable distance. Its position is parallel to the first. The dip is to the south-east, and its width about ten feet. The ore in these veins is highly magnetic, some of it possessing magnetic polarity. It is a coincidence which deserves at least to be alluded to, that in another even richer locality of magnetic iron ores, namely, that of Mount Pleasant and Succasunny—in Morris county—there exist two extensive veins or series of veins, and that the predominant character of the western vein in that neighbourhood, just as at Ringwood, is to produce a cold short iron.

About midway between Ringwood and Pompton, or six miles from each place, a vein occurs in a similar position to the others on the west side of the Ringwood Valley, and having exactly the same bearing, namely, north-north-east.

Westward of the iron range here laid down, there would appear to occur between this and the vein of franklinite and zinc of the valley beyond the Wallkill mountain, more than one considerable and valuable vein of magnetic ore. We may mention the veins of Charlottesburg and those of the Wallkill mountain, four miles east of Franklin furnace. The details here presented being brought forward chiefly for the sake of arriving at some useful results of a general nature respecting the extent and structure of the veins and nature of the ore, auxiliary to any further developments which may be made hereafter, our attention will be given to those districts only where sufficiently numerous facts of the proper practical bearing occur.

The next district in the region remarkable for the quantity of its iron ore, is the range of country extending for several miles north-east of Succasunny, in Morris county. The formation as far to the north-west as the Green Pond mountain and Succasunny plains, is the usual granitic gneiss of the region, containing a large excess of hornblende in its composition. The strata generally dip to the south-east, and at an angle exceeding sixty degrees. A series of parallel veins of very fine magnetic iron

ore give particular interest to the region. I shall allude here to two of these in consequence of their great length and well developed features. Though no sufficiently accurate explorations have been made to establish, with certainty, the continuity as one vein of the several portions where mines have been opened in the same line of bearing, yet little doubt prevails that the veins range unbroken throughout a space of considerable extent. For the sake of present convenience, we shall venture to designate the two ranges of mines as two veins; for whether they be so or not, inasmuch as they occupy two parallel lines, the question of their continuity is of little importance. I incline to believe that each supposed long vein is, in fact, a string of several nearly in a line.

Beginning to the north-east of Hibernia, these veins are traced through a range of mines to some distance south-west of Succasunny, a length of ten miles at least. The veins are nearly parallel, ranging almost north-east and south-west, are exactly in the direction of the strike or bearing of the neighbouring strata. Their dip is also parallel to that of the primary stratified rocks, which they seem never to cross, but rather to divide along the planes of stratification. In this range, as in that of Ringwood, the eastern, or rather south-eastern, vein furnishes the best ore, and it has upon it, therefore, the greatest number of mines. In the excavations at Hibernia, upon the eastern range of ore, the vein is about eight feet thick, and the ore highly magnetic, of a granular structure and good quality, though rather largely intermixed with small granular crystals of foreign mineral matters not metallic. In the same direction, as nearly as can be made out from the difficulty presented by the distance, a vein of similar ore passes a few hundred feet to the south-east of Mount Hope furnace, and is mined pretty extensively at the Thebant mine of Joseph Jackson, Esq. Here the vein is nearly vertical, inclining rather to the south-east. The average thickness is ten feet. The rock near the vein is a rather micaceous gneiss, the walls being regular and unbroken. This is one of the localities in which the horizontal *columnar structure* of the ore is very obvious. A "*horse*"—a wedge of rock—separates the vein for a short space in one or two places. This mine is on a

hill, three hundred feet above the adjacent streams. The ore is of excellent quality, though compact, the foreign matter mingled with the magnetic oxide of iron being a green variety of hornblende, with quartz. The mine is one hundred feet deep, and the length of the excavation exceeds one hundred and fifty feet. Upon the same supposed south-eastern vein, and one mile further to the south-west, is the Mount Pleasant mine. The depth of this is two hundred and twelve feet, the dip still to the south-east, and the average thickness of the vein about eight feet. It does not lie above the drainage of the district, and is therefore drained by a series of pumps, very well contrived, which are driven by a small stream setting in motion a water-wheel. The rock adjacent to the vein is here an almost pure hornblende in extremely beautiful massive crystallization.

The next spot to the south-west where any conspicuous opening has been made upon the same range is at Jackson's mine, a mile and a half north-west of Dover. Here the general features are the same as in the other mines, the dip being 50° to the south-east. A band three feet wide, in the vein at this place, is good ore, having a soft and granular structure; while the other portion of the vein yields an ore that is *red short.** No seam of rock or mineral matter appears to divide the two bands; and their occurring with opposite properties, side by side, is a little curious. The adventitious matter in the red short ore is the same as that in the ore of standard goodness. This mine is no longer wrought. About half a mile more to the south-west is another excavation, yielding the same kind of ore, and presumed, from the direction, to be in the same vein. The next, and by far the largest vein of the range, is half a mile farther on, at Gen. Dickerson's, near Succasunny. Here the including rock is a variety of gneiss, consisting chiefly of quartz and felspar, with occasionally a little mica and oxidulated iron disseminated. The dip is about 60° to the south-east. The mine, which is nearly full of water at present, has been wrought to a depth of about

* *Red short* signifies a brittle or short condition of the iron ore, when at the ordinary welding red-heat; by which, in place of welding, it crumbles under the blows of the hammer. Such iron, carefully manufactured, may make a very good tough metal when *cold.*

eighty feet. In the horizontal drift, along which the vein has been chiefly worked, the quantity removed has been very great. Here the average thickness may be stated at about twelve feet; though near the entrance of the mine, in consequence of an irregularity, the mass of ore seems to have been at least thirty feet across. This being in a disturbed portion of the stratum, the presumption is, that the vein does not continue far of this dimension. The general structure of this ore is highly granular, showing a frequent approach to the octohedron, the regular crystalline form of this species of iron ore. It is also sometimes of the compact variety. It is considered equal to any in the state for the quality of the iron which it produces. The same vein is said to have been opened still further to the south-west; but the remotest point to the south-west to which it has been traced, I have not ascertained.

As before intimated, another range of magnetic iron ore occurs parallel to that here sketched, and at a distance of about a fourth of a mile to the north-west. Its thickness is about the same, or rather greater than that of the first. Its prevailing dip is to the same quarter, the south-east; and to all external appearance, it is the same kind of ore precisely. And yet, though intermingled with the same foreign minerals, and possessing nothing to distinguish it from the other, by the eye, and as an ore having exactly the same habitudes in the furnace or the forge, it yields an iron in all respects different in properties, and of inferior value. The metal from this ore is *cold short*, that is to say, brittle or short at ordinary temperatures, though really valuable at a welding heat.

Mount Hope mine, now no longer worked, is upon this vein. The width of the vein is not precisely known, though it is seemingly between twelve and fourteen feet. What is presumed to be the same vein, is seen again in the Harvey mine north-west of Dover. This vein, once pretty extensively wrought by a shaft, is now closed. The ore resembles that of Mount Hope. Another excavation has been made upon the same line, opposite to the Jackson mine, on the other or east vein. The vein has been tapped in numerous other places, sufficiently contiguous to each other to prove how extensive its course between the strata

must be; but it is needless to our purpose to go more into particulars at present.

Not far from Mount Pleasant, there is a small mine, upon a vein which is supposed to lie to the south-east of those above traced. But little is known of the length or course of this vein, any further than that its direction and dip are parallel with those of the others. A similar vein is known, and has been mined to a considerable extent, near Pomerville; and no doubt many more exist in the district, though nothing has been done to develope them, and no useful information has reached me touching them. It should be mentioned that the long ranges of ore above traced are almost exactly in the bearing of the vein near the old Charlottesburg furnace, on the Pequannock.

Scott's mountain, in Warren, is another district abounding in this valuable mineral. Some facts regarding the veins in the vicinity of Oxford furnace, the most important locality in that quarter, will close the details which we have to offer upon this head. Here, as elsewhere, the direction of the veins is parallel with the bearing of the strata of granitic gneiss—which include them. There appear to be at least two principal veins, but the precise thickness of either it is difficult to state, owing to their varying materially in dimensions. The mass of ore, however, is enormously great. They are divided here and there by thin strata of the rock, into several parallel branches, so that the aggregate width of ore has not been wrought in many places. The adjoining strata are, moreover, considerably disordered, and the veins are in consequence thrown out of direction by two or three pretty large *faults*. These are connected with detached or broken off portions of the lodes, two of which are known to sweep round a curved or almost semicircular form, with a thickness of perhaps one hundred feet to each vein.

Some portions of the adjacent strata contain the oxidulated iron in a crystalline state disseminated in sensible proportions through the rock, or rather in certain layers, either associated with the hornblende, or replacing it.

In quality the greater part of this ore resembles that of the ranges before described, being the magnetic oxide of iron, either compact and massive, or in granular crystallization. It has the

defect common to nearly all the veins in the primary region; that is to say, it is apt to be *too* compact for easy reduction in the smelting furnace. It yields an excellent iron, and seems especially well suited for making inferior castings.

### CONCLUSIONS AND HINTS DERIVED FROM THE PREVIOUS FACTS.

The first theoretical inference naturally suggested by the remarkable manner in which all the veins without exception occur, is that the strata of the formation were, in all probability, at a pretty steep inclination previous to their appearance between the rock; for it is inconceivable how a forcible injection of fluid ore could enter a series of beds, lying in a nearly horizontal position, without in one case causing and occupying fissures *transverse* to the strata. The fact that similar veins, those of the altered white limestone of Sussex, occupy a corresponding position in reference to the neighbouring strata, and appear to have been produced after the formation of the limestone, is another argument giving probability to the idea that their origin was subsequent to the appearing of the gneiss.

On the other hand, it is not difficult to conceive that if the beds were previously nearly vertical, or at a high angle, the molten ore would more easily insinuate itself between the layers of the rock in which direction, of course, the strata would most readily give way, than enter the mass in directions oblique to the edges of the beds. If the rule be a general one, that these veins range and pitch parallel with the strata, we are led to some important general views for seeking and commencing mines in this region. One is that the veins of ore may be expected to follow the same layer or bed of rock for a considerable distance, and that the nature, therefore, of the *adjoining rock* will often prove a clue to recover a known vein in the direction towards which it is prolonged. Another is, that when levels are cut or shafts sunk to reach a vein, the indications of which are supposed to appear upon the surface, the excavations should be made on that side of the presumed *outcrop** of the

* *Outcrop* signifies the exposed portion of an inclined stratum or a vein, or the space it occupies at the surface.

vein, which is towards the *underlie* or dip of the gneiss, for the vein, keeping parallel with the rock, will descend in that direction.

Suggestions concerning the treatment of these ores in converting them into iron, can be of service to the manufacturer only in proportion as they are the results of numerous and precise chemical investigations into their composition. But this species of research requires the command of a degree of leisure, which my hitherto constant occupation in the field has not afforded me. I am enabled, however, to present a few analyses, made with a view more especially to ascertain the nature of those impurities which frequently injure the quality of the iron made from these ores, and which impede their reduction.

Analysis of the Franklin Iron Ore, or Franklinite.

| | |
|---|---|
| Peroxide of Iron, | 64.32 |
| Oxide of Manganese, | 16.08 |
| Oxide of Zinc, | 12.50 |
| Magnesia, Alumina, Earthy matters, Silica, &c. | 6.65 |
| | 99.55 in 100 grains. |

Analysis of Gen. M. Dickerson's Magnetic Iron Ore, at Succasunny.

| | |
|---|---|
| Peroxide of Iron, | 70.00 |
| Protoxide of Iron, | 28.25 |
| Oxide of Titanium, | *a trace.* |
| Oxide of Manganese, | *a trace.* |
| Loss, | |
| | 98.25 |

Analysis of Magnetic Iron Ore, from Oxford Furnace, Warren County,

| | |
|---|---|
| Peroxide of Iron, | 67.25 |
| Protoxide of Iron, | 26.50 |
| Oxide of Manganese, | 0.50 |
| Oxide of Titanium | *a trace.* |
| Silica, | 2.10 |
| Alumina, &c. | 3.00 |
| | 99.35 |

Analysis of Magnetic Iron Ore, from Ringwood, Bergen County.

| | |
|---|---|
| Peroxide of Iron, | 69.20 |
| Protoxide of Iron, | 27.00 |
| Oxide of Manganese, | 0.80 |
| Silica, | 1.00 |
| Alumina, | 0.75 |
| Lime and Magnesia, | 0.75 |
| | 99.40 in 100 grains. |

It deserves the attention of those engaged in the manufacture of iron from these ores, that very frequently the portion of the vein immediately underneath the soil, and the fragments and grains of the ore which often fill the soil in very considerable abundance, are in a much softer condition than the ore in the main body of the vein. The action of atmospheric agents upon it, appears to have rendered it much more friable; and, consequently, it mingles readily when in the furnace with other materials, and thereby greatly facilitates the smelting of the mass of which it forms a portion. I am not sure that the clay and earthy matter which remain attached to this surface ore, even after it is washed free from the loose soil, do not account in part for its beneficial effects; for it seems very possible that the highly silicious nature of the foreign minerals in the ore may counteract in part the fluxing agency of the limestone, and render it less efficient than when other ores are smelted. In fact, some trials have been made at the Oxford furnace, which consisted in mixing a loamy clay with the ore, in addition to the limestone, and the results were decidedly encouraging. The loose surface, therefore, merits the attention of iron smelters. The soil containing it is washed, at Oxford furnace, in a stream of water running through troughs, after which it is sifted, and the increased product proves that the extra labour spent in preparing it, is economically bestowed.

In two or three places in the iron region, magnetic separating machines are in use to clean the ore of the foreign mineral matter which is mixed through it. They are applied, of course, only when the quantity of non-metallic matter is so large as to constitute a motive for removing it, nor are they admissible, except when the ore is highly magnetic throughout. One is in use at Ringwood, and another at Hibernia.

We may be permitted in this place to indulge the anticipation, that the more extensive introduction of the hot-blast, may show that it is especially suited to overcome the difficulties encountered in the reduction of this species of ore, which, either from the nature of the impurities in it, or from its uncommonly com-

pact structure, seems to demand, in some cases, a more than usually elevated temperature to insure its ready fusion.*

## RED SANDSTONE REGION—GENERAL VIEW.

Under this title we mean to comprehend the geology of the entire district, lying to the south-east of the primary region just described, and bounded on the other side, or on the south-east by the Hudson river, Staten Island Sound, the Raritan river from its mouth to the mouth of South river, and from thence by the irregular line to Trenton, which was before laid down as constituting the upper limit of the horizontal clays and sands of the lower division of the state. It embraces therefore the south-eastern portions of Hunterdon, Morris and Bergen, together with the whole of Somerset, all Essex, and a portion of Middlesex counties. Pursuing the descending order, the strata consist, first of a course variegated calcareous conglomerate, then a very wide series of alternating shale, sandstones, and conglomerates, in which the prevailing colour is red, and last, and inferior to all, an inconsiderable primary formation near Trenton, of granitic gneiss, which for convenience may be included in the same chapter with the others, though of a much older geological date. That the lower beds of the formation, rest in an unconformable posture upon the gneiss or primary strata near Trenton, is placed almost beyond a doubt; when we advert to the steep south-east dip of the latter, where it is in several places only a few hundred yards from the out-crou of the former, in which the universal dip is at a gentle angle towards the opposite point. The gneiss can be traced following nearly the line of the Delaware and Raritan Canal for about six miles, and a little to the north-west of this, the sandstone rocks are every where met with so ranging, that if we supply the small interval in which neither of the rocks is seen, the sandstone will rest upon the upturned edges of the other. In the neighbourhood of Rockville, Bucks county, Penn-

* See a description of some experiments with the hot-blast at the Oxford Furnace, in the Journal of the Franklin Institute.

sylvania, we have unequivocal evidence that such is the material position of the two classes of strata.

In consequence of the absence of any discovered contact between the gneiss formation of Trenton, and the great red sandstone series above it, and more especially in consequence of the apparent unconformability of the whole of this group to the gneiss rock, and overlying limestone of the south-eastern edge of the primary region, it becomes, at the present stage of research, difficult, if not impossible, to arrive at satisfactory conclusions in regard to the true relative age or position, in the scale of our formations of the set of rocks before us. One remarkable feature about this whole red sandstone series is, that across all the state, from the Delaware to the New York line, the invariable dip of the strata, except where locally disturbed by ridges or dikes of trap, is towards the north-west. This is seen by inspecting the northern profiles. But it will be remembered, from the facts previously developed respecting the position of the formations of Warren and Sussex, to the gneiss rocks of the highlands or primary hills, that those beds owe their inclination to the north-west, in all probability to the upheaving of the gneiss, which upon its south-eastern side, has tilted off the limestone towards the opposite point or the south-east. Had the conglomerate and red sandstones adjoining this limestone just mentioned, been in existence previously to the upheaving of the gneiss, it seems difficult to explain why all of this series should not also be found dipping away to the south-east from the primary hills. It appears, therefore, to be a just conclusion, consistent with long received principles of geological reasoning, that these conglomerates and red sandstone strata, were produced after that action had taken place; and that, therefore, they constitute a newer formation than the rocks lying to the north-west of the primary hills. The order of superposition of all these rocks will, it is believed, be more clearly ascertained by studying the geology of the states to the south-west of New Jersey; because as we advance in that direction, the primary rocks which fill up the interval or interruption between the two groups, under comparison, sinks into insignificance, or finally disappear altogether. In Virginia especially, we may hope, from the survey now on foot there, that the true

relations of these beds will be established at an early day. I have seen enough on the Potomac and in various places across Pennsylvania, to lead me to believe, that the variegated calcareous glomerate is of more recent date than the limestones and slates of the great valley adjacent to the Blue mountain in New Jersey.

### SECTION I.—*Variegated Conglomerate.*

This, which is the uppermost rock, and therefore the first to be described of the great red sandstone group, has been traced, keeping within a short distance of the gneiss or its overlying limestone, through a line of several rather remote localities, nearly the whole way from the Delaware river to within a few miles of the New York line.

*Description.*—In almost every other portion of its range, this stratum is an extremely heterogeneous rock, being composed of pebbles or water-worn masses of all sizes, from that of a man's head down to that of a small pea; the materials of which belong to most of the older formations discovered in the region. A large portion of the very motley mass will be found to be made up of various-coloured sandstone pebbles. Sometimes there is a considerable mixture of pebbles from the primary rocks; and again in certain parts of its range, throughout nearly the whole thickness, the stratum seems to consist of pebbles of limestone, firmly cemented in a limestone paste. Very usually, the cement or imbedding paste contains a sensible proportion of the materials of the red argillaceous shale of the strata herewith. In fact, where the Baltimore and Ohio rail-road crosses this rock in Maryland, the chief part of the cement is nothing else. This admixture of red matter in this pebbly rock in New Jersey, easily explains itself. The harder sandstones and limestone would retain the fragmentary state, and the soft red shale would be reduced to powder or mud, by the extraordinary action which brought together this vast mass of water-worn materials.

A large portion of the formation in its course across New Jersey, exhibits all the characters of the rock, which has furnished the columns of the Hall of Representatives, and which at

Washington goes under the name of Potomac marble. In fact, from the numerous intermediate places, between the Hudson and the interior of Virginia, where I have crossed the stratum, and found it occupying the same relative position in our series of rocks, I entertain no doubt, that it prevails as a nearly continuous stratum throughout the whole of the extensive line of country, included between these points.

The limestone variety, where the cementing matter is not too soft, affords a material of the highest beauty for ornamental uses; and it is a just subject of surprise that so little has been done to call attention to its numerous applications. The rock is frequently so exclusively composed of materials derived from limestone, that it makes as good a limestone for converting into lime by burning, as many strata which do not possess the conglomerate structure. It has been in reference to this, its most practically valuable feature, that I have felt especially solicitous to fix as nearly as possible the range which it pursues across the state, that those portions of the red sandstone district needing lime for the improvement of their agriculture, might be induced to seek it from this formation, which, when sufficiently calcareous, is of course the nearest source.

Upon the Delaware it shows itself in a belt of more than a mile wide, between Milford and Spring mills, coming to the river nearly opposite Gallon's run. It rests conformably upon the upper layers of the red sandstone, which it joins probably about one mile to the north-west of Milford. Dipping to the north-west, or directly towards the eastern base of the Musconetcong mount, its near vicinity reduces it almost to a certainty that it meets the strata of that hill in an unconformable position, as it may be seen exhibited in profile No. 3.

The angle of dip is about twenty degrees. A little below Johnson's ferry on the Delaware, the rock near the road is greatly weather-eaten, owing to the facility with which the more calcareous portions are washed out, and the resistance offered to decay by the sandstone and other hard pebbles, which make up a large proportion of the mass.

Following the formation in its course to the north-east, nearly parallel with the base of the Musconetcong mountain, I have seen

it next displayed in the vicinity of Clinton, upon the fourth branch of the Raritan. In this neighbourhood it adjoins a pretty extensive tract of the older blue limestone, which has a prevailing dip to the south-west, while from all the evidence thus far collected I am induced to believe that the dip of the conglomerate here as elsewhere is to the north-west. In this quarter it would yield a tolerably pure lime.

It skirts New Germantown upon its north-west, in a tract perhaps a mile wide and several miles in length, extending nearly as far north as the Lamington river. At New Germantown it is an almost pure limestone, and is somewhat largely used for making lime. The pebbles are of various shades, blue, yellowish and red, and much of the cementing matter is tinged red. It is susceptible of a high polish, and constitutes a beautifully variegated conglomerate marble. The dip of the rock in this portion of its range is still to the north-west, at an angle of about twenty degrees. The usual size of the pebbles is about an inch in diameter, though a part of an inch larger. They arc not fully rounded, but occasionally exhibit edges and angles, though much blunted and worn as if by attrition. The superposition of this rock to the red shale or sandstone series upon which the village of New Germantown rests, is very evidently shown in its vicinity. On the north-west side of the little valley which borders the town we see the conglomerate, while upon the south-east side we behold, within a few hundred feet, and dipping in the same direction and at the same angle, the north-western edge of the red shale.

The next place where I have witnessed unequivocal traces of the formation is at the foot of the Montville inclined-plane, upon the Morris canal. It then forms the abutments of the mill dam at Judge Cook's, where it will he found to agree very strictly with the slightly calcareous variety which forms the largest part of this stratum upon the Delaware. At Montville the pebbles are often very large, and consist principally of primary rocks and red sandstone, so that it would be useless to attempt burning it for lime, although a limestone layer may possibly occur nearer the top of the stratum, or which is the same thing, a little farther to the north-west, for that is the direction of the dip of the stratum at this place.

A very little to the north-west of this rock we meet the base of the primary hills, in which the dip is at a steep angle seventy degrees to the south-east. It is traceable very plainly over a course of nearly a mile past Ryerson's, at Pompton. In this point of its range I detected what I look upon as its actual contact with the inferior sandstone series. Over the red sandstone rests a bed of rather thin silicious slate, the upper portion of which is pretty calcareous; and immediately upon this reposes the very close conglomerate containing a pretty large share of limestone pebbles. This occurs near the Ramapo, a mile to the north-east of Ryerson's. The dip of the whole is to the west, the angle being between fifteen and twenty degrees.

The conglomerate is seen again with the same dip about half a mile to the west of this, and contiguous to a ridge of gneiss, which appears to cause some local displacement of the neigbouring strata. This is upon the border of the plain through which runs the Ringwood stream; and it seems altogether probable that the difficulty of tracing the conglomerate more extensively in this quarter arises, first, from the irregularities in direction of the strata, caused by the intrusion of the trap; and in the next place, because the western part of the formation may rest beneath the deep covering of diluvium which forms these plains. At the spot last mentioned the conglomerate was disclosed by some too credulous miner in an excavation for silver ore, led astray by the occurrence of very minute crystals of yellow sulphuret of iron. The rock is nearly all limestone, and specimens which have been polished prove its exact identity of character with the Potomac marble. The conglomerate is traceable along the side of the Ramapo near Ryerson's barn, where it has the same dip and general composition, though it is less calcareous.

Upon a hill side, bordering the Ramapo meadow, the surface is strewed with here and there detached and weather-eaten masses of limestone, which strangely enough are highly abundant in fossils of the older order.

Pains were taken to ascertain whether or not there exists here a regular stratum of this limestone, but the success was only partial.

Boulders of considerable size were found imbedded almost

immediately upon the conglomerate; and masses, moreover, have been seen composed of both rocks, one side being limestone and the rest conglomerate: from all which it is pretty obvious that there either is, or has been, a limestone stratum overlying the conglomerate. A sufficient abundance of the calcareous rock must, at all events, exist to make this discovery, though local, of some importance to the neighbourhood, when all other sources of lime are at a considerable distance.

Some portions of this superficial limestone possess an exquisitely fine grain, and soft bluish dove-colour, which undoubtedly would render it valuable as a beautiful variety of marble. The fossils belong to those species of shells and corals most usual in the lower fossiliferous rocks; and they seem to differ in no respect from the organic remains of the strata north-west of the Blue mountain. Too few, however, were collected to enable me to institute a sufficiently strict comparison, although, should the rock containing them be found in regular place, it will be an interesting, and for the sake of scientific results, an important comparison to prosecute farther.

Much obscurity exists as to the exact course which the conglomerate takes between the points at which I have here described it, more particularly across the interval between New Germantown and Montville. Whether it takes a straight course across the Mendham limestone deposit, or is deflected materially more to the east by the Mine mountain, and the primary ridges which pass by Morristown, is more than my opportunities for examination enabled me to ascertain. It seems, however, more probable that if it ranges over this space, its track is to the eastward of Morristown.

### RED SHALE AND SANDSTONE FORMATION.

Nothing need be said beyond what has already been sketched to convey a sufficiently precise conception of the range and limits of this very wide group of strata. The line formed by the junction of the conglomerate, marks out its north-western boundary; while its extension to the south-east has been speci-

fled in the "general view" of this section of the state given in the commencement of the chapter.

*Description*.—The greatly predominant rock over the wide area occupied by this group, is a dull red, highly argillaceous sandstone, in which the proportion of clay is often so great as to give it the texture and fracture of a shale. Other portions are more arenaceous, the sandy particles, however, being most commonly extremely minute. Not an unfrequent variety of the rock answers to the description of a true red sandstone, containing a small quantity of mica, and splitting into regular blocks and flags. Several beds of the series, especially low down in the mass of strata, are rather coarse conglomerates, the materials showing that they in great part originated from rocks of the primary class, the rock having therefore a yellowish hue from the amount of quartz. Some of these conglomerates contain, mixed with the other pebbles, flat ones of the red shale, imparting to the mass a rather mottled exterior.

The prevailing red hue of the mass is obviously due to its containing a considerable proportion of iron in a high state of oxydation. Some beds of the shale and fine grained sandstone are green and bluish-green; and other large tracts, especially adjacent to the ridges of the trap, have a dull blue colour, great hardness, and sometimes a ringing sound when struck.

The character and qualities of the several strata which make up this formation will be made to appear by describing them in the descending order, as they present themselves adjacent to the Delaware river, or upon the line of Profile No. 3. It was not considered essential for general purposes, nor would time have permitted me to trace the several subdivisions of the series in their range to the north-east; though whenever a particular stratum has been crossed, and clearly recognized, its position will be alluded to.

The upper strata, or those in immediate contact with the variegated conglomerate, are mainly composed of the more common very argillaceous red sandstone, having a deep brownish red colour. The rock answering to this description extends from the conglomerate, which is one mile north-west of Milfordtown, to within half a mile of Frenchtown; or over a width

measured upon the profile of about four miles. The Nockamixon cliffs, upon the Pennsylvania side of the river, exhibit a fine display of these upper beds. The angle of dip to the northwest being very gentle, though considerably greater than it seems to be from looking at the face of that precipitous escarpment, the direction of which is not sufficiently in the direction of the dip to make the full degree of inclination apparent. The chief portion of the beds, in this part of the series, is apparently arenaceous enough to furnish a very good sandstone for ordinary purposes of building.

Whether in other parts of their range, the beds lying immediately below the conglomerate, are of the variety exhibited near the Delaware, is yet a question; though, from all that I have seen, I believe that the upper belt has this general argillaceous character. Near Pompton, however, where the very top only of the series is exposed, the red sandstone and shale occur in somewhat diversified features. In a quarry near that place, the red sandstone may be seen in its ordinary character, alternating in thin beds with a very heterogeneous fine-grained conglomerate made up of a great variety of materials, and presenting, as it were, a miniature of the variegated conglomerate above it. These sandstones are parted by very thin layers of the soft shale, almost in the state of a compressed red clay. At the dividing surface of the harder and softer layers may frequently be seen organic impressions of a class pretty evidently belonging to some of the older aquatic tribes of the vegetable kingdom; they are mostly in the shape of stems.

Upon these sandstones there rests a thin bed of a gray silicious slate, very schistose, though of too coarse a texture to warrant a prospect of its being turned to useful applications. Besides the sand in its composition, there is a moderate proportion of mica. Its laminæ coincide with the planes of stratification, and the thickness of the whole mass is inconsiderable. The variegated conglomerate of this neighbourhood, previously described, rest in a conformable or parallel position upon this slate. The whole of these rocks dip to the west.

To return to the rocks upon the Delaware, or rather upon the line of the third section or profile, we pass from the series of

beds above described to another, in which the rock differs chiefly in being more arenaceous, much harder, and having never or very rarely the irregular shaley fracture which distinguishes the argillaceous beds. The colour of this set of strata is a brighter red than appears in the former. Its fine compact grain, and its splitting into regular flagstone layers, render it a useful building stone, evidently capable of resisting exposure to the weather. It extends to about the valley of the Lockatong creek, showing signs of increasing compactness, as we pass towards the lower beds, which in fact graduate into a highly indurated and altered group of strata lying beneath.

From the Lockatong to the Wickheckcoke these strata form an elevated table-land, the surface of which is about four hundred feet above the Delaware. It extends from the valley of the river, where it is about three miles wide, expanding in breadth to the north-east until it reaches the valley of the south branch of the Raritan. Its lower edge follows a line commencing at Bull's Island, and passing west of Sergeantsville and Flemington. Here it bends to the north to follow the south branch, to within three miles of Clinton. The upper or north-western limit is less clearly defined, as the highly indurated strata in question pass, by nearly insensible shades, in some places, into the slightly modified strata before mentioned, upon the north-west. An approximation, however, to its boundary will be had by drawing a line from a little below Smithsville, on the Delaware, through Pittstown, to near the south branch of the Raritan.

Throughout this area, the rock preserves a pretty uniform external character; that of a highly indurated baked shale and sandstone, the prevailing colour being very dark dull blue, sometimes a deep gray, and sometimes greenish. It has a great tendency to split into rhomboidal fragments, has often a somewhat splintery fracture, and certain varieties yield, when struck, a clear ringing sound which has erroneously procured it the name of clinkstone in the neighbourhood.*

The tract where this rock exists goes in Hunterdon county under the name of the *Swamp*, owing to the prevailing cold wet

* Clinkstone or phonolite is a felspar rock of the trap family, usually fissile, and is sonorous when struck, whence its name.

character of the soil. Little or no true trap rock is visible in the district, except along the southern border, where, as for example north-west of Flemington, it may be seen following in direction pretty nearly the range of the altered strata. It is likely that numerous dikes of trap do exist, especially next the south-eastern limit of the table-land, but concealed beneath the soil, or perhaps existing as injected veins not reaching the surface of the rock. The regular stratified structure and north-west dip of the strata seem, however, not to have been changed, even where the rock appears to have undergone the most decided change in all its external features from the extremely elevated heat, to which, without doubt, it has been subjected since its original deposition. There is a frequent alternation of the highly indurated beds with others exhibiting but little departure from the commoner red shale and sandstone character. It will be perceived, that I have laid down upon the profile, the probable position of the chief outburst of trap supposed to be connected with the modification of so large a portion of the strata of the district. It is in a line with the trap near Flemington.

In the range of country to the north-east of this tract, called the Swamp, the strata, except where intersected by some trap ridges hereafter to be mentioned, seem to have sustained no similar alteration of texture and colour, nor are the changes which do appear in the strata for some small distance from the other masses of trap which occur in this region, of precisely the same nature as witnessed in the rock of the Swarnp. The round Valley Mountain, a semicircular ridge of trap rock, has disturbed the order of dip in the strata, for two or three miles from its base, between Whitehouse and Flemington, while it has exerted no sensible influence in altering the features of the rock.

The beds, which underlie those of the Swamp, though they seem not to have experienced the same decided changes from temperature, differ materially from any of the red shale and sandstone beds above specified upon the profile. They present a series of alternating red sandstones and coarse yellowish conglomerate, occasionally parted by beds of the softer argillaceous slate or shale.

This somewhat varied group of beds extends in width from

the Wickheckcoke to below Centrebridge run. The conglomerates of the series resemble closely those which occupy an inferior position in the entire red sandstone formation, or in other words, which appear within three miles of the gneiss at Trenton. A pretty large portion of the pebbles, which frequently are half an inch in diameter, are quartz and felspar, the latter occasionally decomposing. With these we may see mingled flatter pieces of red shale, the whole bound together by a small amount of ferruginous matter as the cement. Much of this latter rock is but a coarse sandstone, and in the vicinity of Centrebridge, and at intervals for a mile and more above it, occurs of a quality excellently fitting it for architectural uses, having been fully tried in the bridges upon the upper end of the feeder.

From these conglomerates and the beginning of coarse sandstones of the neighbourhood of Centrebridge, to the lower series of somewhat similar conglomerates and sandstones at Scudder's creek, about five miles above Trenton, the predominant rock is the argillaccous red sandstone alternating between soft shale and hard arenaceous and micaceous sandstone. The colour, though most usually red, is sometimes dull bluish or greenish. It exhibits cross joints in great plenty and regularity. Much of the rock in this interval gives proof of its having been somewhat consolidated by an elevated temperature, if we may judge from its compactness and baked aspect and the sonorous ringing which it returns when struck, and more especially the extent to which it is divided by cross joints. With one single exception upon the line of profile, the dip is invariably to the northwest, at about the usual inclination of nearly twenty degrees. This exception occurs between Alexsockin creek and the ridge of trap about a mile above it, and is where the trap in bursting up through the stratified rock has thrown it out of its usual inclination, and caused it to dip to the south and south-east. This disturbed position does not, however, prevail over perhaps more than half a mile; and it is singular enough, that adjacent to and between the three other bold ridges of trap which cross the strata below, no similar displacement of the prevailing dip has taken place. I may mention in this place, that the same fact attends nearly all the principal outbursts of trap rock in the

state, namely their producing no disorder in the original attitude of the strata, though evidence sufficiently ample will be offered presently, in proof that the trap must have issued through the stratified rocks after their deposition.

Upon the north-west side of the large ridge of trap called Goat Hill, there are changes in the mineral contents and structure of the adjacent strata highly curious and important in a scientific point of view. What I allude to is, the existence in the sandstone of a profusion of nodules and crystals of epidote, tourmaline, and other minerals hardly ever found but in primary and volcanic formations, but occurring here in consequence, no doubt, of the heating influence of the vast mass of trap, as it has issued from the earth's interior, in a molten state. When I come presently to treat of the trap rocks of the red sandstone region generally, I shall dwell more at length upon the interesting mineralogical changes of this nature which offer themselves to view in this and one or two other localities.

It will be discerned upon the profile that the stratified sandstone rises almost to the top of Goat Hill, upon its eastern slope, preserving throughout its ordinary dip to the north-west, but dark and indurated. Between the Bellemont and Smith's Hill ridges, the strata are in places altered to nearly the aspect of the rock of the swamp district, and in one or two places small traces of copper show themselves. The dark blue, or almost black, altered shale, upon Moore's creek, has been erroneously taken for a slate or shale indicative of coal; but evidence enough has already been brought forward to show that the formation before us is altogether out of the coal series.

From Abner Scudder's creek to Hill's creek, a belt of nearly two miles upon the profile, a prevailing rock is a coarse-grained pinkish sandstone, consisting of transparent quartz sand, with numerous white grains or specks of somewhat decomposed felspar, and small flattish pebbles or flakes of the more argillaceous red sandstone. The chief ingredient in this rock is silicious sand, either transparent and white, or stained yellowish by iron. The predominant reddish colour of the rock is due to the minute particles and little fragments of the red shale in its composition. The group of beds here described yield altogether the best

building material upon the Delaware. The rock is pretty extensively quarried at the State Prison quarry, Green quarry, and Hill quarry, and upon the opposite side of the river at Yardleyville. Its stratification is usually very regular, and much of the rock is at the same time easily wrought, and capable, from its composition, of resisting well every atmospheric source of decay. These and the next succeeding strata are discernible over a considerable range, pursuing a direction nearly parallel to the canal towards Princeton.

From Hill's creek, which is about three and a half miles above the State-House at Trenton, to within about one mile of the same, we pass over the lower conglomerate series which terminates the system of strata, thus far discovered to belong to the great and important sandstone formation under review.

The materials which make up this lower set of rocks are pebbles and grains of sand of the same minerals which are recognized as composing the primary strata, upon the upturned edges of which these are presumed to rest. The rounded fragments are from the size of coarse sand to an inch in diameter, and comprehend grains and pebbles of quartz, some of which are of the semi-transparent, partially opalescent kind, pretty abundant in certain strata of the gneiss. Associated with the quartz there is much felspar, white or yellowish, and partially decomposed; also, a small share of mica and a considerable quantity of hornblende. Throughout some of the strata there is dispersed a greater or less proportion of hydrated oxide of iron, in minute yellow specks. The decayed condition of the felspar, and the stains from the oxide of iron occasionally impair, in some degree, the value of these rocks for objects of architecture. The dip of the bed is to the north-west inclining about twenty degrees. Want of parallelism of the planes of stratification, and some minor irregularities, as if from trivial sliding of the beds upon each other when they were uptilted, tend to interfere with the value of many of the quarries in this range, by marring that uniformity with which building stone, for many purposes, must split. A good display of these rocks, in their more distinctive features, is to be witnessed in Dean's quarry, a mile and a half from Trenton, upon the Feeder. The same variety shows itself

upon the Delaware and Raritan canal, about six miles to the north-east of Trenton, where it agrees in all particulars with the inferior beds upon the Feeder.

It is believed that the foregoing strata make all the principal varieties under which the formation shows itself in any part of its range across the state, from the Delaware river to the boundary line of the state of New York. By inspecting the geography of this region of the state, it will be obvious that the area attributed to this great sandstone group diminishes in width as we proceed to the north-east, and this is easily explained, when it is stated that the inferior strata which have been described, together with the underlying formation of gneiss, disappear in their course to the north-east, by vanishing in succession, first the gneiss and next the conglomerates, beneath the horizontal deposits of sand and clay, subordinate to the newer formations of the south-eastern part of the state—that is to say, the horizontal beds which conceal them, intrude further over them, towards the north-west, as we advance from the Delaware to the Raritan.

The gneiss is lost when we get about six miles from Trenton, upon the canal, and the upper beds of the pink sandstone of Scudder's creek, on the Yardleyville rock, disappear under the same covering, somewhere near the mouth of Stony brook. It is plain, therefore, that the south-east edge of the region, from thence on, can present us only the middle members of the great group of the common red sandstone and shale description. This idea is verified by observing the character of the strata as they display themselves upon the Raritan, Staten Island Sound, and bordering the Hudson river. It is needless, therefore, to describe in detail the subdivisions of the series, where they are traversed by the first and second profiles, since their general characters are already laid down, and since their nature can be pretty nearly ascertained by prolonging the several beds specified upon the third profile, along their line of bearing or strike, which is almost exactly north-east. We have only to add, that their dip, throughout their range, is, as it is upon the Delaware, almost invariably to the north-west, and that the steepness of their in-

clination is, if anything, a little reduced as we advance to the north-east, or to the Hudson river.

### OF THE TRAP ROCKS OF THE RED SANDSTONE REGION.

To avoid tedious and uninteresting details, of a merely geographical kind, I shall omit tracing the range of the various ridges and dikes of *trap* which traverse the strata of this formation, and refer my readers to Gordon's map of the state, making mention, that I have found all the hills within the sandstone district, whose topography is there sketched, to consist of trap rock in some of its several varieties. The principal ones I shall enumerate, and have to state that the general accuracy of this portion of the map is highly creditable to the topographer, though there are several minor ridges not engraved.

Proceeding from the Delaware, the hills and ranges of trap are, Goat hill, continued past Rocktown, Bellemont, Smith's hill, and the hills between Pennington and Woodville; also Rocky-hill, in a line with these, and its continuation across the Millstowe, in the hill near Kingston. Next the table land, called Rock or Sourland mountain, we have the Roundvalley hill, and a few miles to the east, the great double or in some places triple chain of Trap hills, which, rising at Pluckemin, pass in a great sweep, nearly sixty miles long, near the towns of Boundbrook, Springfield, and Patterson, to approach the primary region again near Pompton. Add to these the Horse-neck ridge, the Spurs of the Preakness ridge, and Snake hill, near the mouth of the Hackensack, and we have remaining only one, the most regular, however, of all. This is the Cloister hill, which, from Bergen Point, upon the New York bay, to the state line, follows the Hudson, in a bold unbroken ridge, bounding the state with a precipitous wall, nearly the whole distance. The rock varies from fine grained compact basaltic trap to coarsely crystallized greenstone, and contains, besides its essential components, hornblende, felspar and augite, various others, in more rare occurrence, such as epidote, prehnite, zeolite, stilbite, analcime and datholite.

The first important general fact connected with the trap masses of the district, is their obvious superposition in numerous

instances, to the general sandstone strata of the country. From what is now universally admitted, concerning the igneous origin of trap, it is plain that, over this portion of territory, it has burst up, in a molten state, through a series of nearly parallel fissures in the strata, and after their consolidation and subsequent disturbance, which caused them to dip towards the north-west, and has overspread their adjacent portions, without effecting any material change in their stratification, and producing only certain modifications in their mineral contents and structure.

That the trap upon its borders rests upon the sandstone beds may be ascertained by viewing the eastern base of the Palisadoes skirting the shore of the Hudson, where several varieties of the sandstone beds show themselves, dipping at a gentle inclination of ten or twelve degrees to the west.

The same thing is finely seen in the bed of the Passaic river, below the Falls at Patterson, the trap reposing over the west dipping beds of the red sandstone. In the first and second Newark mountains, the same is repeatedly witnessed. Of the alterations induced upon the strata in contact with, or adjacent to, the trap, some are of a kind often discerned in other quarters of the world, and are, therefore, familiar to geologists, while others again are of a nature much more rare, and calculated to have a bearing upon some important doctrines now coming into vogue among modern cultivators of the science.

The facts first alluded to are such as may be seen at the Falls of the Passaic at Paterson. In the cliffs above, we behold the trap, which, in several parts of the hill, has the columnar structure well displayed. Beneath, and within a few yards of the level of the river, may be seen the junction of the mass with the sandstone, the true trap and true sandstone, separated by five or six feet of rock, having an intermediate character, and resembling a toadstone or amygdaloid, holding nodular crystals of several minerals, prehnite, analcime, and some others. Beneath this, a layer of the sandstone, of a few inches thickness, exhibits a baked appearance, and is full of small vesicular cavities, as if produced by the extrication of some gaseous matter or steam. Similar appearances are known in the trap region, near New Haven, and are not especially remarkable. But the other class

of changes caused by the trap upon the neighbouring strata are of a much more curious nature, as I have before hinted. These changes are not simply modifications in the external features, compactness and texture of the stratified rock, but are connected with an internal crystallization of the original materials of the bed showing itself in numerous nodular concretions, consisting of several minerals scarcely ever found but in rocks of the primary and volcanic sort. Their occurrence in the instances to be mentioned, is attributable to the intensely high temperature which the trap has been enabled to impart to the contiguous shales and sandstone, in which these crystallizations have been induced. The phenomenon will be more apparent by describing the facts as they have been discovered in two principal localities.

Upon the Delaware, about half a mile below Lambertsville, the range of trap composing the axis of Goat hill, crosses the Delaware in a somewhat oblique direction. To the north-west of this ridge, on both sides of the river, the strata dip as usual, but are affected in a striking way in their composition for at least a fourth of a mile from the trap. In the quarry north of Lambertsville, we discover the commencement of the change in question. Here the red sandstone, varying but little from its ordinary colour and only rather more compact, contains a multitude of large spheroidal nodules of pure green *epidote*, many of them an inch at least in diameter. They seem not to be distributed promiscuously through the rock, but are arranged somewhat in layers, parallel to the surface of the strata, though they are often several inches asunder. Two or three hundred feet nearer to the trap, we find the rock darkened and harder, and the number of nodules present in it far greater, though generally of much smaller size. The common colour of the rock here is a very dull purplish blue or a slate colour, and that of the included nodules a dull black or deep blue. They are of all sizes, from minute specks to that of a large hazel nut, and possess every shade of relative distinctness from the material enclosing them. They seem to consist of some imperfectly formed mineral, perhaps tourmaline, in a semi-crystalline state. These spherical nodules or specks, are oftentimes surrounded by a crust or coat-

ing of another material, usually nearly white, and I have remarked that the more obviously formed this crust appears, the more crystalline or fully developed is the interior kernel, which, in this spot, seems to approximate in features to black schorl or tourmaline. A few hundred feet nearer the trap, or almost at its base, the rock presents a still different aspect, being of a dark gray hue, somewhat coarse-grained in surface, suggesting it to have been a sandstone, containing little or no clay, as it has nothing at all of the baked pottery or jasper texture of that previously described, which has plainly been shale or very argillaceous sandstone. This gray rock is speckled with innumerable small crystals of most regularly formed *tourmalines*, some of which are more than half an inch in diameter. Upon the opposite side of the river, below New Hope, we meet with very nearly the same order of things, except that the rock containing the completely formed tourmalines is absent.

In one thin layer of the altered red argillaceous rock on that side, the mass which has a pink hue contains, blended with the crystallized epidote, some minute, but perfectly formed crystals of the mineral called idocrase of a beautiful wine colour.

Now, two things are apparent to any one studying these changes,—first, that the quantity of alteration as evinced in the degree of developement of the crystalline nodules and obliteration of the ordinary features of the rock, augments in regular gradation as we draw nearer to the trap; and secondly, that the kind of mineral matter thus brought together into these concretions, is intimately dependent upon the nature of the stratum, or in other words upon the composition of the materials in which this crystallization has taken place. It may be adverted to as a singular point of connexion subsisting between the minerals and the rocks imbedding them, that both epidote and idocrase contain a small quantity of lime in their composition, which chemical analysis shows to exist in a good deal of the red shale, at the same time that the gray and red sandstones are usually destitute of it as far as examined; and hence, perhaps, the reason why the tourmaline occurs in a material which was evidently once such a sandstone.

Another interesting neighbourhood, where similar crystalliza-

tions are perceivable upon an equally striking scale, is upon the Delaware and Raritan canal, where it passes through the Trap range, or Rocky hill, near Kingston.

As we approach the southern base of the ridge, the red argillaceous sandstone displays the same series of changes before noticed, that is, its colour is deepened, and dark crystalline knots or kernels are abundant in it; we then come upon the true trap which at the river is not wide. Immediately upon the north side of the trap the sandstone series re-appears with the ordinary dip to the north-west, but presenting remarkable modifications. These occur opposite the toll-house, at the little village of Rocky Hill, upon the canal, in a quarry one hundred feet to the north of the trap rock. The inclination of the strata being not more than fifteen degrees, the lower beds in the quarry cannot be fifty feet remote from the subjacent trap. They are filled to such a degree with various crystalline matters, and show therefore so much inequality of composition and hardness, as to be unfit to work for building stone. The lower we descend in this quarry, the more the rock departs from the character of a sandstone, though at a certain distance down, the change of texture is precisely what is desirable in a material which is ordinarily too easily acted on by the weather. It deserves especial mention, indeed, as a highly important practical fact, that the whole of the superiority in the stone from this quarry has resulted from the kind of change I am describing in the stratum of the rock, which gives it entirely new capacities for resisting decomposition or dissolution by frost. About one hundred feet from the trap, the rock is in the condition of a very close-grained, compact, and reddish, or purplish sandstone, of a somewhat argillaceous texture, full of dark spherical nodules, of a radiated structure of the dimensions of a pea or less, and very numerous. The mixture of the mineral is obscure from the absence of a definite crystalline character. This stratum is a very durable rock, and is extracted in regular masses, furnishing a building stone in considerable request. In the middle of this stratum, there is a thin bed four feet wide, which seems originally to have been a sandstone containing much felspar. It is full of small irregular cavities, the sides of which are studded with a black mineral, crys-

tallized in regular prisms, found to be perfectly formed schorl. Numerous fissures or joints in the rock are occupied with the same black mineral always highly crystallized. The rock from this bed is rejected as a building stone. Upon the top of the thick stratum in which this is but a narrow layer, there is perceived a considerably nearer approach in the rock to its ordinary unaltered aspect, that is to say, it is more red, softer, and with less of the jasper texture, and contains moreover kernels of epidote, pretty pure, and well developed. This variety extends from where it first shows itself, or about one hundred and fifty feet in vertical thickness from the trap, to a distance of a fourth of a mile, where it is well exposed and excavated in another quarry. It is perceived gradually and regularly to approach nearer to the ordinary unaltered nature of the red sandstone; but is even in the second quarry distinguished for the distinctness and size of the green spheroidal masses of epidote. The degree of baking which it seems to have received even at this distance from the trap, has given it a closeness of texture which fits it finely for purposes in which a durable and regular building stone is wanted. Near the same quarry, the rock contains a narrow band of nearly pure epidote about an inch and a half thick. Beyond this second quarry, towards Griggstown, the rock soon assumes its usually soft slaty texture and deep red colour.

We behold, in the facts adduced from the two neighbourhoods above described, that the epidote seems always most distinct and abundant where the rock has been of the argillaceous sort, and the heating action moderated by distance, not reaching an intensity sufficient to modify greatly the original colour of the stratum. On the other hand, the dark mineral is developed seemingly in the same rock, wherever we find it more adjacent to the source of temperature. And we perceive, moreover, that in both vicinities, wherever the rock itself departs from the ordinary composition, we discover a corresponding variation in the *nature* of the minerals superinduced. Other localities corroborate the same points, and a hope may be expressed that some curious general rules may at a future day be established, in regard to the relations of the minerals to the strata containing them.

It is in consequence of the degree of theoretical importance

which Lyell and other eminent geologists of Europe attach to every fact capable of casting light upon the changes which rocks of an igneous or volcanic nature can produce in the structure of masses of purely aqueous or sedimentary origin, that the above facts are alluded to in this place.

In a detailed and minute investigation of the formations of the state, a study of these rocks of altered texture would be fraught, I doubt not, with much highly useful information of a strictly practical kind, in reference especially to a right selection of stone for purposes of architecture. I conceive that the very best varieties of building rock in this region of the state, will be found in the indurated strata, contiguous to the ridges of trap, where the baking process has obliterated the slaty cleavage, and that soft friable texture which usually renders so large a portion of the red sandstone of the district of no value. As this section of the country is not well supplied with building stone, capable of withstanding frost and the weather, the hint that durable varieties generally abound near the trap ridges may prove of service. From what has been said, it will be seen that the most probable position for discovering the best kinds, is neither too near the trap nor too remote from it, but is to be indicated by the amount of *baking*, which the rock appears to have undergone. This should not be too great, lest the rock be too hard and difficult to cleave into regular blocks; nor yet too little, as then it will be still soft enough to be operated on by the frost. When a rather compact and extremely durable kind is sought, I would suggest that it will usually occur within one or two hundred feet of the trap, and may be known by a bluish or dull purple colour, and by a multitude of dim round spots, the commencement as it were of the crystalline nodules. On the other hand, when a rock of rather softer variety but cleaveable into larger blocks is desired, then I would propose the beds rather remoter from the trap, in which the stone retains a pretty bright red colour, and contains large nodules fully formed of green epidote.

I do not mean to assert that these altered strata will always appear bordering the ridges of trap; but I find them in a frequency far greater than might be expected, and their importance therefore is considerable. By following the base of a range of

trap, we shall find that, though at first we may not meet with any of those exact degrees of induration, in the strata which we seek, we cannot pursue the search far in the longitudinal direction, without falling upon a locality where all the requisite varieties present themselves. Much aid will be derived from inspecting the spots and nodules upon the fragments scattered over the surface of the soil.

*Of the copper ores of the red sandstone region.*—Considerable enterprise has displayed itself from time to time, in exploring this region for copper; and several mines have been opened and pursued amid different degrees of encouragement, but have never heretofore terminated in permanent success. As the existence or non-existence of a sufficiently copious supply of copper ore at several places in the formation, is a question in which capital is materially interested, and as much money has already been expended in tracing it, and yet more may be invested in the same search hereafter, it seems important that I should bring forward all the facts which I have been enabled to collect, which are calculated to guide those who are bending their attention to the subject. It were desirable, if it were practicable, to refrain from saying anything that might interfere, however indirectly, with the pecuniary interests of individuals; and I feel the greater necessity for caution in pronouncing upon the probable richness of particular localities, because in reality the facts to which I have had access, are too few and meagre to justify in some instances a decisive judgment. Still, as I wish these facts to have a practical and salutary bearing upon future mining enterprises in the state, I hold it necessary to bring forward all that I have gathered, and to suggest the general conclusions, to which if they do not lead us with certainty, they at least approximate us. The facts to which I have reference, are such as exhibit the mode in which the copper ores occur, this being intimately connected with the presumption as to their quantity, and the manner in which they ought to be sought for and worked.

The principal spots where mining operations have been undertaken at various times, are near Belleville, Griggstown, Brunswick, Woodbridge, Greenbrook, Somerville, and Flemington. For details concerning the early history of the mines at Bruns-

wick, Belleville, and Somerville; I must refer to Gordon's Gazetteer of the state. At the same time I must express my belief, that far too high an impression is conveyed in that work, of the metallic riches of those localities. With the exception of the Flemington mine, which is now going forward pretty vigorously, and which is a more recent enterprise; these different works are all at present in such a state of decay, as made it impossible for me to ascertain *by direct inspection*, the mode in which the ore is distributed in the strata of the several mines above mentioned. My information upon this head, has been derived from examining the masses of ore and rubbish near the mines, and especially from the testimony of persons familiar with the works while they were in operation. Everything that I have witnessed or collected in regard to them, has confirmed me in my opinion, that the ore does not exist in any instance in the shape of a *true vein*; nor have we evidence in fact, that a regular copper vein, properly so called, has thus far been met with any where in the formations of the state.

By a true vein is meant "the mineral contents of a vertical or inclined fissure nearly straight, and of indefinite length and depth." Such veins have usually a well defined line or plane of separation between their contents and the rock on each side, which is named the *wall* of the vein. Now the chief peculiarity in the copper ores of the region before us, is that they occur, not in regular sheets of mixed metalliferous and mineral matter, traversing the rock, but in irregularly ramifying and intersecting strings and bunches, in which the masses of ore are not so often blended with the usual foreign materials of metallic veins, as with portions of the adjacent red sandstone or shale, in a more or less *altered* state. The nature of these accumulations of metalliferous matter, will be best understood, however, from a statement of some particulars of two or three of the principal mines.

In the Schuyler mine, near Belleville, in Essex, the principal body of ore is stated to be imbedded in a stratum of sandstone twenty or thirty feet thick, and to dip about twelve degrees from the horizon, rather by steps than regularly. It has been worked two hundred and twelve feet below the surface, and one hundred and fitly feet horizontally from the shaft. The chief ores are

sulphuret and carbonate of copper, and they occur almost invariably blended throughout portions of the indurated red sandstone. Judging from the latter fact and the gentle dip of the mass, which appears to be about that of the neighbouring strata, it is pretty obvious that it has but little claim to the character of a true vein, though, while appearances are against it, it is not meant to assert that the body of ore in this mine may not be considerable. It would seem as if a certain stratum of the rock had been injected with the metallic matter, not filling a cleft or fissure in it but dispersing, and as it were dissipating itself through the substance of the sandstone. There is no trap exposed any where in the district which embraces the Schuyler mine.

The Franklin copper mine occurs a few hundred feet from a ridge of trap about a fourth of a mile from the canal, at Griggstown, in Somerset. Judging from all the indications around the mine and from good information, the ore occurs above the trap, but in and beneath masses of the altered red shale. The ores have occasionally the aspect of coming from very thin veins or strings one or two miles wide, in which they are mixed with carbonate of lime, felspar, hornblende, &c. composing what is probably a true gangue. The best ore here is a soft *blue sulphuret*, always in association with carbonate of lime. But by far the greatest proportion of the ore is red oxide and carbonate of copper, mingled with highly altered red sandstone, containing the usual mineral nodules, in some cases beautifully crystallized, of epidote and schorl or black tourmaline. The deepest shaft sunk was one hundred and ninety feet, drained by a very long adit. All is now in a state of dilapidation. A large sum was expended in working this mine. My *impression* is that the ore exists scattered so irregularly and intermingled with so much rock, as to render the attempts at mining it very costly.

At the base of the trap ridge, two miles north of Somerville, the mine known as the Bridgewater copper mine, was wrought at one time with considerable spirit, but without profit. The ore is usually very rich, being characterized by the large proportion of massive red oxide which it contains. There has also been found a good deal of native copper, and also the green carbonate and green phosphate, together with a minute quantity of native

silver. This mine is now shut up, but various sources of information as well as external appearances testify that here also the ore is very irregularly dispersed, though some of the bunches and narrow strings into which it passes seem to be extremely rich.

The copper mine at Flemington, now wrought, has been kindly thrown open to my inspection, and I have been enabled to procure there a much better insight into the structure of the copper ores of the state than I could otherwise have acquired. In that mine the appearances are strikingly corroborative of the absence of a true vein, and of the idea put forth that the ore has been injected or sublimed into the body of the red shale and sandstone stratum. There seems to be a belt of metalliferous rock of very variable width, sometimes as wide as twenty or thirty feet, which preserves nearly a north and south direction for several hundred feet. What the total length of this may be no one pretends to know, but two miles due south from where it is explored in the present Flemington mine, there are strong indications of a precisely similar character of ore. In the Flemington mine, the ore, which is a mixture chiefly of gray sulphate, and carbonate of copper, exists, intimately blended or incorporated with the semi-indurated and altered sandstone, and the mass has therefore somewhat the aspect in certain portions of a conglomerate of re-cemented fragments, the metalliferous part being the cement. Most commonly the ore is thus minutely disseminated, though now and then it occurs in lumps of great purity and considerable size. The line of rock containing the ore has no definite separation from the unaltered red shale outside, and it is therefore not always easy to judge of the precise space which it occupies. The ore in this mine is of good quality, and so far as I have been able to ascertain the dimensions of the band containing it, are such as to admit the establishment of a large mine, should the proportion of metallic matter to the rock in the mixed mass prove correspondingly great. The mine seems at present to be very judiciously worked; cuttings are made across the ore in a series of east and west alleys to ascertain its extent and position. In the present stage of the enterprise the mine at Flemington seems to exhibit much to encourage its further prosecution. It must be

confessed that while mining is of all arts the most precarious, it is especially so where the metalliferous deposit does not occur under the shape of a regular or true vein or lode. The doubts which some entertain regarding the final success of this and other copper mines in the state, proceed chiefly from the views taken regarding the manner in which the copper ore is diffused.

In reviewing what we have here brought forward of the copper ores of the state, it will be seen that they do not occur under circumstances to make the adventurous miner sanguine in following out to a costly issue, the numerous indications of this metal which so frequently meet us throughout the red sandstone region. If my views be sound, that the copper does not show itself in true veins, then I contend that a double degree of caution is necessary. It is true that numerous cases are known in other countries, where rich mines have been wrought in masses of ore which were not genuine veins, and it is no less true that in such a mine as that of Flemington, there may exist a highly profitable proportion of ore amid the rock; but nevertheless, when the deposits are like those common in the copper region of New Jersey, mining becomes peculiarly precarious. I have been thus explicit upon this subject, in expressing my convictions touching undertakings in mining, from a persuasion, that one main advantage to be anticipated from a rightly conducted geological survey, is the aid which it is capable of affording to capital, of invigorating some branches of wholesome enterprise, and of checking rash and visionary expenditures, by a faithful statement of what every district possesses, and when necessary of what the state does *not* possess. The one is as needful as the other, if it be our motive to give the industry of the community a right direction. It may retard and it cannot strengthen the spirit of useful enterprise, to permit capital to be misapplied, through ignorance, to purposes which, if followed up, lead to loss and disappointment. As therefore mining is in its infancy in this country, and as much salutary knowledge is wanted on the subjects connected with it, I have felt it the more incumbent upon me to give my views upon the probable richness of some of those mineral localities of the state, where such undertakings have been on foot.

## GNEISS FORMATION OF TRENTON.

The very extensive belt of stratified primary rocks, which follows a line nearly parallel with the Atlantic coast, forming the western limit of the tide in the rivers of Virginia, Maryland, Delaware, and Pennsylvania, crosses the Delaware at Trenton, after having been regularly and gradually contracting in width from Georgia to this point, where it very soon entirely vanishes, dwindling to a point about six miles to the north-east of the state metropolis. Its further course through the state is concealed by the overlying horizontal deposits of clay sand referable to the greensand series and the general diluvium. The formation again comes into view in Staten Island, Long Island, and New York.

Where it crosses the Delaware, this belt of gneiss is about three and a half miles broad, narrowing in its course to the north-north-east, until by the increased overlapping of the newer beds upon it, the visible portion of the formation fines away almost to a point, about the six mile post upon the Delaware and Raritan canal. The triangular area which it forms has the valley or the Assempink very nearly, for its south-eastern boundary, while its north-western border is the easily recognized strata which forms the lowest members of the great overlying group of sandstones. Throughout the whole included space, the mineralogical character of the rock is extremely well marked. It is most usually a triple mixture of quartz, felspar, and hornblende, or in place of this, frequently mica. Like the material of the other primary zone of the state, the highlands, it has gone very frequently under an improper name, being called a granite, and sometimes a sienite. Its well marked dip and stratification—its occasionally schistose structure, and the decisive fact of its running with strict continuity into the acknowledged gneiss rock of the Schuylkill above Philadelphia, are arguments sufficient to establish its claim to be considered a portion of the Atlantic gneiss formation.

A little north of Trenton, and near its border, there is a quartzose variety of the rock, containing a little mica sufficient to divide it into the laminated form, but the mass of the rock is

a close-grained stratified mixture of felspar and quartz, almost a petro-silex in aspect. This band consists in places of an intimate mixture of quartzose and felspathic matter fused together. Splitting into rather well-formed large slates, and having a smooth surface, it furnishes a very good flag stone for the walks and steps in Trenton.

Wherever its stratification can be seen, it is found to dip at a steep angle nearly seventy degrees to the south-east. And there can be no doubt that it underlies unconformably both the newer, secondary, or greensand strata on its south-east, and the ancient, secondary, or argillaceous red sandstone formation on its north-west. The variety of the rock which possesses the aspect in the general of a sienite, often contains such an excess of hornblende, as to cause it to resemble closely a greenstone or basalt, for which it might be taken, were it not for the evident marks of the stratified structure in almost every mass. In some portion the quartz is blue, semi-transparent, and opalescent, and the hornblende and felspar show a tendency to decomposition. It is met with in this variety upon the canal about two miles from Trenton, and in several places further to the north-east, as far as where the rock ceases to show itself in place, which is about three and a half miles from the town. It may be traced perhaps two miles further, by observing the character of the diluvium above it.

Its economical importance consists chiefly in its including several valuable varieties of building stone, well adapted to structures demanding solidity and strength. Some of it would make a very fine road stone, approaching to the greenstone employed in England, and imported from the islands of Guernsey and Sark. To the scientific world it is interesting, as presenting one of our few localities of the zircon which occurs in this stratum about fifty yards above the bridge at Trenton. The soil over this formation is a very promiscuous mass of diluvium derived from the gneiss and the formations to the north-west. It is generally gravelly, though benefiting readily under proper management. In the valley of the Assempink it is often a greenish sand and gravel, derived from the quartz and hornblende, and is there rather sterile.

No doubt it is the prolongation of the formation which shows itself in Staten Island and beneath the city of New York. The varieties of this rock at Trenton are those of the gneiss formation of the Schuylkill near the north-west boundary of the tract, that is in the vicinity of the quarry. There both the quartzose and the sienite varieties occur. I am led, therefore, to think that the more south-eastern portions of the formation on the Schuylkill, that is, the true micaceous gneiss, the mica slate, and perhaps the soapstone, all lie to the south-east of the visible primary formation of the Assempink valley, and exist probably under the greater part of the county of Middlesex, deeply covered up by diluvium and the strata of the greensand or marl formation.

In closing the task which Your Excellency has been pleased to assign to me, it remains for me to express my earnest hope, that the manner in which it has been executed may meet your approbation and that of the citizens of the commonwealth at large. Feeling and duty both prompt me to acknowledge in this place my gratitude for the many friendly aids I have received from yourself personally, and the inhabitants of New Jersey generally, during the progress of this survey.

I am fully aware, probably more fully than any other person, of the imperfect style in which the report here transmitted represents the geology of New Jersey. No one who has not traversed its formations systematically with an eye to utility and science, can be truly sensible how rich a field for research the State presents. I consider the examination which I have made as no more than a general review of its mineral resources, so that if it shall be found that the facts and views made known through this report, are even in a small degree friendly in their influence upon the agriculture and domestic arts of the State, it is to be regarded as but an earnest of far greater benefits to flow from a detailed geological survey more systematically followed up.

With sincere respect and esteem,
Your Excellency's
Very obedient servant,
HENRY D. ROGERS.

*Philadelphia, Feb.* 12*th,* 1836.

It was my intention, as intimated in the body of the foregoing Report, to bring together the several analyses which it contains in the form of a general table, for the sake of making the reference to the chemical details as easy as possible. But the general wish to have the Report appear immediately, previous to the adjournment of the legislature, has induced me to dispense with it, especially as the table in question is not essential, being merely designed to embody details already given. Its object will be fully answered by the following index to the analyses.

ANALYSES

I take this occasion to give notice, that with a view to collect and impart all the information desirable, respecting the mineral productions of the State, I shall willingly inspect and privately report upon any materials which may be sent to me by the inhabitants of the Commonwealth, provided the postage and freight be previously paid.

H. D. ROGERS.

University of Pennsylvania,
or 297 Chesnut Street,
Philadelphia.

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ERRATA.

In the Analysis, page 29, for "Oxide of *Magnesia*," read "Oxide of *Manganese*."
In the note, page 93, for "a flask of," read "a flask, *with*."