

The southerly side or greenstone portion of the trap range appears to have been elevated in such a manner as to have caused but little disturbance to the sandrock lying between that and the range of simply altered rocks lying still farther to the south; but near to the junction of the sandrock and greenstone there is usually a red slate resting against the trap, and which may be said to fill up, in a measure, the irregularities in the ranges of hills. This slate, which is sometimes seen of 100 to 200 feet in thickness, though usually it appears as a mere band, is traversed by irregular and imperfect veins, of what may be denominated a ferruginous steatite, containing placentiform masses of greasy and milkish quartz, that sometimes contain more or less of the ores of copper. The earthy carbonates of copper are also sometimes so intimately connected with these veins of steatitic matter as at first to be scarcely recognized. More rarely, distinct, very thin veins of green carbonate of copper occurs, well characterized, in this red slate, though these veins are never of any great length. The red shale extends, more or less perfectly, along the whole length of the trap range, skirting that range of hills upon the south, but I have not yet been enabled to devote sufficient time to its examination to enable me to determine whether any portion of these veins can be regarded as of practical importance. The examinations which have been made would lead me to look unfavorably upon these veins, and I regard them as having an origin completely distinct from that of the veins which traverse the northerly escarpment of the trap rock.

Having thus considered all the general circumstances under which the several ores of copper, zinc, lead, iron, manganese and silver have been noticed in connection with the trap rock and the sedimentary rocks, immediately resting upon it, it becomes important to consider how far inferences may be drawn from these examinations, as to their occurrence in such quantities as to be of practical importance. I have already stated that so far as regards the ores of lead, iron, manganese and

silver, I am led to conclude that at one of the points examined do they occur in veins, or otherwise, sufficiently developed to warrant favorable conclusions as to their existence in sufficient quantities to be made available, and from all that is now known of the country, I am led to infer that neither of these, unless it be iron, will be so found.⁴⁷

The examinations which have thus far been made of those portions of the veins containing ores of zinc, have not been extended sufficient to enable me to determine with much satisfaction, their extent as a whole. At several points in the veins, these ores are sufficiently abundant to admit of being profitably worked, but I would be unwilling, from an examination of a few points, to attempt to determine the character of the whole.

In considering the practical value of the copper ores of the upper peninsula of Michigan, where we are as yet compelled to judge from our examination, of what may be said to be the simply superficial portions of the veins, we can arrive at no safe conclusions, except by comparison of the district with those districts similarly situated, which have been extensively worked in other portions of the globe. Comparisons of this character, to be really useful, must necessarily be sufficiently minute to enable us to understand the relations which the ores in the district compared bear to each other in all respects, which circumstances renders it necessary that a degree of minute information should be at hand, that is not at all times to be obtained. As the information on hand, with respect to the copper and tin veins of Cornwall, England, is more minute than that of any mineral district known, I propose, in order to avoid confusion, to confine my comparison to this district, simply premising, that however closely the two districts may resemble each other in character, it does not follow, as an axiom, that because the district with which we compare our own has been largely and profitably productive, that of

⁴⁷These remarks are intended to apply directly to the trap region. Beds of bog iron ore occur, east from Chocolate river, which probably may at some future day be profitably worked.

Michigan must necessarily be so too, for it will be seen, as the subject is pursued, that there are not only several points in which it is impossible with our present knowledge of that of Michigan, to institute comparisons, but there are also some points on which there is a considerable degree of discrepancy.

The comparison instituted, in the main, is intended to refer rather to the character and contents of the mineral veins of the two districts than to the geology, although some general reference becomes necessary to the geology of the districts to render the comparison perfect. The topography of the Cornish district bears a close resemblance to that of Michigan, both districts being marked by their irregular and broken outline, and by the occurrence of more or less frequent, nearly insulated knobs, rising to a considerable height above the elevation of the general ranges.

Although the older rock of Cornwall, or that from which the metalliferous veins of the district may be said to have their origin, is more distinctly granitic than that of the metalliferous region upon Lake Superior, the elements of which the rocks are composed, may be regarded as essentially bearing a very close resemblance; a resemblance, which it is conceived, would have been still more perfect had the granitic rocks of Cornwall been subject to the action of secondary causes similar to those of the region under consideration. The rocks resting upon or against the granitic rocks of Cornwall, consist of clay slates, hornblende rocks, &c., which bear little real analogy to the rocks resting directly upon the trap of Lake Superior, but it is conceived that the composition of these upper rocks has little bearing upon the origin of the metalliferous veins, and may be regarded as in a measure unimportant; and however much these rocks may differ, they are traversed alike by the metalliferous veins of the lower rocks in such a manner, that the close resemblance cannot be mistaken.

It is a matter of history that the ores of tin have been, more or less, extensively raised in the mineral district of

Cornwall, from the earliest settlement of the Island of Great Britain, but the working of the veins of copper at an early day, does not appear to have been carried on to any very considerable extent. The great importance to which the produce of copper from the Cornish veins, (in a district which, compared with the mineral district of our own state, is of very small dimensions,) has arisen, will be shown from the accompanying table, which I have reduced from the official returns included in the several years, and which table, it will be seen, shows for a series of years, the average annual amount of copper produced from the ore, the average amount for which it sold, together with the amount per cent. of copper contained in the ore, and the average value of the copper, per pound, at the smelting house. This table, which has been drawn with great care, from data that can scarcely lead to incorrect results, will not only serve to show the large aggregate amount of the metal produced, but it also shows, from the low average per cent. of metal contained in the ores, (if we had no further knowledge upon the subject,) that much capital must be required for, and a large amount of labor applied to the raising and smelting of these ores; a circumstance which should be carefully borne in mind, in all that relates to the mineral district of Michigan.

Table showing the average annual produce of the Copper Mines of the County of Cornwall, England, from 1771 to 1822.

YEARS.	Average No. of tons of ore per year.	Av. No. tons copper produc'd per year.	Average amount per year for which sold.	Av. per cent copper produced from the ore.	Av. val. of the copper per lb.
					c. m.
1771 to 1775—5 years.	28,749	3,449	\$ 846,283	12	10 9
1776 to 1780—5 "	27,580	3,309	826,609	12	11 1
1781 to 1786—6 "	34,354	4,122	962,380	12	10 4
1796 to 1802—7 "	51,843	5,195	2,125,046	10	18 2
1803 to 1807—5 "	70,923	6,160	3,174,725	8	23
1808 to 1812—5 "	70,434	6,498	2,886,835	9	12 9
1813 to 1817—5 "	82,610	7,272	2,878,723	8 8	17 6
1818 to 1822—5 "	94,391	7,757	3,111,811	8 2	17 9

The general resemblance in the mineral contents of the copper veins of Cornwall and those of Michigan, is for the most part, very great, though in some respects there is a considerable discrepancy. It should, however, be remarked that some difficulty exists in comparing the mineral veins of Cornwall, where several of them have been worked to depths, varying from 1,000 to 1,500 feet, with those of Michigan, where the examinations are nearly superficial.

In making these deep excavations, not only in the county of Cornwall, but also in the copper districts of Bohemia, Hungary, Silesia, Transylvania, Saxony, &c. (some of the veins in the latter district having been explored to a depth very considerably greater than those of Cornwall,) an immense mass of facts has been accumulated, with respect to the general formation and mineral character of veins, or lodes of copper, which facts have led to an understanding of many of the contingencies connected with its associations, so universal, that when applied to this mineral, they may be regarded as general laws, that may fairly be inferred to govern, with more or less certainty, all those lodes or veins which have similar geological relations. Though a general consideration of those relations of the veins of other countries, may perhaps be regarded as somewhat foreign to the present report, I deem it more advisable to refer to these general laws in such a manner as to leave the reader to judge by comparison, the condition in which the ores of Michigan may be fairly inferred to occur, rather than to draw conclusions directly, and in so doing it will also become necessary to refer to some of the characters of mineral veins, or lodes, in general.

Veins are usually divided into two general orders, viz: "*contemporaneous veins*, or those which are formed at the same time as the containing rock, and *true veins*, whose formation is supposed to be subsequent to that of the rocks which are contiguous to them." A *true vein* may be defined to be "the mineral contents of a vertical or inclined fissure, nearly

straight, and of indefinite length and depth."⁴⁸ The contents of a true vein, as a general rule, differ widely from the character of the rocks which it intersects, though this does not invariably hold good, and the vein also, as a general rule, has well defined walls.

The contents of contemporaneous veins, bear a much closer resemblance to the rocks which embrace them, and as a general rule, they are shorter, more crooked, and less perfectly defined than true veins.

The metalliferous veins being contained under the head of true veins, it is to these that the whole of my remarks will be directed.

Metallic veins are the repositories of most of the metals excepting iron, manganese and chrome, which occur more frequently and abundantly in beds than in veins. The thickness of metallic veins varies from a few inches to many feet, and the same vein also varies in thickness in different parts of its course, sometimes contracting to a narrow string of ore and then expanding again to a width of many feet. The deposits of metal in the veins are as irregular as the widths of them, and so much so as to render the profits of mining proverbially uncertain. Ore is generally found to occupy certain portions of the veins only, differing constantly in extent, whether the length or depth on the course of the vein be considered, or the portion of its width which is filled up by it. No veins occur which are regularly impregnated with metal to any great extent, and when ore is found, it is in what the miners aptly term bunches or shoots, or in interspersed grains and strings, which are more or less connected with, or embraced in, vein-stone, that, according to the rock which the veins intersect will be fluor spar, calcareous spar, quartz, &c. The unproductive parts of veins, even in the most profitable mines, generally far exceed in extent the productive parts, but that mine is considered to be rich which has either frequent or extensive shoots of ore, and the great art of the miner consists in tracing

⁴⁸Carne, on the mineral veins of Cornwall.

and working the valuable accumulations of the metals, with as little waste of labor and expense on the poorer portions of the veins as possible. "In the mines of Cornwall the ores of copper and tin commonly occur in detached masses, which are called bunches of ore, and the other parts of the vein being unproductive are called *deads*."

The depth to which metallic veins descend is unknown, for we believe no instance has occurred of a *considerable vein being worked out in depth*, though it may sink too deep to render the operation of the miner profitable, or it may branch off in a number of strings which are too much intermixed with the rock to be worked to advantage.⁴⁹ Some veins appear to grow wider while others contract as they descend.

The superficial part of a vein generally contains the ore in a decomposing state, and it frequently happens that the ores in the upper and lower parts of a vein are different; thus, "in Cornwall, blende or sulphuret of zinc often occupies the *uppermost* part of the vein to which succeeds tinstone, and at a greater depth copper pyrites." When a metallic vein, in its descent, passes through different kinds of rock, it is frequently observed that the products of the vein vary in each bed, and when it passes through regularly stratified beds of the same rock there are particular strata in which the vein is always found most productive. This change in the productiveness of mineral veins is more particularly noticed at or near to the transition from unstratified to stratified rocks; thus granite, syenite and those rocks which have a granitic form structure are frequently noticed to contain metals at or near their junction with stratified formations. On the other hand the veins which traverse stratified rocks are, as a general law, more metalliferous near such junctions than in other portions.⁵⁰

Where a rock is crossed and penetrated by a great number of small veins in every direction, the whole mass is some-

⁴⁹Koenig.

⁵⁰Lyell. Necker.

times worked as an ore, and is called by the Germans a "stock-work." Where the ore is disseminated in particles through the rock, such rocks are also worked for the ore, when it exists in sufficient quantity.

As a general rule, those metals which are oxydable at ordinary temperatures, or which readily combine with sulphur, *rarely occur in a metallic state*, but are usually found in combination either with sulphur, oxygen or acids. The chief ore of copper raised from the mines of Cornwall, is the yellow sulphuret, though the blue and green carbonates and arseniate are more or less distributed; native copper and the oxyds are also, though more rarely, found.

By a comparison of what has been said upon the character and mineral contents of metallic veins in general, I trust a just view of the real condition in which the ores of copper are invariably found, will have been conveyed, and that, by the aid of this we will be enabled to examine, without undue expectations, those mineral veins which occur within the limits of our own state. In the main, the resemblance between the character and contents of the copper veins of Cornwall and Michigan, so far as can be determined, is close; the veinstones (with the exception of fluor, which I have never observed in the latter,) are essentially the same; but in instituting this comparison, it should be borne in mind that the metallic veins of Cornwall have been in progress of exploration for centuries, and that shafts and galleries have been carried to great depths, while of those of Michigan, simply superficial examinations have as yet been made, and these in a wilderness country, under circumstances of the utmost embarrassment, and attended with the most excessive labor, privation and suffering.

In respect to the character of the ores which occur in the two districts, there are important differences, for while pyritous copper is the most important workable ore, not only in the Cornish mines, but also in those of other portions of our globe, it is comparatively a rare occurrence in the mineral

district of Upper Michigan; for, as I have already mentioned, the mineral of the trappean portions of the veins in the latter district, is essentially made up of strings, specks and bunches of native copper, with which more or less of the oxyds and carbonates are associated; while those portions of the veins traversing the conglomerate are characterized by the occurrence of the oxyds and carbonates, with occasional metallic and pyritous copper, or the places of all these are supplied by ores of zinc, associated with more or less calcareous matter. In the thin mineral veins of Presque Isle, pyritous copper is more abundant, where it is associated with sulphuret of lead, as before mentioned.

The occurrence of this native copper in the veins, and the manner in which it is associated with the veinstones, in all respects corresponds with the ordinary association of the other forms of ores, in those veins that have been extensively worked in other portions of the globe; but I confess that the preponderance of native to the other forms of copper, was regarded as an unfavorable indication, at least until this had been found to be more or less universal with respect to all the veins. It should, however, be remarked, that in those portions of the veins where the quartz of the vein and the accompanying rock are very compact, the native form is much more common than in those portions where the veinstone and accompanying rock are more or less cellular and soft.

The worked copper veins of Cornwall, are stated by Mr. Carne, to average from three to four feet in width, and to have a length, as yet, undetermined. But few have been traced for a greater distance than one to one and a half miles, and but one has been traced for a distance of three miles.

The veins which I have examined in the mineral district of Michigan, exceed the average of those last mentioned, but the imperfect examinations which have been made, render it difficult to determine this with certainty. I have traced no one vein for a further distance than one mile, and usually for distances considerably less. It was not, however, supposed that

these veins terminated at the points where they were left, but the further examinations were abandoned at these points, in consequence of physical difficulties connected with the present condition of the country.

The native copper is frequently free from all foreign matter, and is as completely malleable as the most perfectly refined copper, but it more usually contains disseminated particles of earthy minerals, chiefly quartz. I have not been able to detect the alloy of any other metal, in a single instance.

The fatigues and exposures of the past season, have so far impaired my health, that, as yet, I have been unable to analyze as carefully, as could have been wished, the several ores furnished by the mineral veins of the upper peninsula, but sufficient has been done to show satisfactorily that the copper ores are not only of superior quality, but also that their associations are such as to render them easily reduced. Of those which have been examined, embracing nearly the whole, (and not including the native copper,) the per cent. of pure metal ranges from 9.5 to 51.72, and the average may be stated at 21.10. Associated with some of these ores I have detected a metal, the character of which remains as yet undetermined.

Were the analysis of the several ores of copper sufficiently perfected, I should deem it unnecessary to lay them before you at this time, for with what is now known of the district, it is conceived, the result would lead to erroneous, rather than to correct conclusions. The analysis of separate masses of ore, no matter how much care may be taken to select the poor as well as the richer ores, for the examinations, will usually be far from giving the average per cent. of what would be the product when reduced to practice. I have, in order to arrive at safe conclusions, not only analyzed, but also assayed many of them, but when we come to consider what constitutes the true value of a vein of copper ore, we will perceive why it is unsafe to judge of the whole by the analysis of small portions.

By reference to the previous statistical table of the product of the copper mines of Cornwall, it will be seen, that the

average produce of the ores since 1771, has never exceeded 12 per cent. of the metal, and that from 1818 to 1822, it was only 8.2. This shows the aggregate, and it is well known that while many of the productive veins are considerably below this, the largest average per cent. of any single vein, in that district, it is believed, has never been over 20 per cent., and it should be borne in mind that this average is taken after the ores have been carefully freed from all the rocky and other impurities, which can be separated by breaking and picking.

The value of a vein may be said to depend upon the abundance of the ore, and the ease with which it can be raised and smelted, rather than upon its purity or richness. Upon this point, with respect to our own mineral region, public opinion would perhaps be more in error than upon any other, and most certainly we could hardly look for a mineral district where the character of the ores was more liable to disseminate and keep alive such errors. The occurrence of masses of native metal, either transported or in place, is liable to excite, with those who have not reflected upon the subject, expectations which can never be realized, for while, in truth, the former show nothing but their own bare existence, the latter may be, as is frequently the case, simply imbedded masses, perfectly separated from all other minerals, or they may be associated in a vein where every comparison would lead to unfavorable conclusions, as to the existence of copper, in any considerable quantities. I have frequently noticed very considerable masses of native copper, occupying the joints of compact greenstone, under such circumstances as I conceive might readily excite in many minds, high expectations, but a little reflection would satisfy the most careless observer of the uselessness of exploring these joints, under the expectation or hope of finding them a valuable repository of the metal. Again, not only native, but also the other ores of copper occur in veins, either so narrow as to render it useless to pursue them, or so associated as to render it probable that exploration would not be attended with success.

While I am fully satisfied that the mineral district of our state will prove a source of eventual and steadily increasing wealth to our people, I cannot fail to have before me the fear that it may prove the ruin of hundreds of adventurers, who will visit it with expectations never to be realized. The true resources have as yet been but little examined or developed, and even under the most favorable circumstances, we cannot expect to see this done but by the most judicious and economical expenditure of capital, at those points where the prospects of success are most favorable. It has been said of the Cornish district, in respect to the supposed large aggregate profits, that "a fair estimate of the expenditure and the return from all the mines that have been working for the last twenty or thirty years, if the necessary documents could be obtained from those who are interested in withholding them, would dispel the delusion which prevails on this subject, as well as check the ruinous spirit of gambling adventure which has been productive of so much misery."⁵¹ And if these remarks will apply to a comparatively small district, which has been explored and extensively worked for centuries, with how much more force must they apply to the mineral district of our own state. I would by no means desire to throw obstacles in the way of those who might wish to engage in the business of mining this ore, at such time as our government may see fit to permit it, but I would simply caution those persons who would engage in this business in the hope of accumulating wealth suddenly and without patient industry and capital, to look closely before the step is taken, which will most certainly end in disappointment and ruin.

The extreme length of what I have denominated the mineral district, (within the limits of Michigan,) may be estimated at a fraction over 135 miles, and it has a width varying from one to six miles; but it must not be imagined that mineral veins occur equally through all portions of it, for sometimes, for many miles together, none have been noticed, and the situation

⁵¹Hawkins on the tin of Cornwall.

of the country is such as to render it probable they never will be. The range and course of the mineral district has been so far defined as to render it unnecessary to say more upon this subject, to enable such persons as may wish to examine, to pass directly along its complete length.

I have thus far omitted to allude particularly to the large mass of native copper, which has been so long known to exist in the bed of Ontonagon river, less perhaps this isolated mass might be confounded with the products of the veins of the mineral district. That this mass has once occupied a place in some of these veins is quite certain, but it is now perfectly separated from its original connection, and appears simply as a loose transported boulder.

The attention of the earliest travelers was called to this mass of metallic copper by the natives of the country, and it has been repeatedly described by those who have visited it. The mass now lies in the bed of the westerly fork of the Ontonagon river, at a distance which may be estimated at 26 miles, by the stream, from its mouth. The rugged character of the country is such, that it is but rarely visited, in proof of which I may state, that upon my visit to it, during the last year, I found broken chisels, where I had left them on a previous visit, nine years before, and even a mass of the copper, which at that time had been partially detached, but which, for the want of sufficient implements, I was compelled to abandon, was found, after that interval, in precisely the same situation in which it had been left.

The copper in this boulder, is associated with rocky matter, which, in all respects, resembles that associated with that metal in some portions of the veins before described, the rocky matter being bound together by innumerable strings of metal; but a very considerable proportion of the whole is copper, in a state of purity. The weight of copper is estimated at from three to four tons.

While the mass of native copper upon Ontonagon river cannot fail to excite much interest, from its great size and

purity, it must be borne in mind, that it is a perfectly isolated mass, having no connection whatever with any other, nor does the character of the country lead to the inference that veins of the metal occur in the immediate vicinity, though, as before stated, the mineral district crosses the country at a distance of but a few miles.

The occurrence of carnelian, chalcedony, agate and amethystine quartz, in the amygdaloidal portion of the trap, has already been noticed, and these minerals are considerably abundant. They frequently possess very great beauty and perfection, and when ground and polished they may be used for all the purposes to which those minerals are usually applied.

Minerals of the Upper or Gray Sandstone

Though the upper sandrock is largely exposed along that portion of the lake coast known as the Pictured rocks, rising to a very considerable height in precipitous cliffs, there have, nevertheless, been no minerals noticed in connection with it, except iron pyrites. Along a portion of the distance, however, the rock of the cliff is frequently colored by broad vertical bands, having a variety of tints, (which have given name to this portion of the coast,) and these bands have been, by some travelers, supposed to indicate the existence of important minerals in the rock; but the coloring matter of these bands is merely superficial. It chiefly consists of the oxyd and carbonate of iron, with occasional faint traces of carbonate of copper, both having been deposited from waters while trickling down the cliffs, the same having previously percolated the rock.

No mineral veins have been noticed in connection with this rock.

SOIL AND TIMBER OF THE UPPER PENINSULA

The impressions which have gone abroad with respect to the character of this region for purposes of agriculture, are, in many respects, exceedingly erroneous, for which reason, I am the more solicitous to call attention to the true character of the country, as it regards the natural productions of its soil and its capabilities for cultivation. It has generally been supposed that the whole country is wild and sterile in the extreme, and that, both from its high northern latitude and the rugged and broken character of its surface, it could never admit of the successful application of agriculture. This impression is, in great part, a mistaken one; for, while much of the country is, as has been supposed, extremely rugged, often presenting a rocky and sterile surface, and is besides exposed to the long and bleak winters of a high northern latitude, and to the cold winds of a vast and boisterous lake, yet, as I have already shown, a large part of the upper peninsula is far from presenting a rough and mountainous aspect; and much of the interior, at some distance from the lake shore, presents situations that are not only sheltered from the severity of the winter, but in soil and timber are wholly of a different character from what has been represented.

Much of the wrong impression which has been received, with regard to the timber and agricultural character of the country alluded to, has, no doubt, arisen from the circumstance that a judgment has been formed of the whole district of country, from the appearance of that part of it which lies more immediately upon the lake shore; and in fact, were we to form our estimate of the whole, from that only which is seen by the voyageur, in coasting along the shore, it would scarcely be possible to form any other than a very unfavorable opinion of the value of the country, in an agricultural point of view. Along that portion of the district which lies upon Lake Superior, about one-third of the entire coast, westwardly from Ste. Marie, is generally low and sandy, and thickly timbered

with evergreens and white birch, which give to it a somewhat gloomy and forbidding aspect. Still further westerly, and extending to the extremely westerly boundary of our state, the coast presents little else than an almost unbroken succession of rocks, bare, and worn by the fury of the lake, and the country, as seen from the water, appears to be occupied by an almost countless succession of irregular knobs, either nearly destitute of timber, or producing only a few stunted yellow pines and firs, or a growth of worthless poplars; while the southern shores of the upper peninsula, upon Lake Michigan and Green Bay, though differing in character, present a scarcely less forbidding aspect, in general, when viewed from the lake. But these unfavorable impressions are almost wholly, or in great part, removed when we penetrate into the interior, beyond these local influencing causes, and become acquainted with the real condition and character of the districts described.

The general aspect of the surface, over the whole of the extensive district under consideration, has been already laid before you, under the head of "topography of the upper peninsula." It may be remarked, in general, that sand is by far the predominating soil throughout the entire district. A soil of this description prevails over the north-easterly or sandstone portion of the upper peninsula. This district which, as has been already described, consists of extensive level plateaus or steppes, with scarcely sufficient irregularities of surface to prevent the formation of numerous marshes, may be said to be timbered, in the largest proportion, with the several varieties of evergreens, among which hemlock, cedar and firs greatly abound. Considerable Norway or pitch pine is interspersed, with occasionally large white pines, though in limited quantity. This region, nevertheless, comprehends many extensive tracts of the sugar maple, lying in body, and these trees are frequently of large size. Several species of oaks are also occasionally met with. Upon the whole, much of this portion of the peninsula is better adapted to the wants of

settlers for agricultural purposes than might, at first view, be supposed, and may be safely relied upon as capable of producing those crops which are of the most importance to the settler. Wheat, in small quantity, is said to have been raised upon Grand Island, in a spot exposed to the utmost rigor of that northern climate, and some species of Indian corn may, no doubt, be successfully cultivated in the most sheltered situations.

The south-easterly portion of the upper peninsula, embracing the lower limestone district, has a soil more nearly approaching to gravelly, and the pebbles composing which are chiefly derived from the northerly outcropping edges of the limerocks. This soil, in consequence, contains much more calcareous matter than that above described, which adds greatly to its fertility. Clays occur to a very limited extent, and clay soils may be said to be in general, rare throughout the district under consideration. Beach and sugar maple are abundant throughout the portion of the district described, mixed with hemlock and birch.

The hilly district, referred to as embracing the whole of that portion of the upper peninsula which lies west of the mouth of Chocolate river, though broken by ranges of knobby and often barren hills, is very far from being wholly or even generally sterile; for the broad and gently undulating valleys, described as occupying the intervening spaces between these ranges of rocky knobs, have in general a soil of dark, rich and deep loam, and in many places are covered with large bodies of sugar maples of unusual size. With this timber is frequently intermixed oaks and large hemlocks, and extensive bodies of the latter timber occur, together with occasional pines. The streams of this district, where they wind through the bottom lands, between the ranges of hills which inclose the valleys, are frequently densely wooded with all the varieties of hard wood timber, and their banks exhibit deep alluvial loams, which, when once brought under proper cultivation, will be unexcelled for fertility even by the rich plains of our southern

peninsula. These loams were sometimes observed to be underlain by a red clay. As a whole, the soils of the hilly portion of the upper peninsula, may be said to be generally superior to those of the extensive easterly portion of the peninsula, and marshes are of less frequent occurrence.

For purposes of lumber, the upper peninsula of our state cannot be said to hold out such inducements as, from its situation, might be imagined. White pine, though sometimes met with in considerable quantity, was not in any instance observed to have obtained to more than medium size, and is not generally abundant. The Norway pine is found in much greater abundance and of fair size, but this species of pine is of comparatively little value, as an article of lumber.

FURS, FISH AND HARBORS OF LAKE SUPERIOR

In the general view I have attempted to give of the character and resources of that portion of our state bordering on Lake Superior, full justice cannot be done to the subject without adverting, however, briefly, to the fur and fish trade of that upper country.

It is well known that the American fur company has for a long series of years, occupied posts, at convenient points upon the lake, as well as throughout the vast territory of the north-west, for the trade with the natives in the furs of the country. Since the year 1835, the general depot of the north-west trade in furs, has been established at La Pointe, one of the Apostles' Islands, near the western boundary line of upper Michigan, and in addition to this, other posts, of a more temporary and minor character, have from time to time, been occupied at various points in the same region. These all formed parts, or, as it were, links of that extended and connected chain, with which this company had been enabled to bind to its interests such an immense extent of territory, and to draw into its storehouses those treasures, in furs, with which this whole region originally abounded. The character

of the company, its immense resources, the perfect system that characterized its operations, as well as its distinguished success, are so well known, and have so often been adverted to by travelers and historians, that I allude to the subject here only for the sake of exhibiting more perfectly the present condition of upper Michigan, and to show what is the extent of the inducements held out to individual enterprize in that region. Nearly the whole of this trade is now, as it has been for a series of years, in the hands of the company referred to, and it has been secured to them by a course of judicious management, as well as by a large command of capital, and so powerful continues to be the influence exerted by this company, as to leave little chance of success to individual opposition, and the trade must continue to flow, mainly in its present channel.

The trade in furs is, however, very far from being of that importance which it was formerly, for the amount of furs has for many years past, been constantly diminishing, as the country becomes exhausted of the game, and so rapid has been the falling off, that at the present time, the amount of furs packed by the company, *at its station*, is scarcely half that which it was five years ago. At the same time, many important changes have been introduced by the company in the manner of conducting the traffic; the system formerly pursued, of granting credits to the natives on goods, sold at extravagant prices, a course not only unjust in itself, but destructive to habits of industry in the natives, has been entirely abandoned; goods are now sold at moderate prices, anticipating only reasonable profits, and an equally fair compensation is allowed for the furs. The company has, furthermore, entered fully into the measures of the government to prohibit the introduction of ardent spirits into the Indian country, and none is now employed in the trade; thus cutting off one of the chiefest sources of misery to the Indian population. I could not fail to notice that, since my last visit to the country, in 1832, the moral and social condition of the Indian population has greatly improved. This is owing, in great part, to the honor-

able and active measures adopted by the company, by which the means of subsistence among the Indians has been much increased, many evils that formerly existed have been removed, and an entire change has been brought about in their condition, and also to the exertions of the several very excellent and worthy missionaries, who have not only both by precept and example, been the means of introducing among them the meliorating influences of christianity, but have laboriously devoted their life to this "work and labor of love."

The American fur company also, at an early day, turned its attention to the fish of Lake Superior, and they have since engaged largely in the business of fishing. Many half-breeds and Indians are employed in the business, and this has also operated favorably upon the natives, and no doubt contributed largely to the improvement observable in their condition. Fair, if not high, wages are paid the Indians, which operates as a stimulus to industry, nor can we award too high praise to the equitable course pursued by the company in this matter.

Lake Superior abounds in trout, white fish and Siskowit,⁵² the two former of which are larger and better flavored than any that are taken in the more southern waters, and the latter fish has been rarely taken at any other station on the lakes; the consequence of which facts is, that the barrels of this company sell in the market at a higher rate than those of the fisheries farther south; but, at the same time, great disadvantage results to the company from the necessity of keeping vessels constantly upon the lake, for the express purpose of the fish trade, thus greatly increasing the expenses and risks attending the business.

During the past season minor companies have been formed and have commenced the business of fishing upon this lake. Two vessels have been hauled around the rapids at the Saut, for that purpose, and as the fish are abundant, there is reasonable prospect that the fishing trade will eventually prove of great importance.

⁵²An undescribed species of the genus *Salmo*.

But cut off as Lake Superior is, from direct communication with the lower lakes, by an impassable rapid, this trade must continue to be carried on under great disadvantages, nor can the other resources of the upper country be fully developed, so long as this barrier exists. The construction of the Saut Ste. Marie canal, which has been long projected, but the necessity for which seems to be not yet fully appreciated, would remove this obstacle to the growing importance of that great region; and when this shall have been done, we may expect to see all the resources of our upper peninsula fully appreciated and made available.

Directly connected with this subject, is that of the *harbors* on the southern shore of Lake Superior; for while such a field for enterprize is opened in that region, it is of essential importance to know what are the facilities it affords for the safe navigation of the lake. Six vessels are already navigating its waters, in the prosecution of the fur and fish trade, and although hitherto, but few harbors have been known to exist, which may be sought as places of refuge, the extreme breadth of the lake does not fail to afford an extraordinary facility in its navigation, by allowing a great extent of sea room, and thus enabling vessels, in case of storm, to "run before the wind."

The harbor afforded by the group of Apostles' Islands, and which is taken advantage of by the American fur company at its present station, is deep and completely "land-locked," and for safety and convenience could not be excelled. The same may be said of the natural harbor afforded by Grand Island and the neighboring shore. Both these harbors have long been known and appreciated, and more convenient and safe retreats could not be wished for vessels driven by stress of weather to "make a port;" nor could harbors be desired affording greater conveniences for permanent stations.

I was enabled, during the past season, to effect a partial triangular survey of several points upon the coast, which seemed to promise advantages as harbors for vessels; and the depths of the water were uniformly taken, also, at the mouths

of streams. The result shows that, although the number of places offering advantages for secure harbors is somewhat limited along a part of the coast, yet that portion of the coast of our state lying upon Lake Superior, may be said to hold out as great facilities, in this respect as any equal extent of coast upon the lakes. It might be supposed that Keweenaw point, from its extreme projection northerly, as well as from the "rock-bound" character of its shores, would serve to add to the dangers of the navigation, but along this rocky coast are found occasional inlets into large bays, stretching behind the extreme outer barrier of rock, and these are almost uniformly deep and completely sheltered, and at some future time, may, with little or no expense, be converted into a series of complete and permanent harbors. One of these bays or inlets, distinguished on the map as Copper Harbor, was surveyed by a series of triangulations and soundings, and was found to afford a bay, convenient for anchorage, about two and a half miles in length, stretching parallel to the coast, and having a depth of from five to seven fathoms, and the entrance to which has an uninterrupted breadth of three-quarters of a mile, with a mean depth over the bar of twenty feet, and a maximum depth of thirty feet. These harbors, from their location with respect to the mineral district of the upper peninsula, as well as from the ease of access they will allow to vessels which are exposed "off the point," must eventually become of very great importance.

A natural harbor, of similar form to that above described, occurs upon a part of the coast east from the Pictured rocks, and in which the place of the cliffs of rock is supplied by cliffs or spits of sand. The bay here formed, behind the outer bar of sand and gravel, has a length of two miles, with an average depth exceeding six fathoms, and the water deepens so rapidly from the shore, that in most parts of it a vessel of the largest draught may approach so closely to the beach as that a landing might be effected without aid from the boats. The entrance into this bay has a width of three-fourths of a mile,

but a bar of sand stretches across it, which would, at times, in its present condition, render the passage into the harbor dangerous, for the average depth of water over this bar does not exceed six feet, though there is a depth in the immediate channel, which is comparatively narrow, of ten feet.

Safe anchorage for vessels may also be found in Keweenaw bay, a deep expanse of water, on the easterly side of Keweenaw point, and which stretches for many miles inland.

PROGRESS AND CONDITION OF THE SURVEY, &c.

Notwithstanding the very many physical difficulties by which the geological survey of the upper peninsula of our state is surrounded, we have, nevertheless, been enabled to accomplish a much larger amount of the work than reasonably could have been hoped; but there still remains much to be done before its geology and mineralogy can be fairly understood. Comparatively little has heretofore been known of the range and extent of the several rock formations, and, while the labor of the past season has shown the most interesting of these to have a much larger area than we had previously been led to infer; it has also shown that the amount of work required, to enable us fairly to understand the geology and mineralogy of that interesting region, was considerably more than we had reason to look for.

The reports of the several assistants, will exhibit to you the progress that has been made during the past season, in the surveys of the southern peninsula. Messrs. B. Hubbard and C. C. Douglass were engaged with me during the early part of the season in the upper peninsula; after which, they returned to carry forward the geological and topographical surveys of the lower peninsula. I was also accompanied, during a small portion of the season, by Mr. Frederick Hubbard, who acted as special assistant, and who has embodied a small part of his numerous observations in the form of a report, which is hereto appended.

The survey of the lower peninsula is mainly completed, but there are some few spaces, both in the geological and topographical portions of the work, which require to be filled up before the results can be fully laid before the public.

The drafting of the topographical portion of the survey has advanced steadily towards completion, and the several county maps are in progress of publication in conformity to your instructions.

While we had hoped to have been able to bring the survey to a close within the time originally contemplated, from the above statement of the progress and condition of the work, it will be seen, that some further time will be necessary for its final completion; but while this time will be essential to reach the object sought to be attained by our state, no further appropriation will be necessary for that purpose.

In closing this report, I feel it a pleasure to refer to the very many acts of hospitality and kindness which have been extended to us by the citizens of Mackinac, Saut de Ste. Marie, and La Pointe. By the aids received at these several places, we have been enabled to accomplish much that otherwise could not have been done, while we have, at the same time, received much that has ministered to our comfort.

To the agents of the American fur company in Lake Superior, I feel very deeply indebted; for, through their polite attentions, I have been enabled to examine districts of country which otherwise could not have been reached, and to them and the several mission families, are we indebted for all that it was within their power to do, to aid us in our laborious duties, or to render our situation comfortable.

DOUGLASS HOUGHTON,
State Geologist.

Report of Frederick Hubbard, Special Assistant

Utica, N. Y., November 20, 1840.

To Douglass Houghton, State Geologist:

Dear Sir—I submit to you, the results of a portion of the observations for the determination of latitudes, magnetic variations, &c., made under your direction, during the recent expedition of the state geological corps to the upper peninsula and southern shore of Lake Superior.

The subject of latitudes was made a matter of particular attention, no regular survey ever having been made by the general government of that part of the lake lying within the boundary of our state. By means of instruments, with which the expedition was furnished, the positions of the most prominent points of the coast have been fixed by celestial observations, and with sufficient care to furnish, connected with the running meander, an accurate outline. Unfortunately, we were not furnished with the proper instruments for the determination of longitudes. This problem, always one of great difficulty, for our purpose, would have required a long series of the most careful observations, with the most delicate chronometers, and a greater devotion of time, than the circumstances of the expedition allowed. The ordinary lunar method, as practiced by navigators, is not susceptible of sufficient accuracy to be of service in a case of nicety.

Several rude attempts were made, however, with such means as we possessed, using a similar method, to fix the longitude of a few points; but I do not place sufficient confidence in the results to deem it of importance to lay them before you.

The latitudes in the following table were mostly obtained by measured altitudes of the sun, Jupiter and the polar star.

*Table of Latitudes.**Ste. Marie Riviere.*

W. side Drummond Island, (exam'pt, May 27.)	45° 58' 23" N
E. side St. Joseph Island. (May 28.)	46° 16' 45"
Pt. aux Pins, Little Lake George.	46° 32' 29"
Saut de Ste. Marie, (head of rapids.)	46° 31' 8"

Lake Superior

White fish point.	46° 45' 18"
Grand Marrais harbor.	48° 40' 5"
Mouth of Train river.	46° 25' 34"
Mouth of Chocolate river.	46° 29' 33"
Mouth La Riviere des Morts.	46° 35' 4"
Mouth Riviere Bay du Gres.	47° 21' 36"
Rock harbor, extremity of Keweenaw point.	47° 24' 32"
Mouth of Ontonagon river.	46° 57' 5"
Mouth of Montreal river.	46° 41' 19"
Village of La Pointe, Madaline Island.	46° 44' 31"

Variation of the compass.—The results, in the subjoined table, were deduced from a comparison of the observed magnetic azimuth of the sun with his true azimuth, as calculated for the measured altitude and place of observation. This method is one of great accuracy, and is almost the only one upon which dependence can be placed, for results which shall not contain an error of more than two or three minutes, due to inaccuracy of observation. The angles were measured with a theodolite, containing a needle of great delicacy.

A small correction to the table is necessary, on account of the diurnal variation. This may amount to some 8' or 10' and possibly may be greater in some instances, when the observations were made during the warmest seasons. As I have not the results of any experiments on this subject, now before me, I have thought proper to insert the date of each observation, and the hour of the day, that the correction may be made when the date can be obtained, with reference also to the metrological table kept during the survey.

By platting these variations upon the map of the coast, it will appear that there is a constant increase in the amount of deflection in passing westward, and at the same time that *the increment is not in proportion to the westing* but is in a

decreasing ratio, the distance between the lines, connecting the points of the same variations, being greater as we recede from the line where the direction of the needle is due north.

From the observations in Riviere Ste. Marie, it appears that the line of no variation passes through that strait, crossing Drummond Island near its western, and St. Joseph through its central or eastern part, with a course about north by west.

The determination of its exact position is a matter of considerable importance, and I regret that circumstances did not allow us, when in that vicinity, to spend more time in the investigation of this interesting subject. The tracing of its supposed irregularities, and the ascertaining of the laws which govern its changes, have for many years attracted the attention of the scientific world.

By marking upon the map the points of 1, 2, 3, &c., degrees of variation, and drawing through them lines parallel to the line of no variation, it will be perceived that there are, in a few cases, important deviations from the general regularity in which the deflections are found to increase. These differences are by far too great to be attributed either to errors in observation, to diurnal variation, or to the effect of atmospheric disturbing causes. I know not what influence the general topography of a country may have upon the directions of the magnetic needle, but it appears highly probable that something may be due to the outline of coast, to the unequal distribution of land and water, and to the influence of an open extent of sea, on the one hand, and of a mountain range upon the other. It might be suspected that these irregularities were the result of local attraction of metallic veins, or of some unknown disturbances in the more immediate vicinity, did they not always occur where they seem to have an obvious connection with the circumstances I have mentioned. In all these cases there is a deflection of the needle towards the open lake, tending, when the land lies to the west of the place of observation to increase the amount of easterly variations, and the contrary. Thus we find, about the Riviere des Morts, where

the trend of the shore is northerly, at the several points to the east of the Keweenaw peninsula, and at the village of La Pointe, lying to the eastward of a high range of hills upon the mainland, a too great deflection towards the east, as if the needle were actually affected by some repulsive influence existing in the land, or a contrary principle, in the water. One or two instances occur, where the attraction is to the west apparently from a similar cause.

Whether this is the true explanation of the difficulty, I will not pretend to decide. The subject is one that merits investigation, as having some bearing upon the science of terrestrial magnetism, many of whose principles are as yet enveloped in mystery.

Table of magnetic variations

				<i>Riviere de Ste. Marie.</i>	
May	27	4 h. 16 m.	P. M.	West side Drummond Island...	0° 9' E.
	20	8 30	A. M.	Small Island in Montreal channel.....	0° 12'
	30	9 16	"	Saut de Ste. Marie.....	1° 25'
				<i>Lake Superior.</i>	
June	8	5 15	P. M.	Grand Marrias harbor.....	3° 29'
	13	6 46	"	Mouth of Miner's river.....	3° 39'
	16	9 11	A. M.	Shore, half mile west Chocolate river.....	5° 36'
	18	8 00	"	Mouth of Carp river.....	5° 32'
	23	8 00	"	Mouth of Pine river.....	5° 36'
	27	8 10	"	Bay on south side Keweenaw point, (at mouth first stream north Portage river).....	5° 37'
	30	5 40	P. M.	Mouth Riviere Bay du Gres....	5° 24'
July	13	4 40	"	Mouth of Ontonagon river.....	6° 33'
	16	4 30	"	Mouth of Montreal river.....	7° 43'
	18	5 40	"	La Pointe.....	8° 33'
	31	9 33	A. M.	Parisien Island.....	1° 11'

Accompanying this you will receive a map of the harbor of Grand Marrais and of Copper harbor, surveyed by your direction, while the geological corps were encamped at those places. That of Grand Marrais is made, exhibiting only the general

outline, a few points being fixed by triangulation, and soundings taken upon the bar at the entrance. Of Copper harbor, a more thorough survey was made; as complete as the limited time of our stay would permit. The outline of shore, positions of reefs, &c., were accurately determined by a system of triangulations, and soundings made across the entrance, and throughout the interior. A mere glance at the map is sufficient to show how little is left for art to do, to render this harbor one of the most secure places of refuge from storms, to be found in any part of the lake.

Respectfully, yours,
F. HUBBARD.

Report of C. C. Douglass, Assistant Geologist

Detroit, January 4, 1841.

To Douglass Houghton, State Geologist:

Sir—In conformity with your instructions, I have the honor to report, that the examinations, assigned me to be performed in the northern portion of the southern peninsula, have been as nearly completed as circumstances would permit. The duties performed under your immediate directions, in the region of Lake Superior, delayed the commencement of this work until the season was so far advanced as hardly to allow sufficient time for the completion of the unfinished work in this portion of the state.

In prosecuting the examinations in this district, I have made collections of duplicate specimens of all of the rocks, together with their contained minerals and characteristic fossils, all of which are deposited, according to instructions, in the geological depot at Detroit, together with a transcript of my field notes.

Previous to making these examinations, it had frequently

been reported to me that coal had been found by the Indians and traders in the high lands lying east from the Traverse bays of Lake Michigan. These reports were soon shown to be without foundation, for the reason that the whole of the rocks of this district, lie below those of the coal formation.

REMARKS ON THE GENERAL CHARACTER OF THE NORTHERN PORTION
OF THE LOWER PENINSULA

The country north of township nineteen north, and *east* of the meridian, is, on the whole, but ill adapted to the purpose of agriculture, being chiefly composed of sandy ridges, with intervening swales, and cedar swamps; many of the latter, however, are merely tracts of moist ground, covered with so dense a growth of white cedar as to be rendered almost impenetrable. The country rises so gradually towards the meridian of the state, as to leave it generally flat and wet; but were the country cleared of its timber, and the water courses freed from flood wood, much of the country would be rendered dry, arable land.

A large portion of the immediate shore of the lake, is low land, either entirely or approaching to swamp.

High land was noticed lying at some distance back from the lake shore, between Presque Isle and the Cheboygan river, which belongs to, and forms a part of, the chain of high land that appears on Lake Michigan, between Point Wabashance and Little Traverse bay.

The greater part of the country, after passing west of the meridian, is of a character very different from that just described, in point of soil, face of country, climate, &c.

From old Fort Mackinac to the Manistee river, the land immediately upon the lake shore, and not unfrequently extending back for many miles, is considerably elevated, and occasionally rises, very abruptly, to the height of from one to three or four hundred feet. The country, (more particularly the northern portion,) continues to rise as we proceed into the

interior, until it attains an elevation equal to, if not exceeding any other part of the peninsula.

This is more particularly the case in the rear of the Traverse bays, where this elevation continues for many miles into the interior, giving to the landscape a very picturesque appearance when viewed from some of the small lakes, which abound in this, as well as in the more southern portion of the state.

The tract of country under consideration, is based on limestones, sandstones and shales, which are covered, excepting at a few points, with a deposit of red clay and sand, varying in thickness from a few inches to more than four hundred feet.

The interior of the northern part of the peninsula, west of the meridian, is generally more rolling than that on the east. It is interspersed with some extensive cedar swamps and marshes, on the alluvial lands, and in the vicinity of the heads of the streams, and some of the lakes. The upland is generally rolling, has a soil of sand and clay loam, and is clad with evergreen timber, intermixed with tracts of beech and maple, varying in extent from a few acres to several townships.

Some of the most extensive of these tracts are in the vicinity of the Cheboygan and Tahweegan rivers, their lakes and tributary streams. There are also large tracts of beech and maple timber lying between the head of Grand Traverse bay, and the Manistee and Muskegon rivers.

The elevated portion of land on the shore of Lake Michigan, known as the "Sleeping Bear," as well as the Manitou islands, which, when viewed from a distance, have the appearance of sand, are found to be composed, (excepting the recent sand dunes,) of alternating layers of highly marly clay and sand. The clay is of a deep red color, and in many places its strata are much contorted.

The hilly region to which allusions have been made, is mostly heavily timbered with beech, maple, bass, oak, ash, elm, birch, &c., interspersed with tracks of hemlock and pine, and with an occasional cedar swamp. In the vicinity of Grand Traverse bay, this character of country extends into the in-

terior for many miles bordering on a series of small and beautiful lakes, which vary in length from two to eighteen miles, and are in general free from marsh and swamp. This country, as also that in the interior of Little Traverse bay, is well adapted to the purposes of agriculture.

Passing south of this rolling district, the country becomes less elevated, and more variable, the soil assuming a more sandy character, and being generally clad with evergreen timber. There are, however, exceptions to this, in some fine tracts of beech and maple, near the lake coast, also in the vicinity of some of the streams in the interior.

It is nevertheless true that there are many extensive swamps and marshes in this part of the peninsula; but it is to be doubted whether, upon the whole, they exceed in quantity or extent, those of the more southern part of the state. In point of soil and timber this portion of the state is not inferior to the more southern, and such are the advantages it offers to the settler, that the day is not distant when it will be sought as a place of residence by the agriculturist. The beauty of its lakes and streams is not any where surpassed. Such is the transparency of their waters as to permit objects to be distinctly seen at the depth of more than thirty feet.

The small lakes abound in the finest of Mackinac trout, whitefish, sturgeon, pike, bass, sun-fish, &c. The transparency of the water is so great, that the Indians are accustomed to spear fish where the depth exceeds thirty feet.

That part of the peninsula situated north of Grand river, is usually regarded by many of the inhabitants of the more southern part of our state, as being either an impenetrable swamp or a sandy barren waste, and as possessing too rigorous a climate to admit of its successful application to the purposes of agriculture.

This is an erroneous opinion, and one which will most certainly be corrected as the facts with regard to this part of our state, come more fully to be known. The inhabitants of Flat, Rouge, Maskego and White rivers, and the Ottawa In-

dians, living on the Grand and Little Traverse bays, and on the Manistee river, have extensive cultivated fields, which uniformly produce abundant crops.

The country on Flat and Rouge rivers is generally rolling, interspersed with level and knobby tracts, but none is so rough as to prevent its being successfully cultivated. The timber in the vicinity of the streams consists of black, white and burr oak, which is scattering, and forms what is denominated openings and plains; small tracts of pine barrens, beech, maple and oak lands interspersed with tracts of white pine.

Settlements are rapidly advancing in this part of our state, and much of the land under cultivation, produces excellent crops of wheat, oats, corn, potatoes, &c., and so far as experience has been brought to the test, is not inferior to, or more subject to early frosts in the fall than the more southern counties in the state.

The soil varies from a light sand to a stiff clay loam.

The country on the Maskego is rolling, and may be considered as divided into beech and maple land, pine lands, pine barrens, oak openings, plains and prairies. Small tracts of the latter are situated near the forks of the river, about forty-five miles from its mouth, and between thirty and thirty-five miles north of the rapids of Grand river. Crops of corn, oats, wheat, &c., were here as flourishing as those of the more southern part of the state. Several families are settled on the prairies and along the valley of the stream. They have two saw-mills in operation, one at the forks of the Maskego river, and the other on a small stream five miles below.

The soil of the prairies and openings is sandy, while that of the beech and maple lands is a sand and clay loam.

The Indians of Grand and Little Traverse bays and vicinity, also obtain good crops of corn, potatoes, squashes, &c. Some of the most intelligent Indians informed me that their crops had never been known to fail entirely, and that they were seldom injured by frosts in the fall or spring. They also

have many apple trees which produce fruit in considerable quantities.

This soil is strictly a "warm one," and exposed as the whole country bordering on Lake Michigan is to the influence of the southern winds, during the summer, and parts of the spring and fall, it seldom fails to be productive.

GENERAL GEOLOGY

For convenience of description, I will arrange the several rock formations in groups, beginning with those that occupy the highest place in the series, descend to the lowest, or oldest rocks. Owing to the great accumulation of superficial materials, which has prevented perfect accuracy from being attained, these divisions may be liable to modification upon subsequent and more minute investigations.

Rocks of Lake Michigan

1	Townships.	Tertiary and superficial materials.	{1. Boulders of granite, &c. 2. Clay, sand, &c.
2	T. 16, N.	Manistee limestone.	
3	" 31-32 "	Shales.	{1. Light blue argillaceous. 2. Black, containing pyrites.
4	" 33 N. "	Corniferous limestone.	{Containing beds of hornstone. Beds of limestone, intermixed with clay and chert.
5	" 34 N. "	Little Traverse bay limestone.	
6	" 34 N. "	Black bituminous limestone.	Composed of congeries of shells.
7	" 34 N. "	Blue limestone, in thick regular layers.	
8		Mackinac limestone.	Very porous and much shattered.

Rocks as seen forming the coast of Lake Huron

	Townships.		
1		Alluvium.	{ 1. Beds of rivers. 2. Incrusting springs. 3. Marl, tufa, peat, &c.
2		Tertiary and superficial.	{ 1. Boulders of granite. 2. Beds of clay and sand, &c.
3	20, 26 N.	Point aux Gres. Limestone.	{ Light colored arenaceous, containing septarea.
4	27 "	Shale.	Black bituminous, contain- ing pyrites.
5	28 "	Thunder bay limestone.	{ Beds of limestone and gray clay or shale, containing abundant fossils.
6	30, 31 "	Black bituminous lime- stone.	Bituminous, composed of congeries of shells.
7	32, 33 "	Blue limestone.	Compact and in thick strata.
8		Mackinac limestone.	{ Very porous and the upper portion much shattered.

It will be seen, by referring to the above sections of the rocks of lakes Huron and Michigan, that the same rocks, with one or two exceptions, occur on both sides of the state, having the same geological position; also, that they have very nearly parallel and uniform positions. And from these outcrops the rocks would appear to have a bearing nearly north 70° west, and south 70° east, which line of bearing corresponds with the outcrop of the black bituminous slate on the east side of Lake Huron in Upper Canada.

ALLUVIUM

Under this head may be included all those formations which are the result of causes now in operation. Such as beds of shells and tufaceous marls, deposition of silt at the mouths of streams, disintegration of rock strata, growth of peat, bog ores, &c.

Shell Marl

Is in general, composed of small fresh water shells, chiefly univalve with occasional bivalve, which multiply most rapidly in shoal ponds or pools of water strongly impregnated with carbonate of lime. For the accumulation of fresh water shells and shell marl, the waters of the streams and small lakes of the northern part of the state, are well adapted. This marl has accumulated in extensive deposits at the outlets and inlets of most of the lakes on the Cheboygan, Tahweegan and Pine rivers. There is also an extensive deposit of marl on the shore of Thunder bay, north of Thunder bay river.

Tufaceous marl is also rapidly accumulating at the rapids of the streams above mentioned, where the deposition takes place in consequence of the water here being much agitated. The carbonate of lime precipitated at these points, is usually in the form of tufa, which readily adheres to whatever it comes in contact with, thus forming balls varying from one to twelve inches in diameter. Most of these balls have a shell as a nucleus.

Tertiary and Boulders

Included in this division are alternating beds of red clay and sand which are nearly co-extensive with this part of the state. This formation overlays and rests unconformably upon the lower rocks of the district, and in which respect, it corresponds with the same formation in the more southern part of the state.

It forms the base of most of the high banks of both lakes Huron and Michigan, and is very finely exhibited at the Sleeping Bear, and on the Manitou islands of the latter lake. It also forms the base of most of the high knobs, in the interior of this section of the state. Most of this clay is very unctious and nearly free from grit, but contains lime in sufficient quantity to injure it for the manufacture of brick.

Primary boulders are very rarely met with on the upland; but those of a small size are very numerous on the shores of the small lakes, where there were also numerous boulders of limestones seen associated with them.

ROCKS OF LAKE HURON

Point Au Gres Limestone

This rock, is for the most part, of a light cream color, of a compact structure, and will afford a tolerable building material. It contains numerous fossils. From this point north, on the lake shore, to Sulphur island, rock was seen at intervals, forming the bed of the lake, which rock was referred to the sandstone formation. This space is undoubtedly occupied by sandstones and shales, the equivalent of those on the coast of Lake Huron from Point aux Barques south, to White Rock.

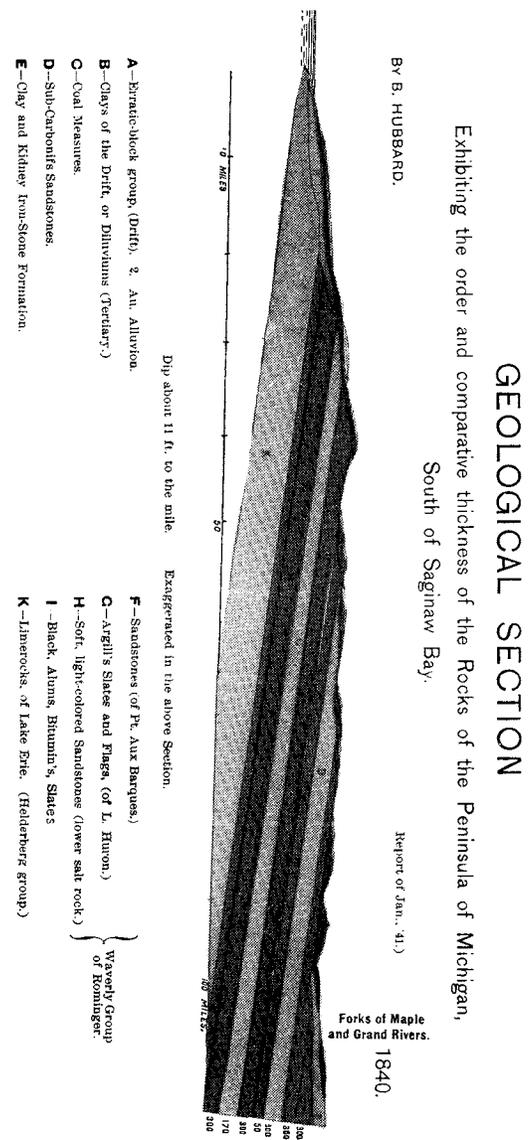
Limestone of a very siliceous character occurs on the Charity and other islands of Saginaw bay, where it was seen in contact with, and overlying, the sandstone, and occupies the same superposition as the limestone at the rapids of Grand river.

Black Shale

A black bituminous shale was first seen at Sulphur island, and also extending along the shore of the main land, for some distance. It is highly bituminous, burning freely when thrown upon the fire, and contains numerous small nodules of iron pyrites. It may be considered as equivalent to the shales of western New York.

Thunder Bay Limestone

This limestone occurs at the south cape of Thunder bay, forming an abrupt cliff, which rises directly from the water to the height of twenty feet. It is composed of alternating lay-



ers of compact and shaly limestone, and fissile clay slate; the latter of which forms a considerable portion of the cliff, containing nodules of iron pyrites and chert. Most of the rock is of but little value for economical purposes. It contains numerous fossils, among the most characteristic of which, are the *Atrypa aspera*, and *prisca*, *Delthyris speciosa*, *Calymene bufo*, *Gorgonia*, *Millepore*, *Catenipora stellata*, *Cyathophyllum dianthus*, *Calamapora spongites*, *Pentremites pyriformis*.

Black Limestone

This rock is seen cropping out at intervals on the lake coast, from Thunder bay island to Middle island, but it either occurs below the surface of the water or so little elevated above it, after leaving outer Thunder bay island, as to be difficult of examination.

Most of this rock is of an inferior character and furnishes a coarse, rough, building material, and is of very little value in an economical point of view. Some portions of it are of a sub-slaty character, highly charged with bituminous, while portions are nearly composed of congeries of fossils. It is undoubtedly the animal matter from the fossils that gives to this rock its bituminous character.

Among the most characteristic fossils found in this rock, are the *Calymene bufo Rowii* and *Blumenbachii*, *Atrypa aspera* and *prisca*, *Delthyris speciosa*, *Calamipora favosa*, *Orthis*, *Cyathophyllum ceratites*, *Orthocera*, *Calamapora favosa*.

Blue Limestone

Limestone of a light blue color, and very compact, was seen at intervals between Middle island and Forty mile point, forming the bed of the lake, or but slightly elevated above the water. It is regularly stratified and very compact, and contains numerous fossils; among those ascertained were the

Atrypa prisca and *aspera*, *Orthis*, *Euomphalus carinatus*, *Cyathophyllum helianthoides*, *Flustra*.

Mackinac Limestone

In the vicinity of the Island of Mackinac, the upper portion of this limestone is chiefly made up of broken cemented fragments. The rock is of a light color, and the fragments of which it is composed frequently contain numberless minute cells. These were undoubtedly once filled with spar, which has been washed out of the exposed part of the rock, by the action of water.

Many of the more compact parts of this rock, when first broken, show numerous small veins of spar piercing it in every direction and owing to the porous character of the upper portion of this rock, it affords but a poor building material; while the lower part of the rock is more compact and has marks of regular stratification. This is more clearly exhibited on Round and Bois Blanc island, and where a much better building material can be procured, than any seen on the Island of Mackinac.

Hornstone, striped jasper, imperfect hogtooth spar, calcareous and fluor spar, and some very imperfect fossil remains, are occasionally found imbedded in this rock. The whole exposed portion has the appearance of having been very much shattered by an irregular upheave.

Limestone of a similar character to that above described, was examined on the main land, to the west of Mackinac island, forming the high bluff known as the "Sleeping Rabbit;" also forming the bed of the lake west of old Fort Mackinac, and extending westerly as far as point Wabachance.

ROCKS OF LAKE MICHIGAN

Rock has not been found to outcrop in that part of the state north of Grand river, lying between townships seven and fif-

teen north, and west of the meridian. But were the superincumbent sands and clays removed so as to expose the rocks to view, they would be found to correspond with those passed over in going south-east from the rapids of Grand river to Monroe county, being a succession of sandstones and shales.

Near the Manistee river, in township fifteen north, limestone appears in elevated cliffs; which rock is probably referable to the same series as that of Monguagon, in the south-east part of the state.

Blue and Light Gray Shales

This shale crops out on Grand Traverse bay, (in township thirty-one north,) forming a cliff of from five to fifteen feet in height, is of a light gray or blue color; most of it highly argillaceous, and is divided into thin laminae, varying in thickness from one-eighth of an inch to two inches. The thin laminated parts of the shale are very friable while the thicker layers are more compact and calcareous.

Minute crystals of spar were seen attached to and filling crevices in the most compact part of this shale. I was unable to detect any fossil remains in the shale.

Black Shale

This shale forms a series of abrupt cliffs, of from one to twenty feet in height, for the distance of nearly a mile on the coast of Grand Traverse bay, (in township thirty-two north,) being four or five miles north from the blue shale before described, and lies below it.

This shale is slightly bituminous, contains numerous nodules and specks of iron pyrites, is very friable, disintegrates rapidly before the action of the waves to which it is exposed, and closely resembles in character, composition and superposition, the shale of Sulphur island of Lake Huron, with which it may be regarded as identical in geological position.

This shale was also examined in the north bank of Pine lake, (in township thirty-three north, range seven west,) where it is but slightly elevated above the water of the lake; contains like the shales before described, numerous nodules and specks of iron pyrites, is slightly bituminous, and is equivalent to the black shales of Lakes Huron and Michigan.

Associated with the shale at this point, are large angular masses of fœted limestone and shale connected together in the same mass; and these masses are frequently traversed by thin veins of pearl spar; the latter also filling the small cavities formed in the rock. The masses of fœted limestone above described, occupy places simply in the lower portions of the shale stratum.

Corniferous Limestone

The rock to which I have given this name is of a light gray color, regularly stratified in layers varying from one-fourth of an inch to twelve inches in thickness, and is very compact; some portions of it affording a good building material. It contains large quantities of imbedded hornstone, in layers, from one to twelve inches in thickness, and which breaks into small blocks on exposure to the atmosphere. This limestone is destitute of fossils, in that portion which was examined.

Little Traverse Bay Limestones

These limestones agree in geological position and character, with those of the cliff in Thunder bay, Thunder bay island and Middle island of Lake Huron.

The limestones of Little Traverse bay rise directly from the water, forming abrupt cliffs, varying in height from five to thirty feet, and for the sake of a more minute description, they may be sub-divided, and considered in a descending series as follows:

	Feet.	Inches.
1. Blue silicious limestone, much of it very compact, and will afford a good material	9	
2. A confused mass of broken fossils imbedded in clay		2
3. Vesiculated chert, colored with iron	1	
4. Flaggy limestone separated into layers, varying from one-fourth of an inch to an inch in thickness	8	
5. Blue clay containing imbedded semi-crystalline grains of iron pyrites	8	
6. Light blue limestone, below the surface of the water; thickness unknown; resembles the limestone of Middle island, Lake Huron		

Most of the limestones of this bay are of an inferior quality for economical use. They are very much shattered, presenting in that respect a strong resemblance to the sandstones of the southern part of the state. Some portions of the rock on this bay are so shattered, as to have the appearance of a mass of loose blocks. Fossils were found in a very perfect state; among the most characteristic of which are the *Atrypa prisca*, *Productus*, *Strophomena*, *Calamapora polymorpha*, *Cyathophyllum vesiculosum*, *Isotelus gigas*, *sarcinata*, *Cerriopora verrucosa*, *Catenipora labyrinthica*.

Blue Limestone

This rock was found outcropping at the first point west of Pine river; also, south of the head of Little Traverse bay, and is there of a light blue color. It is elevated a few feet above the water of the lake and stream, where it embraces the black bituminous limestone, next described. The latter occurs here, in two or three thin layers, which are filled with fossils.

The blue limestone is very compact, in strata varying in thickness from one to two feet. These strata are much warped, as if by irregular uplift, destroying all regularity of dip. It contains numerous fossils, analogous to those of Middle island of Lake Huron.

Black Limestone (Subordinate.)

Embraced in the blue limestones, is found the out thinning edge of the black limestones of Thunder bay island. It is seen in the bay beneath the waters, and between one and two miles south of the head of the bay, in the bed and banks of a small stream, where it consists of several layers, from two to twelve inches in thickness; is highly bituminous and is almost wholly composed of congeries of shells, which undoubtedly give to it its bituminous property. It burns when thrown upon the fire, with a brisk flame, so long as any of the bitumen remains, but the mass is not reduced in size by the burning.

It is the bituminous character of this rock, which has given rise to the reports that coal existed in the vicinity of the Little Traverse bay.

The Indians attach great value to this rock, for its inflammable quality; and upon inquiry being made of them, respecting it, they professed to be entirely ignorant of the existence of any rock of that character, in their region of country.

Deer Licks

Springs which have their waters slightly saturated with muriate of soda, and the salts of lime and iron, are occasionally to be met with, in that portion of the state under consideration. In character and quality of water, they are equivalent to those which are found in Macomb and St. Clair counties, and cannot be considered as of much practical importance.

Ancient Lake Ridge

In prosecuting my examinations in the north part of the southern peninsula, portions of ancient lake ridges were met with, which were found to correspond with that whose character was determined by Mr. Hubbard, and described in his report of last year, as occurring in the southern part of the state. No large continuous ridge was met with, through the

country examined by me, but rather a series of small ridges, which were found to be composed of water worn pebbles, gravel and sand, not unlike those composing the present lake beach, and having an elevation, as nearly as I was enabled to judge, of one hundred and forty feet above the present water level.

These ridges were found the most fully exhibited on the islands and on the main land bordering the straits of Mackinac, and occur under circumstances that would seem to show that the water of the lakes had subsided gradually, or, (which would produce the same effect,) the land had been gradually elevated.

COLUMBUS C. DOUGLASS,
Assistant Geologist.

Report of B. Hubbard, Assistant Geologist

Detroit, January 24, 1841.

To Douglass Houghton, State Geologist:

Dear Sir—Immediately upon my return from the portion of our state bordering on Lake Superior, where my services as assistant had been required during a large part of the season, I recommenced the detailed surveys in the organized counties of Michigan proper. These were conducted with a more especial view to the determination of the extent and value of the coal district of the peninsula. The counties in which minute examination have been made during the past season, are Barry, Clinton, Shiawassee, Genesee, Lapeer, St. Clair and Macomb; and examinations have been extended generally over other counties previously examined, in part, in order to the more full and satisfactory completion of the duties assigned me.

Maps of the Counties.—The labor of correcting, while in the field, maps of those counties which were assigned to my geologi-

cal and topographical supervision, has been completed, and the plats are now in the hands of the state topographer, to be prepared for publication. A great mass of information, both of a practical and purely scientific character, and which could not be transferred to the maps, nor be suitably embodied in the annual reports, has been compiled from my field notes, arranged for future reference, and for such use as may be found advisable in the final report on the survey. Particular attention has been devoted towards the full collection of all such details as would give a completeness to the several objects aimed at, in this department of the survey, and I may be permitted to say that no source of information, known to me, has been neglected, which could subserve interests of so important and comprehensive a character.

Purpose of present report.—The report of Mr. Douglass, of last year, embraced a general view of the extent of the coal bearing rocks, so far as then ascertained, and their details in the counties of Jackson, Ingham and Eaton; my own having been confined to the rocks below the lowest of the coal bearing series. Without further recapitulation of the facts heretofore submitted than may be unavoidable, I propose, in the present report to exhibit a comprehensive view of all the rock formation, *throughout the organized counties* of the state.

The “*geological section*,” hereto prefixed, will serve to exhibit, at a glance, the succession of the rock formations, from the universally superimposed sands and gravels, down to the great limerock formation of the southern portion of our state, bordering on Lake Erie. It is intended to show the rocky basis which would be exhibited to view, if the country could be cleft through, in a line from Lake Erie to Maple river, in Clinton county. The rocks in this section are grouped according to their distinguishing characters and relative position, and each group is distinguished by an alphabetical letter. The *sub-divisions* of some of the groups, are given in the body of the report.

GENERAL GEOLOGY OF THE ORGANIZED COUNTIES OF MICHIGAN

In the “section” alluded to the rocks, embraced within the district under consideration, are divided into groups, as follows:

- A. Erratic block group, or Diluviums.—a. Alluviums, ancient, recent.
- B. Tertiary clays.
- C. Coal measures. { Upper coal and shale.
Lower coal and shale.
Including sandstones.
Limestone stratum.
- D. Sub-carboniferous sandstones.
- E. Clay and kidney-ironstone formation.
- F. Sandstones, of Point aux Barques.
- G. Argillaceous slates and flags, of Lake Huron.
- H. Soft, light colored, sandstones.
- I. Black, aluminous slate.
- K. Limerocks, of Lake Erie.

These will now be considered, as nearly as may be, in their consecutive order, beginning with the highest in the series.

ERRATIC BLOCK GROUP, OR DILUVIAL DEPOSITS

These consists of sand, pebbles, and large water-worn masses of previously existing rocks, with occasional small, local beds of clay. They have a thickness varying from one to upwards of one hundred feet; they form a universal mantle to the rocks, and constitute the soils of all the interior counties.

As this whole deposit is one of transport by water, and is made up of the detritus and disrupted fragments of heterogeneous formations, its character depends upon that of the rocks from which it is derived. For instance, *sand* constitutes by far the greater proportion, and this circumstance may be, in part, accounted for, from the fact of the immense extent of

sandstone rocks existing farther to the north; and in part, by the fact, further disclosed by the geological researches in the peninsula, that an immense thickness of rocks, mostly sandstone, which composed the upper series of the coal measures, has been broken up and removed from our geological series. *Fine gravel* constitutes the diluvium in the next proportion, and is the result of a similar abrasion of rocks of harder materials. Owing to the friable nature of the sandstones, as might be expected, few large bowlders of that material occur. Limestone pebbles and bowlders are abundant; a condition which also might be looked for, when we take into view the immense extent and thickness of the limerocks of our state, they being by far the most prominent formation above the primary.

These relations of the component parts of our diluviums, give a character to the *soils* of the peninsula, which enables us to compare them most favorably with those of most other states of the union. Though being very generally what may be denominated sandy or gravelly, and often answering in appearance to a description of soils which, in the eastern states, are considered as absolutely barren, the variety and due intermixture of their components, and more particularly the large proportion of carbonate of lime which is combined with them, either in the form of pebbles, or in a very comminuted state, impart to them unusual strength and fertility. The latter circumstance is that which so admirably adapts them to the growth of wheat, and in this respect, most of the soils of the peninsula may fairly be pronounced unrivalled.

Whatever may have been the causes which swept these materials over the face of the rocks, whether oceanic currents or bodies of floating ice, the character of these *diluviums*, as well as numerous accompanying facts, plainly imply that they came in a direction northerly from their present beds, and often from great distances. Consequently we find intermingled, as well as scattered upon the surface, numerous rounded fragments of those primary rocks which are known to exist in

the peninsula of northern Michigan and in Canada, from the size of the largest "hard-heads" down to fine gravel. In proceeding from our state southerly, these deposits are found gradually to thin out, evincing a diminution of the sustaining power with the increased distance from the original bed of the transported materials. So that, while the peninsula of Michigan has been most liberally supplied with an uncommonly deep and arable soil, made up of a variety of materials, the states of Ohio and Indiana, on the south, are in great parts destitute; its place being supplied by the clays of the next lower formation.

The deposition of these materials took place with or without apparent order and uniformity, according to the character of the existing surface, and other circumstances which may have governed the transporting forces. From this cause considerable variations are to be found in the depth, nature and composition of the diluviums, and hence, also, material differences are occasioned in the soils and other characteristics of the country. In many places a uniform stratification has taken place, as if the result of quiet deposition. This is more particularly apparent on the east and south side of the main ridge of the peninsula, and may be considered as a natural consequence of so considerable an obstacle as this partial barrier must have interposed to the force of northerly currents. Here, wells have been carried to the depth of 90 feet, through beds of stratified gravel.

Throughout all the diluviums, thin local beds of clay are of frequent occurrence, and occasional strata of hard pan or cemented pebbles. These clays, unlike those of the tertiary, contain little or no lime.

Most of the country thus covered by the diluvial deposits, exhibits the action of strong currents and eddies in a very striking manner. Districts of many miles extent frequently present a continued and close succession of rolling knobs or cones of gravel, with deep intervening basins. The more

ordinary character of surface is a gentle roll or slight undulation, occasionally subsiding to a perfect plain.

Except where a deposit of clay underlies, the growth of timber is almost invariably scanty, constituting what are denominated "oak openings." The character of their timber changes with the varying conditions of the soil, from white and black oak to burr oak or hickory, and the plains are frequently altogether destitute of timber. A dense growth of the usual hard wood timber sometimes occurs over isolated tracts, in swales, or along banks of streams. Of the character of country described are found the three most southerly ranges of counties, with the exception of those which immediately border the peninsula on the great lakes, together with parts of the adjoining counties, and the counties of Ingham and Eaton. All the latter have a sub-stratum of clay, belonging to the great deposit to be presently described, and in consequence differ very materially in surface, soil and timber.

To this extreme thickness and comparatively loose texture of the diluviums, may be ascribed the great abundance of springs, and consequently of the small streams which irrigate the whole surface of the state, affording abundance of that element so desirable to the farmer. An undulating surface gives to most of these a sufficiently rapid flow to preserve a healthy current and to furnish a sufficiency of mill power. From the same cause, also, little difficulty is experienced in obtaining pure water by sinking of wells, and it may safely be said that Michigan is better supplied with living water, uniformly distributed, than any other state in the Union.

The vast numbers of small lakes for which Michigan is so remarkable, are due to the same causes. They occupy generally deep hollows, seemingly scooped out of the mass of diluvium, and are fed by the living springs that percolate through it. The number of these peninsular lakes is stated by the state topographer at not less than 3,000; being in proportion of one acre of water to every thirty-nine of dry land.

Another striking feature in the peninsula landscape, is the

number and extent of wet prairies or marsh. Of these the proportion is much larger than of the lakes, and they often cover many miles of surface. These have their origin also from springs, issuing from the diluvium, aided often by the artificial dams of the beaver, and from being originally mere pools or shallow lakes, in time they become receptacles for beds of marl and peat. From the very tolerable hay which these prairies afford, and the very early supply of tender "feeding" for cattle, in the spring, the apparently waste places have been an invaluable aid to the settlement of the country. The primitive settler came hither, not to a desert waste or a "howling wilderness," but to lands cleared without aid from the woodman's axe, and verdant with unsown crops. He did not wait to provide pasture, but brought his herds and flocks with him, and the marshes furnished them ample sustenance throughout the year. And we hazard nothing in saying that these marshes, waste as many of them are now suffered to be, are destined to become still more valuable in sustaining the failing vigor of the country whose youthful prosperity they promoted. Their successful drainage is no longer a matter of experiment. Scarcely a marsh of much extent exists, which is not capable of thorough drainage, with comparatively small expense, and, when thus subdued, of furnishing a soil rich almost beyond comparison. The literally exhaustless beds of marl and peat with which these marshes abound, constitute another item of value no less important. But the consideration of these may more properly be referred to the head of *Recent Alluvions*.

But though affording a medium for the absorption of rain waters and their percolation through strata of gravel or quicksand, the diluviums are rendered sufficiently retentive, by the alumine contained in them, and by seams of cemented gravel and sand. Were it not for this, the moisture absorbed by our light, sandy soils, would soon be drained off and lost to the crops. A sub-stratum of cemented gravel, retentive of water, is common to many if not all the prairies, and to this circum-

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stance, may, no doubt, in great measure, be ascribed their accumulation of rich loam and consequent fertility.

Much curious inquiry has been excited on the question of the causes which produced the peculiar varied and open character of so large a portion of our peninsula. After the view which we have just taken of our diluviums, it may seem less a matter of surprise, that portions of the state should be adapted to the production of a dense growth of hard timber, and others only to the several species of oaks or to hickory, according to the continually varying conditions of the soil and its substrata. The existing analogies of the vegetable world, which exhibit similar results elsewhere, might lead us to infer these changes, and we may, without doubt, attribute to the peculiar characteristics of our diluvial envelop, and its varying conditions, the accompanying peculiarities in the natures of the country and the growth and character of its timber.

How far the impervious character of the "hard pan," which so generally, if not universally, forms the sub-stratum to the prairies and plains, may account for the destitution or sparse growth of large trees, we are not altogether prepared to decide, and, therefore, avoid for the present, considerations which at best may be considered somewhat theoretical. Nor will we assume to decide, with confidence, upon the extent of the effects produced by the ravages of the annual fires which formerly swept over these tracts. It is but reasonable to conclude that all these, and perhaps other concomitant causes have operated together in producing the results we witness, while, according to peculiar circumstances, one of these several causes may have operated more or less powerfully than others.

Ancient Alluvion

As the consideration of that immense mass of materials to which has been applied the name of *diluviums* or *erratic block group*, was necessary, in order to a correct appreciation of those lesser deposits now to be considered, (which are asso-

ciated with, and in fact compose a part of the former,) that important group claimed our first attention. We come now to the consideration of a class of deposits which may be called *alluvial*.

Some interesting facts in relation to the assumption that the waters of the great lakes were formerly at a much higher level than at present, covering a large part of the border portions of the peninsula, were noticed in my report of last year. During the past season a continuation of the "ridge," which is supposed to coincide with the beach of the ancient lake, has been traced through Macomb into St. Clair county, and further facts, confirmatory of the positions assumed last year, were observed in other more northerly districts. In the county of Macomb this ridge has been much broken up by crossing streams, and is very irregular, showing frequently the existence of large entering bays and curvatures of the coast. This was the more particularly noticed from the fact that elsewhere, so far as observed, the course of the ridge is very remarkably continuous and well defined. In this county, also, a number of inferior ridges of evidently similar origin, were observed, between the main one and the present lake shore; leading to the supposition, that the subsidence of the waters did not take place gradually and constantly, but that sudden lapses occurred and the water line had been stationary at intervals.

The soil and detrital matter superficially covering that portion of the peninsula which is embraced between this ancient lake ridge and the present shores of the lakes, I have denominated *ancient alluvion*, to distinguish them as well from alluvions now in process of formation as from the immense mass of *diluviums* which overspread the whole interior of the State beyond this separating ridge.

The portion thus distinguished by alluvial deposits, embraces a broad belt of border country, varying in width from about 25 to 50 miles. It is, with small local exceptions, heavily timbered and very level. But, on passing the bound-

ing ridge, there is, in general, an almost immediate change to a soil of coarser character, and a more undulating surface. This ancient alluvion is a deposit, from a quiescent condition of the waters, and similar to that which is now taking place in the beds of the present lakes. It forms, in general, but a thin mantle to the underlying formations, consisting often of mere ridges of sand, and owing to the deprivation of its lime, has, in general, less fertility than the diluviums.

The heavily timbered district is not altogether coincident with the extent of this alluvion, but is dependent chiefly upon the following cause. Throughout their whole extent, the alluvions are underlaid by the tertiary clays. These are a formation anterior to both the diluviums and alluvions, and are frequently found extending far beyond the old lake ridge. The country thus underlaid, is that which is almost wholly clothed with a dense growth of timber. This formation will be found described under the head of tertiary clays.

Recent Alluvions

Under this head, I shall here allude only to local beds of marl, bog ores and peat.

Marl occurs in the greatest abundance, universally distributed throughout the diluvial district, and consists of local deposits, which originate solely from the lime so profusely contained in the diluviums. Such beds are in constant process of formation and increase, wherever that ingredient exists. As it is present in a much less degree in the ancient alluvion, no extensive beds are consequently found throughout the district occupied by the latter.

Bog iron ores are deposits, originating in a similar manner, from the iron contained in the soil, which is dissolved out by the rain waters and collects in low grounds.

Peat beds are exclusively of vegetable origin, and are common both to the alluvial and diluvial districts.

The character, abundance, and value of the marl, peat and

bog ore beds of our state, having been fully dwelt upon in the reports of last year, I shall make no further remarks upon their practical applications. I cannot avoid, nevertheless, once again directing the attention of the farmer of Michigan to the fact of the unexampled abundance in which the two former occur, conveniently distributed for universal use *as a manure*, and urging the use of them, as the cheapest, and in most cases, the best of mineral manures, and which will be found a very important means of improvement in his agricultural economy.

Organic Remains

Bones of the mastodon were last year discovered, in the ancient alluvion, in the western part of Macomb county. They were mostly so much decayed as not to bear exposure to the atmosphere, and a molar tooth only has been preserved. Similar relics were, several years ago, disinterred on the Paw Paw river in Berrien county. There is now in possession of a gentleman in this city, a vertebral bone of enormous size, said to have been found, many years ago, upon the St. Joseph river, and which is pronounced by the State zoologist, Dr. Sager, to be the caudal vertebra of a whale. It measures in vertical diameter, including spinous process, 18 inches; transverse diameter, including lateral processes, 2 feet; diameter of body, 11 inches; length of body, 10½ inches; length of spinous process, 9 inches. Its weight is 21 lbs., which is probably less than one half its original weight, as the bone is partially decayed.

TERTIARY CLAYS

These extensive deposits belong to an era subsequent to the removal of the upper coal bearing rocks. They cover all the border counties on the east and west slopes of the peninsula, and, in some instances, stretch far inland. These clays extend over more than two-thirds of that part of the state

which lies south of Saginaw, Maple and Grand rivers, embracing nearly the whole of the counties of Ottawa, Allegan, Van Buren, Berrien, Monroe, Wayne, Macomb, St. Clair, Sanilac, Huron, Tuscola, Saginaw, Lapeer, Clinton, and Eaton, and a large portion of Ingham, Genesee, Shiawassee, Ionia, Kent, St. Joseph, Branch, Hillsdale, and Lenawee. The remaining portions of the counties last named, and very nearly the whole of Oakland, Livingston, Washtenaw, Jackson, Calhoun, Kalamazoo, and Cass, are destitute of this sub-clay formation, and their diluviums rest immediately upon the rocks.

A dense growth of timber almost invariably accompanies this formation, whatever may be the immediate soil. We find this observation applicable to large portions of Eaton, Ingham, Clinton, Shiawassee, and Genesee counties, though these counties are based in part on the sandstone rocks of the coal series, and have sandy, diluvial soils, while the sandstone country south of them presents little else than oak openings and plains.

These clays are an extension of the same formation which covers the western and northern part of Ohio, and the east and north of Indiana, and which constitutes the soil of a large proportion of those districts.

The upper portion is a gravelly, yellowish clay, varying in thickness from one to fifteen feet, and having an average probably not exceeding 5 feet. Beneath this is a similar clay of a blue color, and which in some places has been found to exceed in thickness one hundred and twenty feet. Both clays contain at least 20 per cent., by weight, of carbonate of lime, and this marly character injures them materially for the manufacture of bricks or pottery.

On the western slope of the peninsula, the place of the yellow and blue clays is sometimes supplied by clay of a reddish color, of great thickness. No fossils have yet been discovered in any of the clays of this formation.

Coal Measures

The rocks which include the coal beds of our state occupy, comparatively, but a small portion of that part of the state under consideration, and are embraced within the counties of Jackson, Calhoun, Ingham, Eaton, Kent, Ionia, Clinton, Shiawassee and Genesee. They consist of strata of sandstone, shale, coal and limestone. Covered as these rocks are, with thick deposits of diluviums and clays, they make out crops at but few points, and the determination of their order and extent has been a matter of no small difficulty. From the dip of the rocks composing these measures, there can be little doubt that the coal basin extends northerly beyond the counties named, perhaps as far as to the head branches of the Tittabawassee and Maskego rivers. But that country is as yet almost wholly unsettled, and though partial explorations have been made through it, since the commencement of the geological surveys, the thick mass of overlying materials has hitherto prevented a determination of the northerly extent of these rocks.

Limestone Stratum

As this stratum, from its position, (being the lowest in the series,) determines the extent of the rocks considered as composing our coal basin, I shall, for the sake of greater precision, give to it the first consideration.

A gray limestone, in irregular, detached beds, is found along the extreme border of the coal bearing sandstones. They are evidently relics, in place, of a thin but extensive stratum, and as no coal has been found below this rock, I have assumed it as the terminating rock of the "coal measures" proper of our state. Following this rock, as it makes its occasional appearance, the southerly limits of the coal basin may be traced by a line drawn from the Shiawassee river, at Corunna, through the easterly parts of Ingham and Jackson,

between ranges one and two east to near Napoleon, in the latter county. It then turns westerly through town three south, ranges one and two west; from whence, taking a direction north-westerly, it pursues an irregular line, passing through Bellevue, in the south-west corner of Eaton county to Grand Rapids, in Kent county. Here the lime rock is more extended and a thickness has been determined to it of fourteen feet. The rock is characterized by the fossils *Nucula* and *Cyathophyllum vermiculare*. This stratum affords the only limestone for the kiln, or other purposes, except occasional bowlders, to be found in the interior of the state, and its value is the more to be appreciated as the formation is itself of very limited extent.

Lower Coal

But two continuous beds of workable coal are ascertained to exist in the state. The lowest of these lies at a small distance only above the limestone stratum, and is associated with a very thick bed of shale, which is also sufficiently bituminous to answer the purpose of an inferior coal.

Coal of Jackson County.—That portion of the lower coal bed which underlies a portion of this county, makes an outcrop in the valley of Sandstone creek, town of Spring Arbor, and has there been penetrated to the depth of three feet. The thick bed of shale opened at Jackson undoubtedly is associated with and belongs to this coal stratum.

Coal of Ingham County.—Passing down the easterly side of the basin the coal is again met with, in the north-east corner town of Ingham county, where it is embraced in a succession of shales and friable sandstone, cropping out in the banks and bed of the Red Cedar river. The coal has here been penetrated two and a half feet. But neither here nor in Jackson county is the entire thickness of the bed determined. "The coal at this point," as is observed in the report of Mr. Douglass, of last year, "is very accessible, and must, ere long, prove of great

importance. It is situated on a stream that may be made navigable for flat bottomed boats and perogues, with comparatively small expense, for a considerable portion of the year, and opening a direct communication with Lake Michigan."

It may here be observed, that the coal of this lower bed, universally, has more than usual compactness and purity, and is equal to the best bituminous coal of Pennsylvania.

Coal of Shiawassee County.—The coal again makes its appearance at the border of the basin, near the county seat of Shiawassee county, where it crops out between thick and extensive layers of sandstone, in the banks of the small creek entering Shiawassee river. The coal has here a thickness of from three and a half to four feet, and is accompanied by shale, the entire thickness of which is not ascertained. This coal is very eligibly situated for mining. It is of excellent quality, and the dip is so slight that but little depth of excavation will be required. This is the only locality in the state where coal, to much extent, has been raised for economical use. Both the coal and associated shale are constantly employed to great advantage at the steam mill of Mr. McArthur, in Corunna, as well as by neighboring smiths.

From an area of eight by nine feet Mr. McA. raised four hundred and sixty bushels of coal and shale, and he informs me it can be sold at the county seat for ten cents per bushel.

The underlying limerock stratum makes an out crop about a mile south-west from this point, in a bed of probably many acres in extent.

Shales of Flint River.—The coal bed and its accompanying shale may be traced still further east, to the Flint river, in Genesee county. Here the former probably has nearly thinned out, as only loose masses are found, in the bed of the river. The associated black shale and slate may be observed in the river banks, (town eight north, five west,) where it attains a thickness of sixteen feet, and is underlaid by the sandrock.

The coal of the Shiawassee and Flint rivers appears to

occupy the extreme edge of the coal basin, which here thins out into a wedge form, narrowing gradually until it terminates in a mere point, probably as far easterly as Lapeer county. The inclination of the strata is north-westerly, to an amount which would soon carry the coal beneath the surface; but appearances seem to warrant the conclusion, that at this point a large part of the rocks of the coal measures, continued north-erly, have been entirely removed.

Upper Coal

The outcrops of this coal, within that part of the state under consideration are of small extent. It is found at the surface on or near Grand river, in the northern part of Eaton county, and with its associated shales and sandstones, occupies the central part of the coal basin, probably including the whole of Clinton and Gratiot counties. Except in the extreme south-west corner of the former county it lies too deep for examination.

Most of this coal is inferior in quality and thickness to the lower coal. It composes several layers, not exceeding in thickness from one to two feet each, and is embraced in alternating strata of dark gray shales, blue clay, sandstones and thin beds of argillaceous iron ore, exceeding in the whole twenty feet.

Coal of Eaton County.—Sections of the alternating strata of coal and accompanying rocks, taken on Coal and Grindstone creeks, were given by Mr. Douglass in his report of last year.

As that report contained full local details of all of the coal-bearing rocks of Jackson, Ingham and Eaton counties, I shall here allude to the rocks of that portion of the state only in such a general manner as will be necessary in order to afford a comprehensive view of the extent and value of the coal measures of our state. By reference to the document alluded to, it will be seen that, though inferior in thickness to the lower coal bed, the several strata of coal exposed on the creeks above mentioned, have an aggregate thickness of from two to

three feet, and no doubt, prove of importance under a more settled condition of that portion of the state.

Included Sandstones of the Coal Measures

Gray and yellow Sandstones.—The sandrocks included between the upper and lower coal are mostly of a coarse, quartzose character, and of a light gray or yellow color. Most of the strata are friable, but harden on exposure. They are distinguished from the quartzose sandstone below the lower coal by containing impressions of the coal plants. These are referable chiefly to the genera *Lipidodendron*, *Stigmara* and *Calamities*.

These rocks are found outcropping at numerous points through the northern part of Jackson county, the western part of Ingham and eastern part of Eaton counties, and portions of Calhoun, Clinton, Shiawassee and Genesee. In all of the above named counties they occur in situations which admit of being economically quarried, and may often be obtained in firm blocks of any dimensions required. From this series of sandrocks was furnished the material for the construction of the State penitentiary at Jackson, and at several places, as at Napoleon, excellent grindstones are manufactured from it.

Red or variegated Sandstone.—This rock immediately underlies the upper coal and shales. Its outcropping edge is found in the valley of Grand river in the northern part of Eaton county, and in the banks of the Lookingglass river, in the adjoining towns of Clinton county, and in township seven north, six west, Ionia county. No fossil plants were discovered in this rock. It has been employed with advantage as a building material. The entire thickness of the included sandstones must be several hundred feet.

The following general section will exhibit, at one view, the relative order and thickness of all the rocks of our coal measures, above described, so far as a sub-division of them has been found practicable.

General Section, applicable to the coal basin of Michigan.

	Thick- ness.
	Feet.
Diluviums and tertiary clays.....	1 to 100
Brown or gray sandstone ⁵³	20
Argillaceous iron ore, in thin included beds ⁵³	1
Coal strata, alternating with friable slaty sandstone and thick beds of black shales and slate, ⁵³ in the whole probably....	30
Red or variegated sandstone, (Clinton and Ionia counties)...	
Light gray, coarse, quartzose, micaceous sandstones. Generally in thick layers and forming ledges, mostly friable and easily quarried. (Seen at intervals along Grand river from Jackson to Grindstone creek, Eaton county).....	Undetermined
Coal and black bituminous shale, (Jackson, Ingham, Shiawassee and Genesee).....	20
Blue, compact, slaty sandstone, (Shiawassee co.).....	
Gray limestone, found in local beds, being relics in place of a once continuous stratum. (Encircles the coal basin from Grand Rapids to Shiawassee river).....	14

The rocks in the above section embrace all those which are included in the division marked C, in the *geological section*, prefixed to this report.

SANDSTONES IMMEDIATELY BELOW THE COAL

These sandstones (marked D, in the plate,) as well as most of the formations below the coal, were fully described in my report of last year. I shall, therefore, now notice them only so far as to exhibit their relative position in the series, viewed as a whole, and the extent of country occupied by them.

These sandstones, which, in the report alluded to, are described under the name of *fossiliferous, ferruginous sand-*

⁵³Counties of Clinton and Eaton.

stones, excepting in some of the uppermost strata, are generally fine grained and of a yellow color. Some strata of the latter abound in marine fossil shells, among which the genus *Nucula* is very abundant, and there were observed species of *Atrypa*, *Bellerophon*, *Euomphalis*, and *Pterinea*.

Though here classed as beneath the coal rocks, these sandstones are associated with that series of rocks which are usually regarded as belonging to the carboniferous era. They occupy nearly the whole of Calhoun county, the lower half of Jackson, and the northern half of Hillsdale county; through which counties their outcrops may be observed at numerous points, or they are reached in almost all the deep wells. It is probable, also, that these rocks occupy most of the eastern portions of Jackson and Shiawassee counties, east of the limestone stratum above described; and they make their appearance, at its eastern edge, on Lake Huron, near the entrance of Saginaw bay.

The aggregate thickness of these sandstones may be estimated at upwards of 300 feet.

CLAY, CONTAINING KIDNEY ORE OF IRON

This very valuable formation immediately succeeds to the sandstones above described, underlying them and cropping out at the extreme southerly bend of the basin. It occupies a part of the south-western portion of Calhoun county, the whole north-eastern portion of Branch county, or nearly so, and part of the western and central portions of Hillsdale.

It consists of an indurated, grayish brown clay, having much the appearance of a shally limestone or dark gypsum regularly stratified, in which are imbedded nodular masses of kidney ironstone. This is a rich and valuable ore and occurs at several points conveniently for working.

This formation is the lowest that is discoverable in this portion of the state, and is not certainly known to make an outcrop elsewhere.

For further description of this clay and its contained ore, I refer you to the annual report of the State Geologist of 1840, and to my own appended thereto, for many practical considerations relative to the value of the ore and its imbedding clay. This formation is marked F, in the plate.

SANDSTONES OF POINT AUX BARQUES

These are mostly a coarse, greenish gray or rusty yellow rock, in some of the layers approaching a conglomerate. They form cliffs along the shore of Lake Huron in Huron county, rising at Point aux Barques to twenty feet. Fossils are rare, but *Atrypa* and *Calymene* were obtained. These sandstones occupy the coast north of town seventeen, being visible in ledges for about twenty miles. The upper portion of the series contains numerous, small imbedded pebbles of quartz, so as to resemble a conglomerate of puddingstone, but no great thickness is observable of rock possessing this character.

An extension of the outcropping edge of these sandstones, it is probable, gives rise to that swell of land which forms the summit level of the peninsula, stretching in a south-westerly direction from Point aux Barques to Hillsdale county, where the green and yellow fossiliferous sandstones, above described, overlie it. But throughout this whole extent no outcrop of the rock is visible owing to the thickness of the diluviums.

These sandrocks, taken in connection with the formation next described, hold a place in the geological series, corresponding to the "waverly sandstones," and "conglomerate," of Ohio, but the deposition seems to have been made under somewhat differing circumstances. No well defined series is apparent in our state answering fully to the Ohio conglomerate; though the upper portion of the sandstones of Point aux Barques approach that character.

The whole thickness of these sandstones probably exceeds 250 feet. This group is marked F, in the plate.

CLAY SLATES AND FLAGS OF LAKE HURON

Alternating with the lower portions of the sandstones of Pt. aux Barques, are strata of slaty sandstone, approaching the character of slate; to which succeeds a compact, micaceous clay slate of a blue color. This latter rock continues to occupy the coast for about thirty miles, or from township twelve to township eighteen north, and rises in ledges of from five to fifteen feet.

The slaty sandstones intervening between these clay slates and the overlying coarser sandstones are of a flaggy structure in some of the layers, and from these were obtained those fine flagging stones which have been extensively used for three years past for pavements in the city of Detroit. Some of these strata are distinguished by *ripple marks*. No fossils have been discovered in this formation.

These slates and alternating sandstones may be considered as the upper salt rock of our state. They have been passed through in boring for salt at Grand Rapids, and found to yield strong supplies of brine. At this point they are found also to alternate with beds of gypsum and gypseous marls, as will appear by reference to the table of the strata passed through, given on a subsequent page. The thickness ascertained to these slates, at that point, is about 170 feet.

SOFT, COARSE GRAINED SANDSTONE

A series of sandrocks answering to this description, and generally of a dark color, succeeds to the clay slates and shales last above described, and has been penetrated at the borings at Grand Rapids, 230 feet. There are, as yet, no data for ascertaining the entire thickness of this series, since it does not make its appearance at any point on the coast of the peninsula, this rock evidently forming the bed of Lake Huron near its foot, and lying too deep for observation. In relative position and perhaps in character, this rock, or a portion of the

series, corresponds with the lower salt rock of Ohio and Virginia, and is the rock from which, in these states, the strongest supplies of brine are obtained. The result of the borings in our own state, thus far, would seem to confirm the opinion that this rock is the equivalent of the lower salt rocks of those states.

BLACK, BITUMINOUS, ALUMINOUS SLATE

Underlying the sandstones above noticed, though, also, nowhere observed to make an outcrop within the portion of the state now under consideration, there is a well characterized black, bituminous slate. This rock makes an outcrop much further to the north, and is described by Mr. Douglass, in his accompanying report, to which I refer you. This slate contains much sulphuret of iron; it will burn readily, and in general character and position it agrees with the black shale stratum of Ohio and Indiana, but its thickness is probably not nearly so great.

LIMESTONES OF LAKE ERIE

This formation, which immediately underlies the black slate, is by far the most continuous and extensive rock formation in the western states. It is found outcropping in several district ranges throughout Monroe county, forms a considerable part of the lake coast and serves as a basis to the islands at the mouth of Detroit river, and is an extension of the rock formation which occupies the whole western part of Ohio and the northern and eastern portions of Indiana. It is found forming the bed of Lake Michigan at its head, and undoubtedly is the underlying rock of a considerable portion of the extreme south-western part of our state. The overlying tertiary clays conceal a great part of this formation.

The character and economical adaption of these limestones have been sufficiently set forth in former reports, to which, accordingly, I refer you for detailed information.

Among the fossils contained in the limerock, I distinguish the following genera: Calymenè and Asaphus, Cyathophyllum, Productus, Terebratula, Spirifer and Dethlyrus, Bellerophon, Atrypa, Strophomena, Orthocera, Ecerinus, Retepora and Madrepora.

In proceeding southerly from the outcrops of the slates of Lake Huron, a limerock is met with, which may be seen in the bed of a small stream near the lake coast, town nine north, sixteen east. In character and fossil contents it bears a resemblance to that of Monguagon, Monroe county, but its position would seem to indicate it rather as an included stratum in the series of sandrocks and shale, which are higher in the geological series.

The following general section will exhibit the order of succession and approximate thickness of the rocks above described, *lying below the coal basin*, and is a continuation of the table previously given of the successive rock formations of the settled portions of our peninsula:

General section, applicable to all the rocks below the coal beds of Michigan in that portion of the peninsula included in this report.

		Mean thickness in feet.
D.	Sandstones of Jackson, Calhoun and Hillsdale. { Coarse quartzose, grayish sandrocks, Fine grained, ash colored and dingy green, interstratified with slaty sandstone and clay shales, Yellow sandrocks, colored by iron, and abounding in fossils,.....	300
E.	Dark gray and blue indurated clay, containing kidney iron. (Counties of Hillsdale, Branch, and Calhoun.)	45
F.	Coarse sandstone, or partial conglomerate, Yellow and greenish sandstones, (coast of Lake Huron, at Point aux Barques.).....	250
G.	Slaty, argillaceous sandstone, alternating with sandstone and clay slates, Blue clay slates and flays, with alternating gypsum beds and gypseous marls, (Lake Huron coast, below Point aux Barques.).....	180
H.	Soft, coarse grained sandstones, (occupies bed of Lake Huron at its foot,) exceeds.....	230
I.	Black aluminous slate, containing pyrites, (coast of Lake Huron at Thunder bay.).....	
K.	Gray limerock, fossils abundant, (west end of Lake Erie.)	

The rocks in the above section embrace all those which are included in the divisions marked D, E, F, G, H, I, and K, in the GEOLOGICAL SECTION prefixed to this report.

DIP OF THE ROCKS

Great irregularities of dip are observable in all of our rocks, which circumstance has increased the difficulty of determining the precise relative position, extent, and thickness of the several strata. Many of the sandstones belonging to, and immediately underlying the coal, are much shattered, as if by

a quick vibratory motion, and a similar cause has occasioned contortions of dip in most of the still older rocks. I have, therefore, refrained from noting the amount and direction of dip at the various localities mentioned. All the rocks on the eastern slope of the peninsula, south of Saginaw bay have a general dip north-westerly, while the dip along the southerly and westerly border of the basin of the coal bearing rocks, is such as to indicate the counties of Clinton and Gratiot as occupying nearly the central part of the coal basin. This being the case, the carboniferous sandstones, with their included coal beds, may be considered as extending far to the north of the Saginaw and Grand rivers, possibly as far as town 23 north, or to the head waters of the Maskego and Tittabawassee rivers. This supposition, the character of that region, as well as the dip of the rocks would seem to warrant. But the country alluded to, is, at present, in an uninhabited condition; the surface, moreover, is very generally level, and so completely overspread by the deposits of diluviums and tertiary clays, as totally to conceal the rock formations. Surveys have, however, been extended into that region so far as was practicable with the means afforded, and much valuable information is collected.

If I am correct in the above conclusion, the coal bearing sandstones, or strictly speaking, the *coal basin* occupy an extent of surface, nearly oval in form, whose centre very nearly corresponds with the true centre of the peninsula. The tract thus embraced is 150 miles in length, north and south, and upwards of 100 in extreme breadth; covering an area of about 11,000 square miles, or one-fourth the entire area of the lower peninsula.

It may be added, that the average dip of all the rocks described, does not probably exceed 15 feet in the mile; though the dip may be said to vary, at different points, from 10 to 20 feet per mile.

BORINGS AT THE SALT WELL, GRAND RAPIDS

The borings for salt at the village of Grand Rapids, Kent county, commenced in the limerock stratum, mentioned above, [page reference omitted], as constituting the terminating rock of the coal basin. At this point, several of the next succeeding series of sandrocks appear to have thinned out, and their place is here occupied by alternating strata of clay slates and sandstones, with gypseous marls and beds of gypsum. These continued to a depth of 190 feet, and below this the borings have been carried mostly through series of sandrocks, to the depth of 415 feet.

Two beds of beautiful crystalized gypsum were passed through, at a depth of about 60 feet, and were found to be from 4 to 6 feet in thickness. This gypsum, it will be recollected, from the notice of it in former reports, appears at the surface at Gypsum creek, three miles distant; showing an inclination to the rocks, at this point, of about 20 feet in the mile.

By reference to a map of the state, it will be apparent that the strongest brine springs, (among which are included those in the vicinity of these borings,) make their appearance along a line which will be found to correspond with the "synclinal axis," or axis of the dip of the rocks composing the great peninsula basin; a circumstance which would be looked for, from the fact that the ordinary law of gravitation would conduct the strong brines to the lowest levels of the rock strata. While, therefore, the depth to which the boring must be carried, in order to reach the lower salt bearing strata, will be greater than would be the case in some other portions of the state, the comparative strength of the brine obtained may be expected to be proportionably increased.

Through the politeness of the Hon. Lucius Lyon, I am enabled to subjoin a section of the strata passed through at the boring above mentioned.

Diagram of strata passed through at salt well of Hon. L. Lyon,
Grand Rapids

		Thick- ness in feet	Total depth, feet
1	Hard gray limerock, irregularly stratified, and in portions cavernous.....	14	14
2	Yellow sandrock, producing fresh water.....	6	20
3	Blue clay.....	2	22
4	Coarse, reddish sandrock.....	5	27
5	Blue clay.....	3	30
6	Clay slate, with thin layers of gypsum interstratified.....	11	41
7	Clay slate.....	18	59
8	Gypsum.....	4	63
9	Clay slate.....	2	65
10	Gypsum.....	6	71
11	Clay slate.....	3	74
12	Bluish sandrock, very hard, with sharp grit.....	8	82
13	Bluish clay rock, intermixed with particles of reddish rock, compact. This rock is strongly impregnated with saline particles.....	18	100
14	Sand and clay rock, alternating.....	7	107
15	Carbonate of lime and gypsum, combined, very compact.....	10	117
16	Gypsum.....	7	124
17	Clay slate.....	9	133
18	Gray sandrock, of very sharp grit, and hard.....	5	138
19	Clay rock.....	2½	140½
20	Gypsum, with vein of salt water.....	6½	147
21	Clay rock.....	6	153
22	Gypsum and clay slate, or gypseous marls, alternating.....	19	172
23	Gypsum.....	3	175
24	Clay rock.....	3	178
25	Gypsum.....	1	179
26	Hard sandrock, producing fresh water.....	1½	180½
27	Clay rock, free from saline matter.....	10½	191
28	Hard sandrock, very compact and of dark color.....	7	198
29	Soft sandrock, nearly colorless.....	18	216
30	" " of dark blue color.....	32	248
31	Loose, coarse grained sandrock, of reddish color, opening a very copious spring of fresh water..	17	265

Below the strata last noted in the above table, the borings have continued through a further depth of 150 feet, but the data received are not sufficiently minute to enable me to extend the table. From the information obtained, they would seem

to have passed through mostly soft, light colored sandrocks of a coarse grain and with a sharp grit, and in the lower portions containing cavities into which the drill sometimes falls several inches. Particles of salt were brought up, and the rock yields a very strong brine.

All the strata, from the depth of 81 to 179 feet, or until the sandrock was reached, were strongly impregnated with saline particles, and yielded brine one-fifth saturated. These clay slates and marls may be regarded as the "upper salt rocks," and they are thus shown to furnish a brine superior in strength to that of many of the salt wells of Ohio, and which, even could no stronger brine be obtained, is capable of sustaining a profitable manufacture.

The brine now obtained, at a depth below the above of about 230 feet, may be supposed to proceed, by veins, from the "lower salt rock," lying at still greater depth, and from which the strongest and best supplies of brine in our State may be expected to be obtained.

The immense quantity of fresh or slightly brackish water which is discharged through the orifice, equal to a hogshead per minute, in the present state of the operations, renders it impossible to decide, with absolute certainty, what will be the full strength, as well as supply, of the strong brine; but from that which can be obtained, it is estimated, that of the brine which the well is now capable of furnishing, from fifty to sixty gallons only will be required to produce a bushel of salt. This, it will be seen, is equal in point of strength, to that obtained from the salt wells on the Kenawha river of the Ohio, where the borings are carried to about the same depth, and at which are manufactured annually, from one to two millions of bushels of salt. Next to those of the State of New York the Kenawha salt wells are considered the best in the Union.

In addition to the quality of the brine obtained, the advantages for the manufacture of salt at the point under consideration, are not exceeded at those places in our country where the manufacture is conducted to the largest extent. The sup-

ply of wood for fuel and other necessary purposes is abundant, and will tend greatly to reduce the price for which the manufacturers will be enabled to furnish this article. And, though the whole matter may be said to be still in an incipient state, there is every reason to feel satisfied with the prospect, which so fair a beginning holds out to the state, for obtaining a result so very desirable, as that of supplying her citizens with this important article from the product of her own manufacture.

SUMMARY

Comprising general observations on the economical results of the survey

From the view we have now taken of the rock strata which compose the lower half of the southern peninsula of Michigan, it will be seen, that the geology is of an exceedingly simple character, while it is, at the same time, richest in the mineral wealth most important to an agricultural community.

Michigan occupies a portion of the great valley of the Mississippi—the richest in the world—and which is wholly occupied by a broad extent of the rocks classed by geologists in the transition and secondary formations. Of these, the great limestone formation, (of which that of the west end of Lake Erie is a portion, and which concluded our view of the several geological groups which make up the organized portion of the state,) occupies the lowest place, and is the lowest and oldest of the rocks found on the lower peninsula of Michigan. The upper peninsula of our state, as will be seen by the report of the state geologist, is constituted of lower and still older rocks, and presents, in consequence, a very different aspect, as well as a different mineral character, from the lower peninsula.

The most important of the minerals usually associated with the rocks of those formations which compose lower, or Michi-

gan proper, are iron and lead ores, coal, salt, gypsum and marls. There are no indications which would warrant the supposition that *lead*, in any valuable quantity, exists on the lower peninsula. At least it may be positively assumed that no ores of lead will be found throughout any of the present organized counties of the state. All the other minerals mentioned, exist, and some of them, as has been shown, in great abundance. The results of the examinations into the economical geology of the state, as regards the most important of its minerals, I shall here briefly recapitulate.

IRON.—An ore of this mineral, under the form of kidney iron-stone, exists, chiefly in the counties of Branch and Hillsdale. It is sufficiently extensive to be of much value, and will give an average yield of about 30 per cent. of metal. This ore is embraced in the clay formation, of which an extended notice will be found in the geological report of 1840.

Iron, under the form of bog ores, is found in various parts of the state. The most extensive deposits, and those alone which it may be safe to assert will yield a rich profit, are at the county seat of Kalamazoo, near Concord, in Jackson county, in the county of Oakland, and perhaps Wayne. No furnaces, for the reduction of these ores, have yet been erected. It is shown, by the late census, that there are fifteen furnaces in the state for the casting of pig iron, requiring 614 tons, and the whole amount of iron imported, under various forms, is much greater. The cost of this importation, which in so heavy an article as iron, is very considerable, might and ought to be saved to the state, by a domestic manufacture from our own material. For more detailed observations, and an account of the localities in which this ore occurs, see geological report of 1840.

BITUMINOUS COAL will be found in abundance for all the wants of the state. The only locality where mining operations have been commenced is at Corunna, Shiawassee county, where this mineral has been already used to considerable extent, and, though in the midst of a heavily timbered country,

is for many purposes preferred to wood or other combustible. Other points also, eligibly situated for the mining of coal, have been made known in Ingham, Eaton and Jackson counties, and it may be fairly inferred, from the facts already determined of the range of coal bearing rocks, that outcrops of the coal beds will be found at numerous other points than those now known in these counties, and that coal will also be discovered in several counties where it is not now *known* to exist, as though parts of Kent, Ionia and Genesee counties.

SALT.—There no longer exists any doubt that this mineral may be obtained at a cheap rate and in any required quantity, for supplying the great and increasing demand in our state. The operations commenced at the state salt wells near Grand Rapids, Kent county, and on the Tittabawassee, Midland county, are not sufficiently advanced to determine the extent of the anticipated profit of the manufacture. The strongest brine obtained, up to this time, at the salt well of Mr. Lyon, at Grand Rapids, will, without doubt, prove as productive as that of the best wells of Ohio and Virginia. So that the present results may be considered as certainly indicative of the success that was formerly supposed would attend the boring for salt, if properly conducted, within our State.

Michigan *imports* salt probably to the amount of three hundred thousand dollars annually, which large amount of money might, as it soon will, be saved to the state, by the supplies furnished from her own resources. The average price of salt at the ports of entry, has been about three dollars per barrel for the last four years. But when the works now in progress shall have been brought into successful operation, supposing no stronger brine to be obtained than that above stated, the article of salt can be furnished at a much less price than it now costs the consumer.

GYPNUM.—An extensive deposit of this very valuable mineral occurs in the vicinity of Grand Rapids. The bed is here very extensive, is about six feet in thickness, and in quality is equal to the best gypsum of Nova Scotia. The

same mineral is found elsewhere in our state, but this is by far the most important locality at present known, and one that affords every facility for quarrying and distributing the mineral over the state. A mill was erected during the past summer, and the ground plaster, for manure, is already manufactured in considerable quantities.

Though the above locality is the only one known at which gypsum occurs, *in the interior* of our state, yet from the ascertained geological character and dip of our rocks, and the associations of this mineral it may be presumed that gypsum and its associated marls will be hereafter disclosed at other points in the vicinity of the above bed, and that it will be found also to occur at other localities, in the interior, which are concealed from present observation.

SHELL MARL occurs in the greatest abundance throughout the state, but more especially among the marshes and lakes of the openings. It forms deposits, varying in extent from one acre to one hundred, and these are pretty widely distributed. Its exceeding great value and cheapness, *as a manure*, is far from being truly appreciated by our citizens. But the time is rapidly approaching when this invaluable mineral will be no longer despised because it is abundant, simple and cheap, and our state will then find, in her numerous marl beds, one of the richest treasures of which she is possessed. For a full account of the nature and uses of this mineral, the reader is referred to page 94 of the report of 1840, and to previous reports.

The character, applications and value of the rocks with which the above mentioned minerals are associated, together with other matters of practical interest, connected with the geological structure of our state, are so fully detailed in the preceding pages and in previous reports, that further allusion to them, in this place, is deemed unnecessary.

From the foregoing facts, it cannot fail to be seen that, while the soils of our state are admirably adapted to the various purposes of agriculture, and for the production of wheat—the most important product of the soil—superior to

those of any known portion of the Union, Michigan possesses, also, within herself, all the mineral treasures that are really requisite for sustaining and renovating her soil, for supplying the wants of her homesteads, and for maintaining those branches of domestic industry which are of the most importance to her people. Thus science discloses those treasures, buried in the earth, which art and industry may appropriate to increase the profits of labor. And though the objects of science are general in their nature, and not confined by the limits of districts or states, the legislator feels a peculiar interest in having those resources developed by its aid, which may be turned to the advantage of his rising commonwealth; commerce, agriculture and the arts receive a stimulus by the new sources of wealth and supply which it opens to the wants of each. In this view, the study of geology becomes one of the most universally useful that can occupy the attention of practical men.

In comparing the extent of our resources thus obtained, with the little that was known concerning them a few years ago, we have reason to feel satisfied with the prospect of future wealth and importance, which it has opened to us. If during the stirring times of an early settlement, so rapid as has been that of our state, for the past five years, less interest was excited by the development of our mineral resources than their importance might demand, a satisfactory cause may be found in the imperfect state of the knowledge hitherto obtained, and in the pressure of the more immediate wants of a new, somewhat fluctuating and unsettled community. During the period mentioned, however, the population of southern Michigan has advanced from a less number, probably than 60,000 to 212,000, a rate of increase unexampled even in the annals of a series of settlements, to the progress of which the world affords no parallel. Meanwhile the liberal course of our state policy has been steadily unfolding her resources, and, at this moment, notwithstanding the burden of a heavy debt, and the accumulated pressure of more widely felt finan-