STATE OF MICHIGAN.
No. 27.
House of Representatives,

February 1, 1841.

Annual Report of the State Geologist.

OFFICE OF STATE GEOLOGIST,
Detroit, Michigan, February 1, 1841.

To the Hon. Speaker of the House of Representatives:

SIR—I have the honor, herewith, to transmit the fourth annual report, and accompanying documents, from this department

I am, dear sir, very respectfully,
Your obedient servant,
DOUGLASS HOUGHTON,
State Geologist.

REPORT.

OFFICE OF STATE GEOLOGIST,
Detroit, February 1, 1841.

To the Hon. the Speaker of the House of Representatives of the State of Michigan:

In conformity with instructions contained in the act authorizing a geological survey of the state, I have the honor to lay before you, an outline of the operations of the department over which I have been placed, together with the general progress towards completion, of the whole work.

It is a matter of regret to me, that the sufferings and hardships to which I have been exposed in conducting the field work over the wilderness portions of our state, have so far impaired my health, as to render it impossible for me to enter into so minute details as had been anticipated. I regret this the more, since it leaves many wide spaces in portions of the present report, which are of much consequence to a proper understanding of the whole. But since the annual reports are intended to refer rather to the progress of the work than to its results, and since the whole will be embraced in a more perfect form hereafter, this defect is of less importance than it otherwise would be.

My individual labors, during the past season, have been chiefly devoted to surveys connected with the northern slope of the upper peninsula, and to this district, the chief observations in this report, will be directed.

UPPER OR NORTHERN PENINSULA.

General description and Topographical features.

The published maps of that portion of the state of Michigan usually known as the Upper Peninsula, are so defective, not only in details, but also in general outline, that the task of giving a description of any portion, in such a manner as to render it intelligible to any person who has not actually traveled over it, is exceedingly difficult. The extent of these geographical inaccuracies is much greater than would at first be supposed, for scarcely a single feature of the interior is given as it actually exists; mere brooks are magnified to rivers, and again, those streams justly deserving the name of rivers, are either wholly omitted or scarcely noted, while the courses of the streams, as laid down, are almost invariably as far from the truth as could be conceived. Nor do the inaccuracies stop here, for even the coast maps of the great lakes, by which our upper peninsula is in part surrounded, are usually so defective as scarcely to be recognized, except in their most general outlines.*

I have already, in a previous report, referred in general terms, to that portion of the upper peninsula bounded by lakes Huron and Michigan, for which reason my remarks at this time will be mostly confined to the northerly portion of the peninsula, or that portion bordering upon Lake Superior.

So little is known of the extent of country constituting the upper peninsula, that it may not be misplaced to make some reference to its dimensions, though at this time most of the estimates must be regarded as mere approximations. The most extreme length of the district is embraced between Point de Tour, of Lake Huron, on the east, and the mouth of Montreal river, of Lake Superior, on the west. From Point de Tour, the direction of the mouth of Montreal river is very nearly north, 80° 30' west, and the direct distance does not vary far from 316 miles. This estimate, it will be perceived, does not include Drummond's Island, which, if included, would add some 20 miles to the length as already given.

*I am happy in being able to except from this otherwise universal charge of inaccuracy, the coast map of Lake Superior published by the Society for the diffusion of useful knowledge. This map was reduced from the surveys of Capt. Bayfield, R. N., as returned to the British admiralty office, and so far as the British coast is concerned, the map is minutely correct. The American coast upon tins map is faithfully delineated in its general outline, but in minutiae it is frequently deficient.

The easterly portion of the peninsula is narrow, and its width, for a distance of 130 miles west from Point de Tour, varies from 30 to 50 miles; west from this, the peninsula widens rapidly, though its width is exceedingly irregular. I am unable, at this time, to state with very much accuracy, the extreme width of the upper peninsula, but the area of the whole may be estimated at very nearly two-thirds that of the lower, or southern peninsula.

The topography and general features of the upper and lower peninsulas differ so widely from each other, that, with the simple exception of a part of the easterly extremity of the upper peninsula, they scarcely admit of a comparison. The wide contrast exhibited by the two districts, is wholly dependent upon geological differences, and these are so strongly marked, that they could not fail to attract the notice of the most superficial observer.

In the last report I had the honor to lay before you, some general references were made to the topography of the southern slope of the upper peninsula, which embraced simply those portions bordering upon lakes Huron and Michigan, and extending from Point de Tour to Monominee river.

Although the rocks of the district extending from Point de Tour to Chocolate river, upon the northerly or Lake Superior slope, belong to an older series than those lying south, and are different in composition, the general features of the two districts, nevertheless, bear a close resemblance. Easterly from Point Iroquois, the country is for the most part flat, or but slightly elevated, and the near approach of the rock to the surface so far prevents the descent of the waters, as to give rise to extensive districts of wet and swaly land. Westerly from Point Iroquois to Chocolate river, the country is more elevated, and has a much smaller proportion of wet land. A range of hills, having an elevation varying from 300 to 600 feet above Lake Superior, commences a little easterly from Point Iroquois, and stretches very nearly west, or but a few degrees north of west, until the western escapement again appears upon the coast, giving rise to the elevated hills of which the Pictured rocks and Grand island form a part. The outline of this range of hills has the most perfect regularity, being unbroken and uniformly covered with a dense growth of timber.

West from Chocolate river, to our boundary line at Montreal river, the physical character of the country is widely different from that of the district before referred to. This country is made up of a series of irregular, knobby ranges of hills, that have a general easterly and westerly direction, with intervening valleys of flat or gently rolling land. These hills not unfrequently rise to a height of from 600 to 900 feet, very near to the immediate coast of Lake Superior, and at a distance of 15 to 20 miles south from the coast, portions of some of the ranges rise to a height of 1,200 to 1,300 feet above the level of that lake. The ragged and broken outline which this district presents, when viewed in detail, from the lake, contrasts in a striking manner, with, that of the country lying east from Chocolate river; for, instead of the regular and unbroken range of hills, uniformly covered with a dense forest, that occur in the latter district, we have a series of ranges of broken hills, with knobs not unfrequently nearly or quite destitute of timber. The escapements of these hills are sometimes so abrupt as to render them difficult of ascent.

The only exception to the general easterly and westerly direction of these ranges of hills, occurs in that range constituting the Porcupine mountains. These mountains rise somewhat abruptly almost upon the immediate coast of Lake Superior, at a point 37 miles north-easterly from the mouth of Montreal river, and from this point they stretch inland, in a direction which, for the first 30 miles, is very nearly south-south-west, after which their course is more westerly, and in the direction of the sources of the Wisconsin river. The most elevated points of the Porcupine mountains, near to Lake Superior, attain an altitude of very nearly 950 feet, but several of the knobs, at a distance inland, rise from 1,100 to 1,300 feet above the level of the waters of that lake.

The valleys, before referred to as separating these ranges of hills, are uniformly heavily timbered, and by far the largest proportion of this timber is beech and maple.

The length of the hilly or mountainous district, estimating in a direct line west from Chocolate river to the boundary line on Montreal river, is very nearly one hundred and sixty miles, and it does not probably extend, at any point, more than 20 to 25 miles south from this line. Estimating this hilly district to extend regularly 20 miles south of a line drawn from the points before mentioned, the greatest width of the district would be opposite Keweenaw point, which extends 67 miles north from this line, making the total width at this point 87 geographical miles. The very great irregularities of the coast, with the numerous deep bays and projecting points upon the north, together with the irregularities of the ranges of hills upon the south, cause so great variations in the width of the district, that it is impossible, with the present information upon this subject, to estimate the width of the district with any great degree of accuracy, Keweenaw bay, of Lake Superior, stretches 60 miles, estimating from the extremity of Keweenaw point, into this hilly or mountainous country.

South from the range of hilly country alluded to, and extending to Green bay, the country at first becomes more level and finally flat, though with several regular and unbroken ranges of hills. In topography and general character, it more nearly resembles that district of country which lies east from Chocolate river.

Of the district of country lying between the hilly country and Green bay, less is known than of any other portion of the upper peninsula. The extent of my duties did not permit me to extend my examinations very far into it, nor was I enabled to obtain any information as to its general character.

The streams which discharge their waters into Lake Superior upon its south shore, are invariably short, and with very few exceptions, the quantity of water they discharge is small. This remark, in fact, may apply to the whole of the region of country surrounding that lake, for this immense body of water is completely surrounded by hills that, at no great distance from the lake, fall away more or less rapidly. Thus, while many of the streams discharging their waters into Lake Michigan, Green bay and the Mississippi river, have their sources near to the south shore of Lake Superior, so also, many of those

streams which discharge their waters northerly into Hudson's bay, have their sources near to the north coast of the lake. The near approach of the summit of the ranges of hills surrounding the lake, to the immediate coast, leaves the area of country draining into Lake Superior, comparatively small.

The most important of the streams entering Lake Superior upon its south shore and within the limits of our state, (commencing near the foot of the lake and enumerating westwardly,) are the Tequoimenon, Train, Chocolate, Death, Yellow dog, Huron, Portage, Fire Steel, Ontonagon, Iron, Presque Isle, Black and Montreal rivers. Besides these, there are innumerable creeks, which are usually known to voyageurs as rivers, for this term is applied indiscriminately to all. The waters of most of these streams are remarkably transparent and pure, with brisk currents and numerous cascades, and they almost invariably contain an abundance of the brook trout, a circumstance which I mention, from the fact that this fish is scarcely known in the streams of the southern peninsula.

The Tequoimenon river, which is the only stream east from Chocolate river, that in reality breaks through the range of sandstone hills, before mentioned as extending westerly from Point Iroquois, has its embouchure about 18 miles south from White Fish point, and near the foot of the lake. The discharge is through loose sands, and there is an average of 4 to 4½ feet water over the bar. Having passed the bar, the water for a distance of 7 to 8 miles varies from 10 to 15 feet in depth.

Some of the sources of this stream approach very nearly to Lake Michigan, being directly at the base of the range of lime rock hills, referred to in my third annual report.

The Tequoimenon river, with the exception of a distance of some 4 to 5 miles, while passing through the range of sandstone hills before alluded to, is, through its whole course, a sluggish stream, though at many points having a strong, deep current. The character of the river, in its passage through the range of hills referred to, is totally changed, for it has there numerous chutes and falls, with almost continuous rapids. At one point, the whole body of water contained in the stream is precipitated by a single leap, from a height of 46 feet, and the effect of this fall is much heightened by the elevated and overhanging rocks that bound the river upon either side.

Most of the small streams, discharging into Lake Superior between the foot of the lake and Chocolate river, have their sources to the north of the elevated range of hills mentioned, or minor branches only descend from those hills.

Chocolate river, which discharges its waters into Lake Superior at a point 146 miles very nearly due west from the Saut de Ste Marie, is a stream of considerable magnitude, though in consequence of the loose sands at its mouth, it is difficult of entrance at ordinary stages of water, even with barges of moderate draught, but when once the bar is passed, the stream is found to be deep, and for several miles has a width varying from 80 to 150 feet.

This stream will be made a point of reference in the strictly geological portions of this report, for it winds along near the line of junction of two widely distinct geological districts; the general features of one being characterized by its ragged and broken hills, while the other is not less marked by its generally level or regularly undulating surface.

Chocolate river takes its name from the dark color of its waters.

Those streams which occur between Chocolate river and Keweenaw bay, are, with the exception of Huron river, small; though were we to refer to the published maps of this district, we would suppose that some of these streams were of very considerable length. But with the exception of Huron river and River Des Morts, I believe they all have their sources, in small lakes lying along the bases of the elevated hills already described. These hills rarely recede farther than three to five miles from the coast, and the length of the streams, forming the outlets of the lakes referred to, is governed wholly by these features.

Ontonagon river, which is one of the most important of the rivers discharging its waters into Lake Superior, upon its south shore, has its embouchure very nearly fifty-five miles east, or rather north-easterly, from the western boundary of the state, at the mouth of Montreal river. Ontonagon river has its sources in a very great number of mountain lakes, situated in part upon the south-easterly spurs of the Porcupine mountains, and in port in the hilly district formed by the easterly and westerly ranges of hills before described; which ranges, upon this portion of the coast, curve very considerably to the south. Some of the sources of the Ontonagon river approach very near to the sources of the Chippewa river of the Mississippi. The great number of small tributaries of the Ontonagon, which are simply the outlets of the small lakes referred to, are concentrated into two principally branches that finally unite and form the principal river, at a distance of about eighteen miles from the coast of Lake Superior. The smaller tributaries are mostly mere torrents, with frequent perpendicular falls, and high banks, sometimes, of precipitous rock. The main stream, from the junction of the two principal branches to within five or six miles of the lake, is rapid and shoal, but below this, the stream is comparatively still, and with a good depth of water. The mouth of the Ontonagon river is obstructed by a bar of sand, over which there is usually, at low stages, about six feet of water.

The principal rivers west from Ontonagon river and within the limits of our state, have already been stated to be Iron, Presque Isle, Black and Montreal rivers. These streams are all short, and the amount of water discharged by each separately is comparatively small. Their waters descend from the elevated mountain region immediately south from the coast, and since the whole

streams are concentrated before passing from these elevations, their waters are discharged in body and they descend with very great rapidity. A greater variety of grand and beautiful scenery than that presented by some of these streams in their descent to the lake, taken in connexion with the rugged and wild character of the country, can scarcely be conceived. I was particularly struck with the great variety of picturesque views furnished by Black rive, in its descent from the elevated country on the west side of the Porcupine mountains to Lake Superior. The stream was estimated to fall about five hundred feet in a fraction over four miles, and this descent is made up by a constant succession of falls, chutes and rapids, which continue with so little interruption that the waters for the whole distance may be said to be constantly white foam. The stream is bounded upon either side by banks elevated from one hundred to three hundred feet sometimes sloping away from the stream, somewhat gently, and again rising in mural precipices of rock, separated from each other by so short distances as to appear scarcely sufficient to permit the passage of the waters of the river. The most considerable fall does not exceed fifty feet, and they are usually from ten to thirty feet in height, but their constant succession and variety, add much to its interest.

Montreal river is a comparatively small stream, made up of numerous small tributaries, that rise among the ranges of hills to the south-west and south-east of its mouth. The passage of the river through the range of hills near the lake, gives rise to several very considerable water-falls, as also to much ragged and wild scenery. Almost directly at the place of embouchure into Lake Superior, there is a perpendicular fall of about 40 feet. This stream, it will be recollected, forms a portion of the boundary between Michigan and Wisconsin.

By the act admitting Michigan as a state into the confederacy, and in which her boundaries are defined, it does not appear to have been the intention to include within her limits any portion of territory lying upon the north shore of Lake Superior, but in consequence of the peculiar shape of the coast at that point where the *national* boundary line "last touches Lake Superior," at the mouth of Pigeon river, a direct line to the mouth of the Montreal river, if followed literally, would throw within the state of Michigan several small rocky islands, together with a few miles of the south cape of Pigeon bay, situate upon the north coast. This boundary leaves in Wisconsin the whole of the Apostles' group of islands, near to the south coast, while it includes within Michigan, Isle Royale, situate near to the north coast of the lake.

Isle Royale is little less than an island of rock, rising abruptly from the lowest depth of the lake, in irregular hills, to a height varying from 100 to 450 feet above the level of the lake. The island has a length of a fraction over 45 miles from north-east to south-west, and a breadth varying from 3½ to 8 miles. The most northerly point of the island is very nearly in latitude 48° 12' 30" north, and the parallel of longitude 89° west from Greenwich, crosses the island a little east from its centre. Its nearest approach to the main land is near its north-westerly end, where it is separated from a point of the north coast, a few miles east from Pigeon river, by a distance of a fraction less than 13 miles. Isle Royale is separated from Keweenaw point, of the south coast, by a distance of 44 miles, and the elevated hills of this point may be distinctly seen from Isle Royale, when the atmosphere is clear.

Nearly the whole of the north-westerly side of Isle Royale is a continuous, elevated, rocky cliff, which will scarcely admit of a landing, but the south-easterly side, together with the easterly and westerly ends, are deeply indented with bays, which form secure harbors. The north-easterly end is made up of a series of elevated, rocky spits, with intervening bays. These spits of rock continue for a length varying from 10 to 12 miles, with a width scarcely exceeding half a mile, and altogether, they may not inaptly be compared to the hand with the fingers half spread. The bays have a sufficient depth of water to admit vessels of the largest class to enter nearly one third the whole length of the island.

Much of Isle Royale is absolutely destitute of soil, and the island has a most desolate appearance; but notwithstanding this, it is of immense value for its fisheries, which are as yet scarcely appreciated.

Though not within the limits of our state, I will briefly refer to the general character of a portion of the country west from Pigeon river, on the north coast. That district of country upon the immediate coast, extending from our national boundary, at Pigeon river, to Fond du Lac, is more decidedly and abruptly mountainous than any portion of the south coast of the lake. The hills rise in broad and somewhat knobby steppes or plateaus, to heights varying from 400 to 1,200 feet above the lake, and the summits of these hills are usually not farther inland than from 10 to 20 miles. The rocks of the hills are very frequently bare over considerable areas, and the valleys containing arable soil, are few and very narrow.

The route of the fur trade to the north-west, via Rainy lakes, Lake of the Woods, and Lake Winnepic, was formerly wholly carried on by passing over these hills, from a point a few miles west from the mouth of Pigeon river. The trail or portage path passes over a low portion of the range, and finally falls upon Pigeon river, which is ascended to its source, from which, by a series of portages, the sources of the streams flowing north-westerly are reached. The hilly portion of the country, though of exceeding interest in a geological point of view, is the most desolate that could be conceived.

GENERAL GEOLOGY OF THE UPPER PENINSULA.

The geology of the upper or northern peninsula of Michigan, when compared with that of the southern or lower peninsula, bears a striking contrast; for while that of the district last referred to is uniformly regular, with

rocks which, though rarely exposed to view, are few and for the most part but little disturbed, over large areas of country, the upper peninsula embraces a much greater number of rocks, distributed over a somewhat smaller district of country, and a portion of which are so much disturbed, as to render their delineation exceedingly complex and difficult.

The widely different topographical features of the easterly and westerly portions of the northerly part of the upper peninsula would lead the most casual observer to infer that the geological features of the different districts would be equally distinct, and in this he would not be disappointed.

I have already referred to the rugged and broken character of the country, extending westerly from Chocolate river to our boundary at Montreal river, and have also attempted to define its general length and breadth. This district, which is essentially made up of primary, trap and metamorphic rocks, with intervening sedimentary rocks, usually occupying the valleys and out boundaries, may be estimated to cover an area equal to a little more than one-fourth of the whole of the upper peninsula. To the east and south of this district the rocks are wholly sedimentary, consisting of a series of sandstones, limestones and shales.

With a view of rendering the local details of the separate formations more intelligible, I will first describe, in general terms, the rocks occurring in so much of the peninsula as has been examined, together with their general extent. This will necessarily involve a repetition of a very small portion of the report last made, upon the subject of the limestones of the south and east portions of the peninsula, but since the examinations of the past year have enabled me to add another member to the limestone group, and to define with more certainty its outline, this may not be devoid of interest.

1. *Primary Rocks*.—The rocks constituting what may be considered as the true primary group of this region, are chiefly granite, syenite and syenitic granites. The members of the group are first seen upon the south coast of Lake Superior, constituting a rocky point known as Little Presque isle, a little south-east from Riv. Des Morts. These rocks frequently appear upon the coast north-westerly, nearly as far as Huron river, and the Huron islands off the mouth of Huron river belong to the same group. West from Huron islands, no rock appears upon the coast which, in a strict sense, I should regard as primary. The rocks of this group rise upon or near to the coast, in irregular and broken ranges of hills, to a height varying from 300 to 700 feet above the waters of the lake, and these hills or ranges of hills are continued in a south-westerly direction. The precise limit of the primary rocks to the westward, has not yet been determined, but they are known to extend nearly or quite to the sources of the Wisconsin river.

A portion of the south-westerly prolongation of the Porcupine mountain range, is made up of rocks belonging to the primary group, but is precise limit here has not yet been determined.

2. *Trap Rocks*.—Flanking the primary rocks already described on the north and north-west, are a series of ranges of hills, stretching in a direction generally south-westerly and north-easterly, which attain an altitude of from three to nine hundred feet above the lake. They are more regular, or rather less broken in outline than the primary hills; a change, how ever, which in the transition is noticed to take place gradually, from one group to the other or in other words, the knobbed character of the ranges becomes less and less apparent as we cross them in a north-westerly direction, or from the primary range. These hills are composed of rocks differing at first but slightly from those of the primary group, but gradually the difference becomes more and more apparent, as we proceed northerly. The rocks of those hills nearest the primary range may possibly be regarded simply as rocks of that group, more or less altered, though the rocks of the outer ranges are plainly trap. The range of these rocks which may be said to commence at the very extremity of Keweenaw point, extends, after a slight curve to the north, in a general south-westerly direction, gradually receding from the coast, until at the crossing of the Ontonagon river, it is nearly 25 miles inland. Westerly from Ontonagon river, the range becomes confounded with the northerly portions of the Porcupine mountains; while west from these mountains, a portion of what may be considered the same range of rock, has taken a more westerly course and approaches the coast, until, at the crossing of the Montreal river, it is but a few miles distant from Lake Superior. West from the Porcupine mountains, a second range of trap is continued at a distance of from fifteen to twenty miles inland. The trap range of Keweenaw point may be estimated to compose one third the entire width of the point, and the southeasterly portions of the range are made up of compact green-stone, while those portions to the north-west are amygdaloid.

The ranges of hills constituting the north-westerly part of Isle Royale, and extending its whole length, are of similar rocks, and single knobs of well defined trap rock occasionally occur, in the very midst of the primary region before referred to, upon the south coast; the proofs of the character of which will be shown as we advance.

3. *Metamorphic Rocks*.—Flanking the primary rocks on the south, is a series of stratified rocks consisting of talcose, mica and clay slates, slaty hornblende rock, and quartz rock; the latter rock constituting by far the largest proportion of the whole group. In traversing the country south-easterly from Little Presque Isle, the point referred to as the most southeasterly prolongation of the granite, this last rock passes almost insensibly into a serpentine rock, which has a regular jointed structure, sometimes approaching to stratification; continuing in the same direction, we find a series of hornblende slates, talcose, mica and clay slates, resting against the serpentine

rocks, and still farther to the south-east the rock becomes almost uniformly quartz. The rocks of this group dip irregularly to the south and south-east, while the cleavage of the slates is very uniformly to the north.

The rocks of the metamorphic group stretch into the interior, in a westerly or rather south-westerly direction, forming the south-easterly part of the hilly region.

Rocks referable to this group also occur upon the north coast of Lake Superior.

4. *Conglomerate*.—The rock to which I shall restrict this term, does not occur, well characterized, at any point east from the district referred to, as the commencement of the trap group, nor has it been noticed resting upon any of either the primary or metamorphic rocks, but is invariably seen resting upon the trap rocks. Commencing upon the north side of the trap, at the extremity of Keweenaw point, the conglomerate flanks the trap upon its northerly side, as far west as the boundary of our state; nor does it stop here, for the same rock is seen at intervals, as far west as the head of Lake Superior. A similar rock also rests upon the trap of Isle Royale, facing the south-east.

In the course of the range of conglomerate upon the south shore, it forms a nearly continuous range of hills, with somewhat steep escapements, but with a generally rounded outline. These hills sometimes rise to a height of from three to five hundred feet above the level of the lake.

The conglomerate attains a very great thickness, being greatest at its westerly prolongation, and it gradually thins out as we proceed north-easterly; but the irregularity in thickness is so very considerable that variations of several hundred feet are not uncommon within the space of a few miles.

The conglomerate rock of the south coast, dips in mass irregularly to the north and north-west, while that of Isle Royal dips to the south-east.

5. *Mixed Conglomerate and Sandstone*.—The rock or rocks to which I have affixed the above name consists of an alternating series of course conglomerates and red sandstones, resting conformably upon the conglomerate rock before described. In strictness, these rocks should probably be considered as a member of the conglomerate itself, but for the sake of convenience in description, I have deemed it desirable to separate them.

The mixed rock was only noticed, as before stated, resting upon the conglomerate, and this only between Point Keweenaw and Montreal river. Its thickness immediately west from and upon the flanks of the Porcupine mountains, is very considerable, but it wedges out rapidly both easterly and westerly, and on the east, near the extremity of Keweenaw point, it wholly disappears.

The mixed rock dips regularly to the north and north-west.

6. *Lower, or Red Sandstone and Shales*.—The red sandstone, with its accompanying red and gray shales, occupies a much larger extent of the country bordering upon Lake Superior than any other single rock or group of rocks. It rests upon the primary and metamorphic rocks, immediately west from Chocolate river; upon the conglomerate and mixed rocks from near Eagle river, of Keweenaw point, west to the head of Lake Superior; upon the primary trap, metamorphic and conglomerate rocks of the north shore of the lake, and upon the conglomerate rock of Isle Royale. It is this rock which forms the basis of the level plateaus or valleys, occupying the spaces between the several ranges of hills south from Lake Superior, and west from Chocolate river. In these last situations this rock is frequently seen undisturbed to surround the bases of isolated knobs of granite, though when near to or in contact with knobs or trap, there are invariable evidences of very great disturbance.

The rocks of this group attain their greatest thickness at their westerly prolongation, gradually thinning out as we proceed easterly.

With the exception of that portion of the coast extending from Point Iroquois, at the foot of the lake, to Grand Island, the predominating rock upon the immediate coast, both on the south and north shore, is this red sandstone; for even the primary trap and conglomerate rocks are almost invariably skirted with a band of it. It is also over this rock that the waters of Lake Superior are discharged at the Saut de Ste Marie.

The sandrock forms the chief portion of the group, the shales occurring rather as beds than otherwise, as will be hereafter described.

The red sandstone both upon the north and south shores of Lake Superior, invariably dips into the basin of that lake, which may therefore be regarded as a synclinal axis.

7. *Upper or Gray Sandstone*.—Upon the south shore of Lake Superior, and extending from Point Iroquois to Grand Island, a sandstone occurs, differing widely in its appearance from that before described. This sandstone rests *unconformably* upon the red sandstone, the former dipping gently to the south or south-east, while the latter dips very considerably to the north or north-west.

The elevated range of hills before described, as commencing a little easterly from Point Iroquois and extending to the Pictured rocks, are composed of this rock. From the Pictured rocks, the range of hills curves more to the south, stretching very far to the south-west, but its precise limit is not yet determined.

In its easterly prolongation the grey sandstone thins out rapidly. It is last seen at the Neebesh rapids of the Riviere Ste Marie, on the east, at which point, in consequence of not having been sufficiently examined farther westerly, it was confounded with the red sandrock in the last report which I had the honor to lay before you.

8. *Sandy Lime Rock*.*—Resting immediately upon this upper or grey sandstone is a sandy limerock, which, although nearly wanting at the very easterly extremity of the peninsula, as we proceed westerly, occupies a more important place. This rock, which, as its name implies, is intermediate between a sandstone and limerock, may be seen on Sailor's encampment island of the Riviere Ste Marie, as also at several points in the vicinity of Monusco bay, from whence it stretches westerly, occupying nearly the central portion of the peninsula, for a distance of at least sixty miles; from which its precise range and limit has not yet been determined. The outcropping edge of this rock appears at a level very considerably below that both of the sandstone to the north, and of the limestones to the south. Its width, for the distance mentioned, varies from ten to fifteen miles, and it dips uniformly to the south-south-east. The sandy limerock has not yet been examined with sufficient care to admit of accurate description. It contains but few fossils, but those few are sufficiently characteristic, were there no other considerations, to separate it from the lower limerocks and shales.

Upon the sandy limerock, to which reference is above made, rests the lower limerock and shales, and upon this last the upper limerock, both uniformly dipping to the south or south-east. These limerocks were described in general terms, in my third annual report, and although many additional facts have been gathered respecting their character, range and extent, it is, perhaps, unnecessary to lay them before you at this time. I will barely add, with respect to them, that the suggestion there

*The names which have been affixed to the several sand and lime rocks are regarded as merely temporary, and are introduced, for the present, barely to facilitate description.

mentioned, that a more careful examination of these limestones would render a farther division of the groups necessary, has been fully confirmed.

I had hoped to lay before you a profile section of the rocks of the upper peninsula, but the impossibility of having it engraved in time to accompany this report, has led me to defer it. I regret this the more, since many of the facts connected with a full understanding of the economical portion of this report, are so intimately dependent upon the general geology of the country, that, in the absence of correct maps, and without a profile section of the rocks, I fear it will be impossible for me to render the most important portion, so far as regards the prosperity of the state, intelligible.

As it is, I can only, in the place of this, lay before you a general section of the rocks of the upper peninsula, together with their thickness, so far as the same has been satisfactorily determined. This section is intended simply to represent the order in which the several rocks rest upon each other.

Having already described in general terms the range and extent of the rocks of the upper peninsula, so far as the same have been examined, the limits of the present report will admit of nothing more than a general description of the characters of these rocks, and I shall not attempt a minute description of any members of the series, except such as are more or less connected with subjects which are supposed to be of immediate practical importance.

Section illustrative of the order of super-position of the Rocks of the Upper Peninsula.

		Thickness in feet.
9.	Tertiary Clays and Sands.	
8.	Upper Limerock Group, (embracing as members, the Drummond Island and Mackinaw limestones.)	
7.	Lower Limerock and Shales.	
6.	Sandy or Intermediate Limestone.	
5.	Upper or Grey Sandstone,	mean 700 ft.
4.	Lower or Red Sandrock and Shales,	extreme 6,500.
3.	Mixed Conglomerate and Sandrock,	extreme 4,200.
2.	Conglomerate rock,	extreme 5,260.
1.	Metamorphic, Trap and Primary rocks.	

PRIMARY ROCKS.

Although the usual ternary compound of quartz, feldspar and mica, occurs but rarely in the primary, in the vicinity of the coast of Lake Superior, and in fact but rarely in any portion of the range which I have visited, nevertheless, the great mass of rocks included within this range, may, in a broad sense, be called granite. The compound above referred to is more common in the westerly than in the easterly portion of the range. The more common rock is made up of quartz, feldspar and hornblende, giving rise to a very dark colored syenite; occasionally mica enters sufficiently into the compound to form syenitic granite, and sometimes the place of the hornblende in the syenite, is supplied by schorl or tourmaline, thus giving rise to a schorl rock.

The rocks of the southeasterly portion of the primary range of hills are more clearly defined as granitic rocks, than those situated more northerly, for they are more distinctly and largely crystaline in structure, and quratz enters much more largely as a constituent into their composition. As we proceed north-westerly, from the south-east boundary of the primary, over the several broken ranges of hills, we find the character of the rocks in mass almost imperceptibly changing. The quartz as a mineral gradually forms a less important part, and it finally almost wholly disappears, leaving a binary compound of feldspar and hornblende, which then assumes a granular structure, constituting greenstone.

The intermediate rock, between the syenite and greenstone ranges, may not inappropriately be called a syenitic greenstone.

The primary rocks which appear in the vicinity of Lake Superior, in the several ranges of hills extending from a point opposite little Presque Isle,* to Huron river, are essentially either syenite or syenitic granite. The rock, as a whole, is extremely compact, and the constituent minerals are mostly in

*A little southeast from River Des Morts.

small crystals, though occasionally the feldspar assumes a more largely crystaline form.

The granitic rocks, so far as the range has been examined, in a southwesterly direction, are largely traversed by dykes, that are almost without exception made up of materials in all respects identical with the greenstone, before alluded to, as forming the more northwesterly ranges of hills. The courses of these dykes or veins are invariably marked by striking changes in the character of the rock traversed, and in the larger dykes, the evidences of the changes produced by the heat of the injected matter, extend to several hundred feet upon either side of the dyke itself. The connection between the rocky matter composing these dykes and the ranges of greenstone, lying northwest, is clearly identified, not only by the perfect similarity in mineral character, but also from the fact, that as we proceed in the direction of the ranges of greenstone, the dykes become much more frequent, until at length it becomes difficult to determine which of the rocks predominate in quantity.

These facts serve to throw much light upon the relative ages of the several ranges of hills, or in other words, serve to show the order in which they were severally uplifted; facts which will be more fully shown when we come to consider the present position of the overlying sedimentary rocks. These facts are not only important, to enable us to understand the many changes which have taken place, with regard to the relative position of the land and water, but they are rendered of practical importance for the reason, which I think may be satisfactorily shown, that the mineral region of the upper peninsula, to be hereafter described, is strictly confined to only the outer portion of the rocks of a single epoch.

The veins and dykes of greenstone, referred to as traversing the granite rocks, do not, in this portion of the group, appear to have any regular magnetic bearing, for they traverse the rock in all directions. Veins of any other matter are very rarely seen traversing the granite. In a single instance, what was regarded as a true vein of porphyry, having a width of nearly three feet, was noticed, which vein is crossed, at angles of 53° and 107°, by a vein of greenstone, having a width somewhat less than that of the porphyry. In this instance, the greenstone is clearly the most recent vein.

The veins of greenstone traversing the granite, vary from a mere line, to 50 or 60 feet in width. The intimate blending of the material composing these veins, together with the chemical differences, causes them to disintegrate or waste away more rapidly than the rock they traverse; the result of which is, that deep grooves are frequently left in the granite, the simple result of the wasting away of these dykes or veins. This is peculiarly the case upon the coast of the lake, where the rocks are subject to the action of the waves, which have, in some instances, so removed the debris as to leave long and narrow bays, with high perpendicular walls, occupying simply the space once occupied by the dyke. The Huron islands, which are simple elevated granite knobs, appear, upon first examination, as a mass of rocks, completely rent in many places, with portions separated from each other by narrow clefts, having perpendicular walls of great height. While these rents are of sufficient width to admit of being traversed by small boats, the perpendicular walls are so little varied in their elevation as scarcely to leave a point, in these narrow passages, where a landing can be effected. A careful examination of these passages shows them to be simply the spaces once occupied by dykes or veins of greenstone, which having disintegrated, and the detrital matter having been removed by the action of the waves, have left the walls of the more enduring granite rock, unbroken and almost untouched.

Upon the north coast of Lake Superior, well defined granite and syenite, or syenitic granite, occasionally appear upon the immediate coast of the lake, but more frequently these rocks are flanked on the south by greenstone, with occasional narrow bands of sandstone; thus precisely reversing the magnetic order of those rocks upon the south coast.

TRAP ROCKS.

Were we to consider the rocks of the district under consideration, strictly in their chronological order, those rocks which I propose to treat as trap rocks, would undoubtedly follow those slates and quartz rocks which are considered as metamorphic, and which may be regarded as identical in time of up lift with those rocks before alluded to, as being intermediate between the granitic and trap rocks. The almost insensible gradations by which the granitic rocks pass into the greenstone of the trap formation, and the near analogy of the whole of the rocks of both formations, to each other, renders it more convenient, at the same time that it is more simple to follow the arrangement or order that I have adopted.

I have already stated that in passing from the granitic region on the south side of Lake Superior, in a direction northwesterly, we cross a series of ranges of hills, varying in height from three to nine hundred feet above the lake, and that in pursuing this course, we observe that the character of the rocks gradually and almost insensibly change, until at length they become well defined greenstone.*

The rocks of the outer or northwestern range of hills, which were clearly the last of the series of uplifts, bears

more unequivocally the evidences of igneous origin, than either of the outer ranges alluded to. The rock upon the south flank of these hills, is invariably very compact greenstone, while upon the north-westerly line it is almost equally invariably an amygdaloid, or at least, has an amygdaloidal structure. The causes of this difference of structure of the rock, upon the opposite

*In the present report, I use the term greenstone, in its generic sense, applying it to all the compact rocks, of a granulated structure, belonging to the trap range. By far the larger proportion of these rocks are greenstone, in its most restricted sense, or in other words, are composed of feldspar and hornblende; but the term is also used to include rocks which in a strict sense would be considered as altered syenite, syenitic granite, hornblende rock and angitic rock.

The term *amygdaloid*, I apply, as it is usully applied to that portion of the rock having a difference of form simply, without any reference to the constituents of the rock. This generic use of terms is imployed for the reason that the limits of the present report will not allow anything more than a very general consideration of the subject. The term *trap* is used in a such a sense as to include both the greenstone and amygdaloid, though it may sometimes prove that the aymgdaloid has had its origin from the fusion of the lower portions of the sedimentary rocks.

sides of this range of hills, when carefully examined upon the ground, are very apparent; for it is evident, as will hereafter be shown, that the uplift of the rocks of this range of hills was wholly upon the south-easterly side, and while the rocks of this portion were in a solidified state, or, in other words, that a point in Lake Superior may be regarded as the fixed axis of the uplifted mass. That this was the case, is shown by the fact that the sedimentary rocks to the south or south-east are scarcely disturbed, so far as regards this range of hills, while the sedimentary rocks on the north or north-westerly side, are invariably tilted to a high angle, near the range of hills, which angle gradually decreases as we pass farther and farther *from* the hills themselves. These sedimentary rocks, which upon the north side always dip from the range of trap hills, are in their close proximity to the trap, inclined at angles varying from 45° to 85°. Dykes of from fifty to four or five hundred feet, are of frequent occurrence, traversing these sedimentary rocks, but the widest of these have invariably been protruded between the strata of the sedimentary rocks, and consequently have the same general inclination. The result of these frequent dykes, which occur at comparatively short distances from the main body of trap, is that the sedimentary rocks frequently so far loose their original character as scarcely to be recognized.

The rocks of the complete north-western escarpment of this range of hills, were evidently in an intense state of ignition while in contract with the sedimentary rocks, as is clearly shown by the very great changes which have taken place in the rocks last alluded to. In fact, I am disposed to refer the origin of much of the amygdaloid rock to the fusion of the lower portions of the sedimentary rocks referred to, for the reason, that as we pass south from this junction, the amygdaloid rocks wholly disappear, their place being supplied by greenstone; and again, so intimately are they blended, that it is frequently impossible to determine where the amygdaloid ceases, and the upper sedimentary rocks commence. Fragments of the sedimentary rocks, the characters of which can be clearly recognized, are not of rare occurrence, imbedded in the amygdaloid rock, a circumstance which although by no means conclusive, should not be overlooked in considering this subject.

I would not wish to convey the idea that the amygdaloid rocks have their origin exclusively from the altered sedimentary rocks, but simply that the change in the structure of the trap, from greenstone to amygdaloid, may and no doubt does depend upon the proximity of the sedimentary rocks to the trap, while the latter was in a state of ignition.

I have been compelled to tread upon grounds which may, perhaps, be considered theoretical, but it would appear to be necessary in order to convey a proper idea of the condition of the rocks composing the range of hills under consideration. These views, however, would not have been alluded to at this time, had it not been for the fact, that an understanding of all that relates to the mineral resources of this portion of our state, is more or less intimately connected with this portion of the subject.

Although the general range of the trap hills has been already given, I will define, as nearly as is in my power, the line of junction between the trap and sedimentary rocks, upon the north escarpment, premising that the elevation at which this junction takes place, is usually at a height of from 100 to 500 feet above the lake, and only in a single instance does this line reach the coast of the lake. Commencing almost directly at the extremity of Keweenaw point, this line passes in a southwesterly direction, gradually receding from the coast; it crosses Sturgeon or Portage lake near its centre, after which it recedes still more rapidly from the coast, until finally it is seen to cross the upper forks of the Ontonagon river, and soon after the whole is apparently lost in the range of the Porcupine mountains; which last range has a course so much to the south-west as probably to completely intersect the first range mentioned. On the west side of the Porcupine mountains, the range of hills and the line of junction appear again, but many miles farther north than they would have been looked for; from thence the true line gradually approaches the coast, until, at its point of crossing the Montreal river, it is but about 2 miles above the mouth of that stream.

To the north and north-west, through the whole of the distance described, this trap is bounded by hills of conglomerate and sandstone, more or less elevated, but usually not exceeding 400 feet. To the north-west of these hills of sedimentary rocks, a dyke of trap is seen to extend for many miles along the line of coast of Keweenaw point, and so great is the width of the dyke, that, unless carefully examined, its character might easily be misunderstood. It lies in a plane parallel to the stratification of the sedimentary rock by which it is embraced, and with that rock dips to the north-west. The dyke is chiefly made up of greenstone, but not unfrequently large portions of the mass consist of amygdaloid, in which the amygdules are filled or

composed of quartz, chalcedony, agate, calc. spar, zeolite, &c.

The dykes just referred to, so far as their relation to the amygdaloidal portion of the trap is concerned, as also the many others similarly situated with respect to the superincumbent sedimentary rocks, will be regarded in the same light as contemporaneous veins, though they are only contemporaneous with the uplift of the strata, and not with their deposit. But there is still another class of veins which not only traverse a portion of the trap rocks, but also the upper sedimentary rocks, and which may be regarded as true veins. These last mentioned veins traverse the rocks at a high angle with the line of bearing of the sedimentary rocks, as also with the line of junction of those last mentioned with the trap rocks. The composition of these veins is widely different from that of the contemporaneous veins or dykes before referred to. As this subject will be treated more at length in a succeeding portion of this report, I deem it unnecessary at this time to refer more particularly to the subject.

A single knob of trap appears under circumstances which add very much to its interest, at what is usually known as Presque isle, an elevated rocky point immediately north-west from Riviere Des Morts, and almost directly within the granitic region. This point of land has its origin from the simple elevation of a mass of trap rock, which rises on the north in abrupt cliffs, varying from 20 to 60 feet in height. The trap is mostly greenstone, though portions of it are so largely impregnated with a dark colored, almost black serpentine, as to deserve the name of serpentine rock.

The knob of trap under consideration, is possessed of additional interest, from the unequivocal evidence of uplift, as also from the manner in which these evidences are exhibited. The cliffs of trap occupy the very extremity of the point, while the neck and central portions are made up of conglomerate or trap-tuff and sandrock, resting upon the trap. These upper rocks also appear upon the immediate coast, in cliffs of from 20 to 60 feet in height, and in many places they are seen resting directly upon the trap. The stratification of these sedimentary rocks has been very much disturbed, and they invariably dip, at a high angle, in all directions from the trap itself. The character of both rocks, at the immediate line of junction, is almost completely lost, and the evidences of change most unequivocally marked. But the most curious feature of the whole is, that the sedimentary rocks, for a distance of several hundred feet, have been completely shattered or broken into minute fragments, which, having retained their original position were again cemented by the injection of calcareous matter. This injection has filled the most minute fissures, and so perfect is it, that, in looking upon the face of a mural cliff of these rocks, the veins may be easily seen at a distance of many rods, forming as it were, a complete net work over the cliff, and so minute is it, that a single hand specimen frequently contains many hundreds of these veins.

This knob of trap, like the rock before described, is also traversed by veins, of a date subsequent to the uplift of the rock.

The whole of the north-western portion of Isle Royale is made up of trap, and in truth that rock constitutes, by far, the largest proportion of the rocky mass of the island. The two northerly ranges of hills, already alluded to as traversing the island, in its greatest length, are wholly trap. The most northerly range of hills, is composed almost exclusively of greenstone, while the rock of the south or south-easterly range, becomes more decidedly amygdaloidal in its structure; thus reversing the order which these portions of the rock bear to each other upon the south shore of the lake.

The ranges of hills immediately bounding Lake Superior upon its north coast, are almost invariably either well defined trap or altered syenite, while the decidedly primary rocks usually appear in ranges of hills to the north of these; thus following the reversed, order of the rocks upon the south coast.

The character of the trap rocks of Lake Superior has perhaps been sufficiently described, to answer the purpose for which this hasty sketch is intended; and I will only add, that they are usually distinctly jointed, and where they approximate to the sedimentary rocks, there is not unfrequently so distinct a cleavage, opposed to the joints in direction, as to give the appearance of stratification. The jointed structure of the trap rocks sometimes, though rarely, passes to what may be termed a rudely columnar structure. Upon one of the long rocky points forming the north-easterly extremity of Isle Royale, this rock assumes the columnar form, and the columns are tolerably well defined, having a height of from 80 to 90 feet. The columns are also seen, but less perfectly developed, forming the coast of a small rocky island, two to three miles south from the point last alluded to. These are the only points in the trap of Lake Superior, where I have noticed the rock to assume this form.

METAMORPHIC ROCKS.

The general direction of the rocks composing this group, has already been described, and they are confined exclusively to the range of hills lying upon the south-east side of the granitic rocks. The general direction of these hills is south-west and north-east.

The outline of the hills of the metamorphic group is less broken than either the granitic or trap ranges, but these rocks sometimes rise in abrupt conical peaks, closely resembling those of the granitic rocks.

The area of country occupied by rocks of this group, is less than that of either the primary or trap, the general average width not exceeding six to eight miles. The precise limit of the group in a south-westerly direction, is not known.

It has already been stated that Chocolate river is the boundary, on the south-east, between these and the sedimentary rocks, and that they extend in a north-

westerly direction from this stream to the granite, against which they rest. The group is made up of an alternating series of talcose and mica slates, sometimes graduating into clay slates, with quartz and serpentine rocks, the quartz rock constituting by far the larger proportion of the whole mass. Since it would be nearly impossible to describe the alternations of these several rocks, in such a manner as to be understood, without the aid of a diagram, or section, no attempt will be made to do so.

The cleavage of all these rocks is usually north or north 10° west, at an angle, which, in the main, varies but little from 80°, but the mass of the group appears to dip regularly to the south or south west. The talcose slates and quartz rocks alternate frequently with each other; and with the rock which has been called serpentine rock, less frequently.

The quartz rock is usually distinctly granular, though it is sometimes compact, with a conchoidal fracture. It usually separates by cleavage into masses, or strata, having a considerable - degree of regularity, and varying from a few inches to several feet in thickness. The rock is usually more or less regularly jointed.

That rock which, for the sake of convenience, I have denominated serpentine rock, bears a close resemblance to greenstone, being essentially composed of granular feldspar and hornblende, with which serpentine is intimately blended. This rock only occurs in the talcose slate as we approach the granitic region, and possibly a more close examination may show it to be a simple series of dykes, lying parallel to the line of cleavage of the slate rocks.

The metamorphic rocks are occasionally traversed by trap dykes. The group of rocks under consideration has been comparatively little examined, and the more minute details connected with it will be taken up at some future time.

CONGLOMERATE ROCK.

The lower of the sedimentary rocks, to which I have attached this name, appears to be invariably connected with, or to rest upon, the trap rock, nor has it been noticed, to any extent, in connection with either of the other lower rocks, for it wholly disappears as we approach the granitic and metamorphic groups. Of all the sedimentary rocks, this is the most variable in thickness, and not unfrequently does a few miles make a difference of several hundred feet. The conglomerate rock may, without doubt, be considered as a trap-tuff, which was gradually deposited or accumulated around the several conical knobs of trap, during their gradual elevation, and which would necessarily occupy the complete spaces or valleys between the several irregular ranges of knobs or hills.

If we regard this conglomerate rock in this light, we will at once perceive why the rock should be variable and irregular in its thickness.

The pebbles of which the mass of the rock is composed consist of rounded masses of greenstone and amygdaloidal trap, of which the former make up by far the larger proportion, and scarcely a pebble of any other rock than trap, enters into its composition. These pebbles vary in size from that of a pea, to several pounds weight, but the average size may be stated at 1½ to 2 inches in diameter. The pebbles are usually united by a mixed calcareous and argillaceous cement, more or less colored by iron, and so firm is this union, that the most compact and tough of the greenstone pebbles, will frequently break through as freely as the cement, and crevices and narrow veins are frequently seen passing indiscriminately across the pebbles and cement. This fact is the more worthy of notice, since the pebbles are almost without exception, made up of the hardest and most indestructible portions of the trap rock.

The conglomerate rock can scarcely be said to occur in such form as to be well defined, in any portion of the country, excepting upon the northern flank of the outer trap range, before referred to. On the outer or northern side of Keewenaw point, the conglomerate commences near the extremity of the point, and extends several miles westwardly, forming a series of abrupt and precipitous cliffs upon the immediate shore, as also, a range of well defined hills, a little in the interior; which hills have an elevation varying from 200 to 800 feet. After appearing for a few miles upon the coast, this rock gradually stretches into the interior, following the line before described as the most northerly boundary of the outer trap range of hills, and invariably occupying a place to the north of this range, and it may be observed, nearly or quite continuously, as far as Montreal river, which stream it crosses at a short distance above its mouth, thus making its complete length, within the limits of Michigan, computing its southerly curve, something over 140 miles; but the rock does not cease at Montreal river, for it may be seen at short intervals in the interior, as far westwardly as the head of Lake Superior.

At the trap knob of Presque Isle the conglomerate is imperfectly developed, but on the south-westerly side of Isle Royale, it is more perfectly developed, flanking the hills of trap upon the southerly side.

The conglomerate rock is imperfectly stratified, in masses of immense thickness, and it dips, upon the south shore of Lake Superior, regularly to the north, and north-west,* usually at high angles, varying from 30 to 85°, while upon Isle

*This variation in the dip is in conformity with the variation in the direction of the trap hills.

Royale and the north shore, the dip is reversed, being south and south-easterly, or in other words, the rock upon all sides dips in the direction of the lake basin.

Upon the south shore of the lake, the thickness of this rock was not estimated at any point west from Montreal river, a little east from which, it attains its greatest thickness, being, as estimated, 5,260 feet. In addition to the great variations in thickness, over comparatively small districts, the formation wedges out as we pass easterly along the range, and so rapid is this change,

that near its easterly prolongation the thickness was estimated at something less than 1,000 feet.

The greatest estimated thickness of the rock upon the north coast, is a fraction less than 2,800 feet.

I have already stated that this rock is frequently traversed by dykes of trap, which are usually parallel to the line of stratification and dip of the rock. These dykes, which have sometimes a thickness of 50 to 60 feet, and even several hundred feet, are sometimes continuous for many miles, and are many times repeated. In addition to the dykes just alluded to, the rock is frequently traversed by veins of a more recent date, which traverse alike the trap and conglomerate rocks, always at very high angles with the line of bearing of the conglomerate. These veins, which are usually more perfectly developed near the line of junction of the two rocks, or for a distance of a few thousand feet upon each side of the junction, are clearly true veins, and since, with a few unimportant exceptions, they are the only veins belonging to this range which are metalliferous, they will be considered more fully under a separate head.

Mixed Conglomerate and Sandrock.

This rock formation is made up of an alternating series of conglomerate and red sandstones, which rest conformably upon the conglomerate rock last described, dipping with that rock, into the bed of Lake Superior. The mixed rock was not noticed upon the north side of the lake, or upon Isle Royal, but upon the south shore the rock was traced continuously for a distance of about 130 miles, extending from a few miles westerly from the extremity of Keweenaw point, to Montreal river. It follows the line of the conglomerate before described, stretching from Keweenaw point, in a south-westerly direction, and again curving to the north-west, forming, as it were, a crescent between the points before mentioned, the result of which is, that the rock only appears for a very limited distance upon the coast of the lake, at Keweenaw point.

From a point about 18 miles easterly from Montreal river, the rock wedges out rapidly as we proceed westerly from that point, and as we continue towards the head of Lake Superior, the rock wholly disappears, or becomes merged in the conglomerate rock below, and the sandrock above. The greatest observed thickness of this rock is 4,200 feet.

The conglomerate portion of the mixed rock consists of strata of conglomerate, varying from a few feet to several hundred feet in thickness, and it is composed of materials in all respects resembling those constituting the conglomerate rock before described and these materials are united by a similar cement.

The sandstone portion of the formation occurs in strata of very nearly corresponding thickness, and the two rocks may be said to form nearly equal portions of the complete mass. But the material of which this sandstone is composed differs widely from that of the true sandrock lying above, for while the latter is chiefly made up of quartzose materials, the former is composed of materials bearing a close analogy in composition to those of the conglomerate rock itself; or in other words the sand consists chiefly of greenstone, so much comminuted as, when cemented, to compose a coarse sandstone. It will thus be seen that the members of this formation differ only in the degrees and fineness of the material, and the character of this material will explain sufficiently why the true conglomerate, and the mixed rocks are referable to the same origin, for the materials of the several members of the group have their origin from the trap rock, and as a whole may perhaps be regarded as a trap-tuff.

The coarser conglomerate of the formation is scarcely separated by lines of stratification, and the strata appears usually in mass, embraced between the strata of .sandstone, but the stratification of the latter rock is perfect, and it bears evidence of having been deposited in shoal water, in the very abundant, perfectly defined ripple marks which it exhibits through its complete range.

No fossils were noticed in connection with either the mixed rock, or the conglomerate lying below it.

Dykes of greenstone occasionally appear in the mixed rock, but less frequently than in the rock below. These dykes almost invariably occupy places between the strata of the rock, and correspond in position to the direction and dip of the rocks by which they are embraced, or in other words, the rocky matter composing the dykes appears to have been injected in a plane corresponding with that of the stratification of the embracing rock. As in the conglomerate below, these dykes have produced very great changes in the color and structure of the mixed rock bounding them upon either side.

In addition to these, the mixed rock is occasionally, (though less frequently than the rock below,) traversed by veins or cross courses of a more recent origin than the dykes, (which latter they usually cross at a high angle,) their course usually being at an angle of at least sixty degrees, opposed to the line of bearing of the mixed rock. These cross veins are usually made up of calcareous spar or a sub-granular limestone, and more rarely of some variety of quartz, and imperfect trap rock, the latter of which is usually of the amygdaloid variety.

Red Sandstone and Shales.

That rock to which I have applied the name of red sandstone, is emphatically the chief rock that appears upon the immediate coast of the south shore of Lake Superior, and the same remark will apply, in a more limited degree, to the complete coast of the lake. A traveller proceeding westerly along the coast, from Grand Island to the head of the lake, would imagine he had seen little else than red sandstone, and in fact, were he to confine his examinations to the immediate coast, he would see no other rock for nineteen-twentieths of the distance. From Grand Island westerly to the mouth of Chocolate river, no other rock is seen in place, and from

Chocolate river to Keweenaw point, embracing the complete width of the primary, metamorphic and trap ranges, the hills forming these groups are almost invariably surrounded or flanked at their bases, by this sand rock, so that even along this portion, the hills are, for a large proportion of the distance, cut off from the lake by a narrow belt of the rock under consideration, and westerly from Keweenaw point to the head of Lake Superior, no other rocks appear upon the coast, if we except several trap dykes in the vicinity of the Porcupine mountains, and a series of more recent deposits of clay and sand, that appear west from Keweenaw point. This sand rock also occurs upon the southerly side of Isle Royale.

The material of which the red sandrock is composed, differs widely from that of the sedimentary rocks before described, for while the rocks last referred to are made up of materials clearly of trappean origin, and in which the material is very rarely quartz, the rock under consideration is composed of materials, the predominating portions of which are clearly derived from the granitic and metamorphic rocks, and in which quartz occurs abundantly, though with this, there is usually associated more or less sand, that has all the characters of the comminuted trap, constituting that portion of the mixed rock before referred to. Magnetic iron sand, sometimes becomes a constituent of the red sandrock, and occasionally continuous strata of several inches thickness, are almost wholly composed of this material. The material composing this rock is usually cemented by calcareous matter highly colored by the per oxid of iron, though not unfrequently these are associated with argillaceous matter.

While the chief mass of the rock is a coarse grained, somewhat compact, sandrock, there are portions of the formation where there are well formed red and grey flags, and red and green shales, forming, as it were, beds of a very considerable thickness, and occupying large districts of country. These red and green shales are more largely developed in that district extending from Granite point westerly to Keweenaw bay, and upon the south side of Keweenaw point, extending from the head of the bay to near the extremity of the point, they are particularly largely developed. These shales more usually occur in alternating bands of deep red and green colors, the red usually largely predominating, and they are made up of argillaceous matter, with sand, the whole of the materials being of extreme fineness.

On the south-east side of Keweenaw bay. near its head, an argillaceous rock appears, and extends for a short distance along the coast, which is an anomaly. The rock is evidently embraced in, or rather may be said to constitute a member of the sandstone series, but it differs widely from any other rock seen in connection with it. This argillaceous rock sometimes appears in the form of a slate, though its most usual form is that of compact strata, frequently of several inches thickness, and which closely resembles indurated clay. A peculiar appearance is given to this rock by the innumerable layers or very thin strata, which compose the mass, being of different colors, sometimes red, grey and dark brown, alternating in the same hard specimen.

The material of which this argillaceous rock is composed, possesses an extreme degree of fineness, and is so soft as readily to be cut with the knife, which qualities render it a fit material for the manufacture of pipes, to which purpose the Indians of the country have long applied it. It has also been applied to use in sharpening tools, but its softness is a serious objection to its use for that purpose.

A similar argillaceous rock also appears at several other, points in the interior, or southerly from that already described, but as yet I have been unable to determine its thickness at any point. The finely represented bands or zones, which may fairly be supposed to represent the original lines of deposition, are very much contorted, and in such a manner as to lead to the conclusion that this change must have taken place very soon after the deposition of the rocks, and while they were still in an unindurated state.

The rocks belonging to the red sandstone formation, bear the evidence of having been almost universally deposited in shoal water, for ripple marks occur abundantly at all points where the rock takes on the decided character of sandrock, and these ripple marks may frequently be seen, for many rods together, as distinctly and clearly defined as they are at the present day in the loose sands forming the bottom of some of the shoal bays of Lake Superior. Fossils are rare in the red sandstone, and in fact, I have never seen any other than fucoides, of which there are three species, that are tolerably well defined.

The red sandrock is less frequently traversed by dykes of trap than either of the rocks before described, though dykes were sometimes noticed traversing the whole of the several rock formations, up to and including the red sandstone. Upon portions of the north coast, where the conglomerate and mixed rocks are more frequently wanting, and where the red sandrock is brought more nearly in contact with the trap, these dykes are of more frequent occurrence. It is deserving of remark, that where the lower rocks are either wholly or in part wanting, the red sandstone usually becomes of a deep brown color, and the material of which the sand is composed, gradually changes from that before described to greenstone.

I have already stated that the sandrock, at its westerly prolongation, attains its greatest thickness, which was estimated at 6,500 feet, but as the rock continues easterly, it gradually and quite regularly diminishes in thickness, and beyond Saut de Ste Marie, the thickness is very inconsiderable. The average rate of diminution which takes place in the thickness of the rock as we proceed easterly, was shown by a great number of observations, upon the south-westerly portions of the coast of Lake Superior, to be a fraction over fifteen feet to the mile, but this rate of decrease could not be

satisfactorily estimated upon the lower or easterly half of the coast. The red sandrock thins out as we proceed southerly or inland from the coast, at a still more rapid rate, as was most satisfactorily shown, where it is connected with the several primary, metamorphic and trap ranges of hills, for all or nearly all the valleys, after passing the outer or northerly range of trap hills, are based upon this sandrock, and since we have every reason to believe that this sandrock was deposited in part, during the gradual elevation of the several chains of hills, it would follow, that over those districts which were last elevated, the rock would attain its greatest thickness. I have already alluded to the order in which the several ranges of hills appear to have been uplifted, and since more particular reference will be made to this hereafter, I leave the subject for the present.

The red sandrock south from Lake Superior, as well as upon the immediate coast, dips regularly northerly, while that upon the north coast dips invariably southerly, or, as has already been said of the lower rocks, this rock dips, upon all sides, regularly into the basin of the lake. The quantity of dip is exceedingly variable, being always very much increased as it approaches the trap, and diminishing as it approaches the primary and metamorphic ranges.

The line of cleavage of some of the members of the lower sandrock and shales is frequently irregular, and opposed to the true stratification of the rock.

UPPER OR GRAY SANDROCK

The only remaining rock which separates the red sandrock from the limestones lying to the south, is a gray, or brownish sandrock, that is almost wholly composed of grains of quartz, usually feebly cemented with calcareous matter. The composition of this rock differs from that of the lower sandrock, in being more exclusively quartz, while in epoch of deposition, the rock under consideration should not be confounded with that of the red sandstone. It has already been stated that the red sandrock of the south coast, dips regularly northerly, while the upper or gray sandstone dips equally regularly south or south-easterly, in which respect the last mentioned rock conforms to the limestones resting upon it, while it rests itself upon the uptilted edge of the red sandrock, below.

I have already stated that this rock was first noticed, rising in hills, at a point not far distant from Riviere Ste Marie, and south-east from Point Iroquois; from this point, it stretches westerly in an elevated and very regular chain of hills, that are upon the coast, as far as Tequoimenon bay; westerly from which the shape of the coast is such that these hills do not again appear upon it, until we reach that precipitous portion of the lake coast known as the Pictured rocks, where the fury of the waves, aided by frost, has acted upon the feebly cemented material of which the rock is composed, to such an extent as to leave large portions of what was originally the northern escarpment of these hills, along this coast, in high mural and overhanging precipices.

Westerly from the Pictured rocks, the ranges of hills, which are composed or made up of this rock, stretch in a south-westerly direction, passing completely to the south of the primary, trap and metamorphic regions. The westerly prolongation of this rock has not yet been determined.

The upper sandrock, like the lower, abounds in clearly defined ripple marks, and its line of cleavage is very irregular, frequently being opposed to the line of stratification over very considerable districts of country. Two indistinct species of fucoides were all the fossils noticed in connection with it.

I was unable to obtain any observations upon the thickness of the upper sandrock, which were satisfactory, but from the imperfect observations which were obtained, I was led to conclude that the average thickness as far westerly as the Pictured rocks, does not vary very far from 700 feet. The upper sandrock, like the rocks before mentioned, wedges out as we proceed, in an easterly direction.

TERTIARY CLAYS AND SANDS.

As in the lower, so in the upper peninsula, the older rocks are more or less covered by deposits that may be severally arranged under the above head. To these deposits it is my intention, at the present time, barely to allude.

Stratified clays and sands, similar to those skirting the borders of the lower peninsula, are seen at many points, and continue for long distances upon the coast of Lake Superior; and they are also largely developed at many points in the interior of the country. These deposits sometimes attain a thickness of from 200 to 300 feet, and they are spread over the less elevated portions of the district. The character of these clays and sands bear a close resemblance to those described in a previous report, as occurring upon the lower peninsula.

ECONOMICAL GEOLOGY.

Rocks.

The series of limerocks resting upon the sand rock last described, were noticed in the report which was laid before you at a previous session, and the limits of the present report will not permit me to refer to them, more fully, at this time. My observations will, therefore, only include those rocks which lie below the limestones. It will be borne in mind that the whole of the group of limestones are embraced in the southerly portion of the upper peninsula, and that their outcropping edges do not reach within many miles of the coast of Lake Superior. This is an important fact, for it shows the whole of the northern part of the upper peninsula to be deficient in materials for the manufacture of lime, which are, in truth, wholly wanting.

Materials adapted to the purposes of building, abound, throughout the district of country under consideration, and though they vary exceedingly in value for that

purpose, yet no portion of the country can be said to be without a supply.

Among the most valuable of the materials for this purpose, the syenites and syentic gravites deservedly rank first, and they occur of a quality which may be advantageously worked at various points in the primary range. Some of the syenites near the coast of the lake are so situated as to be readily quarried, and they may be made to furnish a beautiful and durable material for building. The color of these syenites is usually a very dark gray, from the predominance of hornblende in the composition, but this is by no means invariably the case.

The metamorphic group scarcely furnishes a fit material for use as a building stone, for the structure of its schists would be an effectual bar against their use, and the difficulties of working the quartz rock will probably prevent that rock being applied to that purpose.

Some of the compact greenstones and altered syenites of the trap range, may be made to furnish an excellent building stone, which, although in powers of resisting the action of disintegrating agents, may be less than that of the unchanged syenite, nevertheless possess a very great degree of durability. The greenstone ranges of hills, frequently for very considerable distances, are made up of rock in which the jointed structure is so perfectly developed, that regular blocks, of a convenient size for building may be obtained, with comparatively little labor.

The conglomerate rock is scarcely applicable to use for purposes of building.

A very good building stone may be obtained from many portions of the lower, or red sandstone formation, and though the cement of this rock is usually not very perfect, yet, frequently, such changes have taken place in the rock, that it has almost taken on the character of granular quartz rock, in which cases, its durability is very much increased. The strata of this rock are usually of a convenient thickness to admit of being easily quarried, and they are so regular that the stone will require but little dressing.

The upper, or gray sandrock, being almost uniformly but feebly cemented, and sometimes decidedly friable, is of less value as a building stone than either of the rocks before mentioned. Those portions of the upper sandrock where the calcareous cement imperfect, but not sufficiently hardened, might be rendered much more capable of resisting the action of the elements if allowed to remain under shelter a sufficient length of time to allow this change to take place.

The value of the limestones of the southern part of the peninsula, for the purposes of building, as also for the manufacture of lime, was mentioned in a previous report upon the geology of that district of country. As has already been stated, these limerocks do not reach within many miles of the coast of Lake Superior, and it is certainly to be regretted, that the shore of the northern portion of the peninsula is destitute of this important material. Nor have I seen any marls of sufficient extent, in the district, to admit of application to any of the purposes to which it is applicable, or to supply, even in part, the deficiency in limestone. All the lime which would appear to be capable of being applied to practical purposes is that of the calcareous spar, composing the veins traversing the sandrock, and these are not only rare, but they are also of very limited extent.

MINERALS AND MINERAL VEINS.

In considering this portion of the subject, I propose to treat the minerals of the different formations separately, so far as the same can be done, and although this method will necessarily cause some repetition, it will enable me to show, more perfectly than could otherwise be done, the connection between those minerals that may be regarded as of practical value, and the rocks to which they belong.

As a whole, the rocks of the upper peninsula are deficient in number of minerals, though some few individual species occur abundantly.

Minerals of the Primary Rocks.

The following list can by no means be regarded as perfect, but it will serve, at least, to convey an idea of the small number of minerals which are found in connection with the rocks of this group.

Schorl,	Mica,
Tourmaline,	Feldsdar,
Hornblende,	" red,
Actynolite,	Quartz.

Minerals of the Metamorphic Group of Rocks.

Quartz, common,	Iron, scaly red oxid of,
" milky,	" hasmatite,
" greasy,	" pyritous,
" tabular,	Steatite,
Serpentine, common,	Novaculite.

Of the minerals enumerated as occurring in the metamorphic rocks, the milky variety of quartz is abundant, sometimes composing almost entire ranges of hills. The novaculite is also abundant, but of a coarse variety. This last is associated with the talcose slates. The remaining minerals appear either disseminated, or forming druses in the quartz rock, though sometimes they occur in thin beds or veins, in the talcose slate, which beds conform to the line of cleavage of that rock. Although the hæmatite is abundantly disseminated through all the rocks of the metamorphic group, it does not appear in sufficient quantity, at any one point that has been examined, to be of practical importance.

Minerals of the Trap Rocks.

Quartz, common,
" smoky,
" milky,
" greasy,
" radiated,
" mamillary,
" drusy,
" amethystine,
Chalcedony,
Carnelian,
Jasper,
Agate, common,
" fortification,
Augite
Actynolite,
Serpentine,
" pseudomorphous,
Chlorite, common,
" earthy,
Steatite, common,
Asbestus,
Amianthus,
Calcareous spar,
Copper, native,
" pyritous,
" black,
" red oxid of,
" azure carbonate of,
" green carbonate of,
" " " ferruginous,
Lead, sulphuret of,
" carbonate of,
Iron, pyritous,
" red oxid of,
" hydrate of,
" silicate of,
Manganese, ferruginous oxid of,
Silver, native, (very rare,)

Since a consideration of the minerals contained in the trap, will also involve a portion of those embraced in the conglomerate, the mixed rock, and red sandrock and shales, I will, before referring minutely to those of the trap rocks, lay before you a list of those which occur most frequently in the sedimentary rocks last mentioned. The fact that veins of mineral matter, traversing the trap, are frequently continued across the several sedimentary rocks, and that dykes are of frequent occurrence in these latter rocks, would lead to the inference that there would be a considerable degree of resemblance in the character of the minerals embraced in these dykes and veins, in both the trap and sedimentary rocks, and to a certain extent, this inference would be true; but it should be borne in mind, as has already been stated, that the veins, in traversing the several upper rocks, undergo very great changes in mineral character.

Minerals of the Conglomerate, Mixed Rock and Red Sandrock.

Calcareous spar,
Quartz, common,
" milky,
" drusy,
Chalcedony,*
Carnelian,*
Jaspar,*
Agate,*
Copper, native,†
" pyritous,†
" blue carb. of,†
" green carb. of,†
" earthy green carb. of,†
" black,†
Zinc, siliceous oxid of,
" carbonate of,
Iron, pyritous,
" black oxid of, (cemented iron sand,)
" red oxid of,
" hydrate of,
" silicate of,

*Occasionally occurring among the pebbles constituting the mass of the conglomerate.

†Chiefly in those portions of the veins traversing the conglomerate.

Mineral veins of the Trap. Conglomerate, &c.

In order to render the subject of the mineral veins traversing the above rock, so far intelligible as may be in my power, I have already been particular to define, as far as could be done without maps and sections, the relation which the trap rocks, together with the superincumbent conglomerate, mixed sand and conglomerate and red sandrock bear to each other, and it will be necessary, in considering the mineral contents of these rocks and the veins traversing them, to keep this relation constantly and clearly in view.

It will be recollected, that the north-westerly range of hills, commencing at the extremity of Keweenaw point, and stretching from thence in a south-westerly direction into the interior, were referred to as being more clearly of trappose origin than either of the other ranges, and that the rock of the southerly portion of this range is either compact greenstone or altered syenite, while that of the northerly flank is almost invariably either an amygdaloid or a rock approaching to toadstone.

The several ranges of hills to the south of that last alluded to, are either well formed, compact greenstones, altered syenite, or, (as we approach the primary range,) imperfectly formed granites. So far as the several ranges of hills, lying south from the northerly range, are concerned, they would appear to be, as a whole, deficient in minerals, and the rocks are not apparently traversed by veins or dykes of any more recent date than that of the uplift of the northerly trap hills.

Veins clearly of a date posterior to the uplift of that portion of the trap rock last mentioned, are of frequent occurrence, and these veins not only traverse a portion of the trap range, but also pass into the conglomerate, and sometimes completely across the three sedimentary rocks, immediately above the trap, thus having an unbroken length of several miles. The class of veins to which I now allude, where they occur in a connected or continuous portion of the range, rarely vary more than 12° to 15° from a right angle to the line of bearing of the sedimentary rocks, and in pursuing this course, they necessarily cut across the dykes of trap before alluded to as so frequently appearing between the strata, and conforming to the dip of the lower sedimentary rocks.

That the veins under consideration belong to a single epoch, is inferred from the fact, that none have been noticed with other veins crossing them, as also for the reason that none have ever been noticed with dislocations, heaves or disturbance of any kind, save what may be referred to causes connected with their immediate origin.

That these veins must be regarded in the strictest sense as true veins, cannot be doubted, and that their origin or source, over the extended district alluded to, has been the same, is inferred from the perfect identity of their mineral contents; for a description of one of these true veins may be said to be essentially a description of the whole. Thus, while the mineral contents of the different portions of the same vein change as the rock traversed changes, the corresponding portions of different veins almost invariably bear a striking and close resemblance to each other.

These veins, as has already been stated, where they traverse connected ranges of the trap, are regular in course and direction, but when they are connected with a single uplifted knob of that rock, they are irregular and can scarcely be defined, appearing, in the latter instance, rather as matter injected into the fissures of a shattered mass of rock, than as connected veins.

The importance of carefully studying the relation which these veins bear to the rocks which they traverse, as also the relation which they bear to the numerous trap dykes, together with the few cotemporaneous veins noticed in the trap, is very much increased by the circumstance, that these veins are more or less connected with, or rather contain, metallic materials, which, it may be fairly inferred, will hereafter become of very considerable practical importance. In fact, so far as we may be enabled to judge from the examinations already made in this district of country, it is confidently believed that most, if not all the metalliferous veins of the upper peninsula belong to veins of the epoch of those under consideration. It is true that native metals, more particularly copper, are sometimes found, in place, occupying the joints or natural septæ of the greenstone, but in these instances, the amount of metal is always comparatively small, and, with one or two exceptions, I have invariably been able to establish some connection between the native metal occupying these joints and the termination of some metalliferous vein that traverses other portions of the rock not far distant, and it is believed that the metal filling these joints has invariably resulted from the action of causes precisely analagous to those which have placed similar metals in the veins to which I have alluded.

The earliest as well as all travellers, who have visited the district of country under consideration, have not failed to make frequent allusion to the loose masses of native copper that have been occasionally found scattered over it, nor has any one failed to allude to the large bowlder or loose mass of that metal, upon the Ontonagon river. Almost invariably, the opinion has been expressed, from the frequent occurrence of these masses, that the metal must be abundant in the country. But, after all, the true sources from which these masses had their origin, or the relation which they held to the rocks of the district, would appear never to have been understood; and all or nearly all that was known of their true relations, was left to conjecture. The result of this has been, that while some have excessively magnified every thing connected with a subject of which, in truth, nothing was known, another class, equally far from what is really true, have regarded these masses of native copper as bowlders transported from high northern latitudes.*

*The vast area of country over which the bowlders of native copper, from the district under consideration, together with its westerly prolongation,) have been transported, is worthy of remark. They are not of unfrequent occurrence in the sand and gravel of the southern peninsula of Michigan, and since the commencement of the geological survey, many of these masses have been met, some of which weigh from seven to eight pounds. In the vicinity of Green bay, a mass was discovered, some ten years ago, which weighed 140 pounds, if my memory serves me correctly. Loose masses of a similar character have been met with in various other portions of Wisconsin, as also at various points in Illinois, Indiana and Ohio. In these eases, the occurrence of these masses of native copper are no more indications of the existence of veins of the metal in the immediate vicinity, than are the immense numbers of primary bowlders scattered over the southern peninsula of Michigan indications of the existence of primary rock in place, in the district where they are found.

As far back as 1831 and 1832, I had occasion to pass, no less than three times, along the south coast of Lake Superior, as also to ascend several of the important tributaries of that lake, and during these years, I passed by three different routes, widely separated from each other, completely across to the Mississippi river. It is true that these journies, made through a complete wilderness, uninhabited except by savages, were necessarily made under circumstances that admitted of only very general observations; but the result of these previous examinations have proved of immense service to me, in aiding the labors of the past season. I allude to these journies and examinations at this time, in order to show you the difficulties by which a full understanding of the subject under consideration is surrounded, for I became satisfied at that time, not only that the subject was not understood by the mass of those who had traversed the country, but that even the natives of the country had no knowledge of the true sources from which the transported masses of copper had their origin.

During the time of the examinations referred to, a bare glimmer of light was thrown upon the subject by an examination of some small masses of, copper, found occupying the joints of the greenstone; as also by the examination of a single vein in the conglomerate, containing the ores of copper, which has since been found to be the termination of a vein that is somewhat obscurely continued from the trap region. While these examinations were sufficient to enable me to draw the inference that the masses of native copper came chiefly, if not wholly, from the trap, and more rarely from those sedimentary rocks resting immediately upon it, it was supposed that this occurrence would follow the general law, and that it, together with the other ores of the metal, would occur in greatest abundance near the line of junction of this rock, with the overlaying sedimentary rocks. Nothing, or at least very little, was known of the true extent or range of the trap rocks, and the very great inaccuracies in the published maps of the country, rendered it almost impossible to apply even the data on hand to such purpose as to relieve the embarrassment.

With a full knowledge of these difficulties, I determined, during the past season, to endeavor to surmount them by so far adding to our geographical knowledge of the coast of the lake and its immediate vicinity as to enable me to place whatever geological observations of importance might be made in such condition that the relations of the several parts might be understood. Having sufficiently accomplished this, I proceeded to a very minute examination of the several rocks overlaying

or resting against the trap, together with a determination of the thickness of the several members and their rate of decrease or wedging to the east. With these data I was enabled, by noting the dip of the rock upon the coast, to determine, with sufficient accuracy for the purposes to which the rule was to be applied, the line of junction between the trap and conglomerate rocks. This rule, when put in practice, enabled me to decide, with a very considerable degree of certainty, this line of junction, when the rocks were covered with a very considerable thickness of detrital matter, and when so covered, I was enabled, by traversing the country, on the line of bearing of the upper rocks, the more readily to gain access to such points as would admit of examination.

These observations soon showed me that this line of junction between the trap rock, arid the south edge of the conglomerate, instead of pursuing a course parallel to the coast, only continued its parallelism for a few miles westerly from the extremity of Keweenaw point after which, for a long distance, it recedes from the coast rapidly. These facts served to explain in part, why the subject of the origin of the masses of copper had remained a mystery, for the country through which this line passes is hardly ever passed over, even by the Indians, and probably large portions of it have never been passed over by whites, but in addition to this, the obscure character of the metalliferous veins is such that they would scarcely attract the observation of the traveller whose attention was not called especially to the subject, for many of the richest ores are so far from having the appearance of the pure metal that they would be the last suspected to contain it in any form.

That the connection of these ores with the containing rocks was not understood by the English mining company, whose attention was turned to this subject, at an early day, is to be inferred from the fact that they commenced their operations at Miners' river, where the rock is the upper or grey sandstone, which has never been observed to contain mineral veins; and also on Ontonagon river, near the mass of native copper, at which point a shaft was commenced and carried about 40 feet through a reddish clay, at which point the red sandrock was reached. Now, although the metalliferous veins sometimes pass from the trap across the red sandstone, these veins in the red sandrock have never been noticed to contain any other ores than those of zinc and iron, unless it be at the immediate point where the vein crossing comes in contact with a dyke of trap, which condition does not exist at the point alluded to, on Ontonagon river. What indications could have induced these Quixotic trials at the points where they were commenced, is more than I have been able to divine, and as might have been anticipated, the attempts resulted in a failure to find the object sought.

Having thus, in a general manner, set forth the obscurity by which the subject of the true source of the transported masses of native copper has been surrounded, together with some of the reasons which have served to prevent its being fairly understood, I will now proceed to a general sketch of the metalliferous veins of the district, so far as the same have been examined; premising, that our knowledge of them is still deficient in very many important particulars, which can only be supplied by a careful and continued examination of the subject, which, in fact, can only be said to be but just commenced.

I have had occasion to refer to the outer or northerly range of hills, or those from which the metalliferous veins may be said to spring, as being composed of trap rock, and lest what has been said may not be fairly understood, I will repeat, that the more southerly part of the range is uniformly composed of compact greenstone, under which head I not only include true greenstone, but also those forms of altered granular gneiss and gneissoid granite, which sometimes are associated with it, while the outer or northerly portion of the same range is usually composed of an amygdaloidal form of trap. The cells of the amygdaloid are usually filled with the different varieties of quartz, carnelian, chalcedony and agate, and sometimes, though more rarely, with native copper, or with calcareous spar, though they are sometimes entirely empty, constituting a perfect toadstone.

The metalliferous veins cross this range of trap, usually very nearly at right angles to the prolongation of the hills, and are frequently continued in the same course, across the upper or sedimentary rocks, thus crossing the latter at an angle varying but little from their line of bearing. While the continuity, of course, of the vein, may remain perfect in its complete passage from the greenstone across the several members of the conglomerate, mixed and red sandstone rocks, the character and mineral contents of the vein undergoes essential change, and not only does the vein appear to be influenced in its mineral contents, but also in its width, for, as a general rule, the width of the vein increases as we proceed northerly, or from the greenstone. Thus, a vein which may appear of only a few inches in width, or as a bare line in the southerly or greenstone portion of the range, increases in width rapidly as it approaches and passes across the amygdaloid, and at or near the line of junction between the amygdaloid and the sedimentary rocks it will frequently be found to have attained a thickness of several feet, while in its passage across the sedimentary rocks it is usually either still further increased in width, or becomes so blended with the rock itself, as to render it difficult to define its boundaries.

These metalliferous veins, like those which occur under similar circumstances in other portions of the globe, do not continue uninterruptedly of any given width, for great distances, nor is their width increased regularly, for they frequently ramify or branch off in strings, that pursue a course generally somewhat parallel to the general direction of the main vein, and which eventually again unite with it. Sometimes these ramifications or branches destroy, as it were, for a considerable distance, the whole vein; but they at length unite again, and the main vein is, after their junction, as perfectly developed as before.

While traversing the most compact, southerly portions of the greenstone, the veins are most frequently made up of a very compact and finely granulated greenstone, sometimes associated with steatitic minerals and silicate of iron, under which circumstances they usually are destitute of any other metallic mineral, but occasionally, instead of the materials above mentioned, their place is supplied by native copper, without vein stone or matrix, and usually free from nearly all earthly impurities, but almost invariably incrusted with oxid, or carbonate of the metal. Those portions of the vein traversing the greenstone, in which native copper occurs, under the circumstances above mentioned, are invariably thin, rarely exceeding 3 to 4 inches in thickness, and usually considerably less, and they are liable to very considerable variation in width, from the divergence caused by the vein traversing the joints of the rock, where these joints produce the same character of change as is produced by the ordinary ramification of a vein.

As these metalliferous veins traverse the northerly portion of the range, or approach the sedimentary rocks, they undergo a gradual change in width as well as in mineral character, and it has been noticed that where the amygdaloid is most largely developed, the vein, as a general rule, has not only a greater width, but also has its mineral contents more perfectly developed, a circumstance which might fairly have been inferred from the fact that those points where the amygdaloid occurs most largely, may be regarded to have been so many centres of intensity of action, at the time of the original uplift of the range, from which circumstance they would remain in a softened state, or in such condition as to admit of the more perfect formation of these cross veins for a longer space of time after that condition had been passed at other points.

In the outer or amygdaloid portion of the rock, the vein is almost invariably accompanied by a veinstone of quartz, involving all the varieties before mentioned, as associated with the trap rocks, which quartz, though occasionally it occurs massive, of several feet in width, usually appears in the shape of a series of irregularly ramifying and branching minor veins, that may be said to constitute the main vein. These subordinate veins of quartz, which may be stated as the true veinstone, vary from a mere line to several inches in thickness, and in the aggregate they may be said to constitute from one-third to one-half the total thickness of the vein. In their branches and ramifications, they sometimes include portions of the rock which they traverse, at other times they embrace imperfectly formed steatite, with silicate, carbonate and red oxyd of iron,* and occasionally, though more rarely, it is associated with carbonate of lime, usually assuming the form of an opaque rhombic spar.

As the main vein traverses the conglomerate and overlaying rocks to, and including the red sandstone, these veins, as a general rule, undergo still farther changes, for very soon after entering the conglomerate, the veinstone changes from its quartzose character, and is made up, either wholly, of calcareous matter, mostly rhomb spar, or of this mineral with occasional ramifications of quartz. The whole usually including, and sometimes investing fragments of the conglomerate or the pebbles of that rock, separated.

As the vein is continued still farther in the direction of and into the red sandstone, these changes are still noticed, and eventually the vein is found to be composed either entirely or

*The latter closely resembling the Gosgan, of the Cornish miners.

mostly of calcareous spar, and eventually so completely is its metalliferous character lost, that it would not, if examined singly, be suspected to be any portion of a metalliferous vein.

The metalliferous character of these veins is most largely developed almost directly at or near to the line of junction of the trap and sedimentary rocks, and they rarely continue, without considerable change, for a greater distance than one fourth to one-third of a mile, on either side of the line, though a few veins were noticed in which in the southerly or trap extension, the character of the vein continued for a distance of over a mile, nearly unchanged, while in its passage through the conglomerate, for half that distance, its character was also perfectly preserved.

The mineral character of the veins is somewhat varied in those having different degrees of thickness, though it is difficult, if not impossible, to lay down any rule which would characterize this change. The different veins vary very greatly in width, ranging from a mere line to 14 or 15 feet, the greatest observed width of any single vein.

In the descriptions of the veins given above, I only intend to include those which are most perfectly developed, for, in addition to these, there are also many which are imperfectly formed and short, and in which many of the above characters are in part or entirely wanting. These latter are usually of little practical importance, and thus far have been comparatively little examined.

Of the metallic minerals occurring in those portions of the *true* veins which traverse the trap rocks, together with that portion of the conglomerate immediately resting upon or against the trap, by far the most important consist of the several ores of copper, with which iron occurs disseminated in the forms before described, and occasionally, though very rarely, native silver has been detected, associated in the same vein. After as minute an examination of the subject, as circumstances will permit, I am led to the conclusion, that the only ores of the metallic minerals, occurring in those portions of the veins, which traverse the rocks last alluded to, which can reasonably be hoped to be turned to practical account, are those of copper.

In these portions of the veins, the metal referred to, occurs very frequently in the form of native copper, with which are associated the red oxyd, azure carbonate, green carbonate, and more rarely what may be

denominated copper black, and still more rarely, pyritous copper. *None* of these have been noticed in a crystaline form.

It must not be imagined that these several minerals make up the whole or even any very considerable portion of the entire length and breadth of the veins, in which they occur, for they are distributed in bunches, strings, and comparatively narrow subveins, in a manner precisely analagous to that in which these ores are usually distributed, in similar rocks, in other portions of the globe. The quartz veinstone, before described, has always so much of the green tinge communicated by the carbonate of copper, that it cannot fail to be detected; but the presence of disseminated native copper, in this veinstone, would, at first, hardly be suspected, and it is not until a fresh fracture has been made, and the mineral closely examined, that the numerous dark points and minute threads are discovered to be copper in a native state. Large portions of this quartz veinstone, (when the included metal can scarcely be detected by the naked eye,) when examined with a glass, are found to contain very delicate threads of native copper, that traverse the quartz in every possible direction, and so completely is this latter mineral bound together, that it is fractured with difficulty, and its toughness is very greatly increased.

The specific gravity of this veinstone is very considerably above that of ordinary quartz, and usually, the difference is so considerable, even in those masses where the copper can scarcely be detected by the naked eye, as to be apparent to even the most careless observer. But in addition to this finely disseminated condition of the native copper in the veinstone, it is also disseminated in a similar manner through the rocky matter embraced by the veinstone and in the amygdaloid and conglomerate portions of the rocks, it sometimes extends, for a distance of from two to three feet into the rocky matter on either side of the veins, sometimes completely, or in part, filling the cells of the amygdaloid rock.

The conditions above described refer to the main portions of the veins only, while there are other portions in which the copper appears to be concentrated in larger masses, constituting bunches and strings, and in which places the sides or walls of the veins are sometimes wholly made up of thin plates of native copper. In these portions of the metalliferous veins where the metal appears, as it were, to be concentrated, it also occurs, much in the form before described, except that the masses of metal vary from the merest speck to that of several pounds weight. In opening one of these veins, at a concentrated point, the observer, unless he had previously examined other portions of the vein, would be led to erroneous conclusions as to its richness, a source of error which cannot be too strongly guarded against; for while the vein, for a short distance, may be found to be exceedingly rich in mineral, the mineral in another portion of the vein may either wholly or in part disappear, a condition which is similar to that observed in those veins of copper that have been extensively worked and found to be most productive, on the continent of Europe and the island of Great Britain.

The excess of native copper, (compared with the other ores,) which occurs, *in these portions* of the veins, is a peculiar feature, for it may be said, in truth, that other ores are of rare occurrence. In those portions of the veins traversing the trap, and where other ores do occur, it is usually under such circumstances as to favor the presumption that their origin is chiefly from that which was previously in a native form; for the carbonates and oxyds, almost invariably appear either investing the native copper, or intimately associated with it, though they sometimes appear in distinct sub-veins. Pyritous copper is so rare, in connection with the trappean portions of the veins, as scarcely to deserve notice.

I have already stated that native silver, occasionally, though very rarely, occurs in the trappean portions of these veins, intimately associated with the copper, but it is in so minute quantities as to render it probable that it will not prove of any practical importance. Other mixed compounds of this metal occur so rarely as scarcely to deserve notice.

Leaving the trap rock, the character of these veins, as they traverse the conglomerate, undergoes important changes; for not only does the veinstone become gradually changed, from quartz to calcareous spar, but the amount of native copper diminishes, and its place is either supplied wholly or in part by ores of zinc and calcareous spar, or wholly by this latter mineral. There are, however, occasional exceptions to this *general* rule, for occasionally the place of the native copper in the veins, in their passage through the conglomerate, is supplied by a variety of complex compounds of the same metal, which compounds are of exceeding interest; but this change would appear always to be intimately connected with, or to bear some relation to, the dykes of trap which traverse the conglomerate rock. Several instances of this kind were noticed upon the northerly side of Keweenaw point, either directly upon or near to the coast, as also at several other places in the interior, westerly from Keweenaw point. A vein, which may without doubt be referred to as one of this character, (though in consequence of intervening bays and lakes between it and the ranges to the south, its connection with the main range has not been seen,) will serve to illustrate the character referred to.

This vein, which reaches the immediate coast of the lake, upon the easterly cape of the bay known to the voyageurs as the Grande Marrais of Keweenaw point, terminates, so far as examinations can be made, in the coarse conglomerate rock. The coast of the lake, for many miles on either side, is made up of abrupt cliffs of a similar rock, the rock as usual, being made up of coarse rolled pebbles of trap, chiefly cemented with calcareous matter, which is usually associated, more or less, with the red oxyd of iron. Immediately south of the coast, a heavy dyke of trap traverses the conglomerate, which dyke corresponds in position with line of bearing and dip of the conglomerate rock.

The vein, which, at its termination upon the immediate coast of the lake, has an extreme width of about 10 feet, may be traced, in the bed of the lake, in a direction north 5° east, for a distance of several rods, after which, in consequence of the depth of water, it is completely lost. This vein, at the point where it appears upon the coast, may be said to be in a concentrated state, or in a condition analagous to that before described, where the native copper occurs in the condition of bunches and strings, though the condition in which the metallic minerals occur, is essentially different from that in the trap; for, instead of native copper, we have several mixed forms of the green and blue carbonates of copper and copper black, more or less intimately associated with calcareous spar, and in the adjoining rock, and in small ramifying veins, occasional small specks and masses of native copper, weighing from 1 to 3 oz., occur, but these are by no means abundant. No quartz occurs as a veinstone, and none of the ores have been noticed in a crystaline form.

It has already been stated, that these true veins, in traversing the conglomerate, frequently almost loose their character, and it becomes difficult to define their absolute width, or in other words, it would appear as if, at the time of the formation of the veins, the conglomerate had not been perfectly cemented, the result of which would be, that the mineral matter, which, under other circumstances, would constitute a perfect vein, would frequently appear in only an imperfect one, or the mineral which would, under other circumstances, make up the vein itself, may have been injected laterally through the interstices of the rolled masses constituting the conglomerate, in which case the mineral would, in fact, take the place of the ordinary cement, thus simply investing the pebbles of the conglomerate. Now, although at the point under consideration, a wide and remarkably distinct vein is developed, the rock, for many feet on either side, has the interstices between the pebbles filled wholly, or in part, with various mixed and irregular forms of the ores, accompanied by calcareous matter, as before stated, and with occasional specks and small masses of native copper.

Those veins traversing the conglomerate take on a similar character, to a greater or less extent, rather frequently, but the place of the copper is more usually supplied by the siliceous oxyd, and more rarely by the carbonate of zinc, which compounds, sometimes may be seen forming a perfect or partial cement to the rock, for considerable distances on either side of the main vein. These ores of zinc, like those of copper, are uniformly amorphous, and almost invariably more or less associated with some form of carbonate of lime, with which they may, under some circumstances, unless closely examined, be confounded.

Although these copper and zinc ores occasionally appear in considerable quantities, in those portion of the veins traversing the conglomerate, they usually embrace or simply encrust portions of the rocky matter; or rather the rocky matter and those ores appear to be coarsely and mechanically mixed. These veins furnish beautiful cabinet specimens of the blue and green carbonates of copper, and more rarely of pyritous copper, together with the other varieties mentioned.

Having already devoted a larger space to the consideration of these veins than had been intended, I will simply add, that in pursuing their course northerly, across the mixed rock and the red sandrock, their mineral character is nearly or quite lost, the veins as before stated, being made up either entirely of calcareous spar or of that material containing very meagre ores or zinc.

The district of country to which these veins have been referred, thus far, only comprises the ranges of hills south of Lake Superior, but veins of a very similar character, and of similar mineral contents, also occur upon Isle Royale. The order and changes in the character of the veins upon Isle Royale is necessarily reversed, or in other words, the southerly point of the vein corresponds to that of the north point in the district south of Lake Superior. The mineral veins of Isle Royale have not been examined with sufficient care to enable me to determine with much certainty, their average width or value. Those examined were mostly narrow, the widest not exceeding 18 inches, but in these the mineral contents are essentially the same as in those upon the south side of the lake.

Native copper, in very thin plates, was occasionally noticed, occupying irregularly the joints of the compact greenstone of Isle Royale, but invariably in comparatively small quantities. It should, however, be noticed of Isle Royale, that the veins, so far as examined, are less perfectly developed in their passage across the conglomerate, and that they very rarely contain any traces of zinc.

Upon the north shore of the lake, no attention was given to the subject of mineral veins, but from the character of the geology of that district, it maybe inferred that they will also be found in portions of it, and that, where they do occur, they will be uniformly either directly upon or not far from the coast of the lake.

In addition to the *regular* veins already described, irregular veins frequently occur, traversing the whole, or portions, of the outliers of trap, or those knobs which appear to have been elevated singly; and although these veins may without doubt, be referred to the same epoch as the regular veins before described, they nevertheless frequently differ considerably in mineral contents.

The limits of the present report will not permit a separate description of these several distinct trap knobs. I will therefore confine my remarks to that already referred to, as occurring upon the south coast of Lake Superior, immediate northwest from Riviere Des Morts, and which forms the promontory known m Presque Isle.

In nearly all those portions of this knob, where the trap, conglomerate and sandstone, are exposed in such a manner as to permit examination, each of the rocks are

seen to be traversed by innumerable irregular ramifying veins, which in the sandstones are made up of quartzose and calcareous matter; but many of which, near the junction of the igneous and sedimentary rocks, are metalliferous, and this metalliferous character is more fully developed as the veins are extended into the trap rock.

The metalliferous portion of these veins, rarely exceed three to four inches in width, and they ramify in such a manner that the mineral uniformly occupies situations similar to bunches or strings, at the junction of the ramifications. The minerals contained in the metalliferous portions of the veins, are sulphuret and carbonate of lead, earthy, green carbonate of copper, pyritous iron, and more rarely, pyritous copper. Occasionally there is a quartzose, or mixed quartzose and calcareous veinstone; but more usually the several metallic minerals are blended in a base of rocky matter. The sulphuret of lead is distributed in the form of small cubic crystals, while the other metallic minerals are usually distributed either in irregular masses, or investing portions of the rocky matter. These associations are referred to, as showing the character which these irregular veins assume, rather than from any supposed value which they may possess for practical purposes.

In addition to the minerals referred to, the trap of Presque Isle occasionally contains asbestus, common serpentine and imperfect agates; the two former minerals usually occupying the narrow joints of the rock.

Before referring to the economical considerations connected with the veins which have been described, I will briefly refer to another situation in which the ores of copper have been observed in intimate connection with the trap range of rocks.

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 steatitac 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 portions 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 none 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.*

The examinations which have thus far been made of those portions of the veins containing ores of zinc, have not been extended sufficiently 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 districts 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 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

*These 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.

of Michigan, to institute comparisons, but there are also some points on which there is a considerable degree of discrepency.

The comparison instituted, in the main, is intended to refer rather to the character and contents of the mineral veins of 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 subjected 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 percent 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. of tons cop- per produ- ced per year.	Av. amount per year for which sold.	Av. per ct. of 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 "	51,483	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 districts 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 Jed 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 were formed at the same time as the containing rock, and *true veins*, whose formation is supposed to be subsequent to that of the rooks 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."* 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.

*Carne, on the mineral veins of Cornwall

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, veinstone, that, according to the rock which the veins intersect, will be fluorspar, 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 and working the valuable accumulations of the metals, with as little waste of labor and expense on the poor 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.* Some veins appear to grow wider, while others contract as they decend.

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 granitiform 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.†

Where a rock is crossed and penetrated by a great number of small veins in every direction, the whole mass is sometimes worked as an ore, and is called by the Germans a "stock-worke." 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 com-

*Koenig.

†Lyell. Neeker.

bination 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 of 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 Presqne 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 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 were more liable to disseminate and keep alive such errors. The occurrence of masses of native metal, either transported or in place, are 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 exite 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 that ruinous spirit of gambling adventure which has been productive of so much misery."* 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 185 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 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, lest perhaps this isolated mass

*Hawkins on the tin of Cornwall.

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 bowlder.

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 bowlder, 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 3 to 4 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 sand rock 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 excepting iron pyrites. Along a portion of the distance, however, the rock of the cliffs 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 travellers, 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 feint 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 winters, 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 the 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 stinted 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 the 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 enclose 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 underlaid 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 a 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 attained 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 northwest, 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 bounded. 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 travellers 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 exent of the inducements held out to individual enterprise 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 this 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 honorable 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,* 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 consequences 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 a reasonable prospect that the fishing trade will eventually prove of great importance.

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

*An undescribed species of the genus Salmo.

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 "landlocked," 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 maps 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 farther 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 such nicety.

Several rude attempts were made, however, with such means as we possessed, using a similar method, to fix the longitudes 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, (encamp't, May 27,)	45° 58′ 26″ 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,	46° 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 lines 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 effected 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 terrestial magnetism, many of whose principles are as yet enveloped in mystery.

Table of Magnetic Variations.

				Riviere de Ste Marie.	
May	27.	4 h.	16 m.	P. M.	West side Drummond Island,	0° 9′ E.
	29.	6	30	A. M.	Small Island in Montreal channel,	0° 12′
	30.	9	16	"	Saut de Ste Marie,	1° 25′
					Lake Superior.	
June	8.	5	15	P. M.	Grand Marrais 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 1st 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 tracts of hemlock and pine, and with an occasional cedar swamp. In the vicinity of Grand Traverse bay, this character of country extends into the interior 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, from 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, sunfish, &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 Rogue, Maskegon and White rivers, and the Ottowa Indians, 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 Rogue rivers is generally rolling, interspersed with level and knobby tracts, but none is so rough as to prevent its being succesfully 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 far inferior to, or more subject to early frosts in the fall than the more southern counties of 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 have 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, and 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.

	Township.		
1		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 “	Corniferous limestone.	Containing beds of hornstone.
5	“ 34 “	Little Traverse bay limestone.	Beds of limestone, intermixed with clay & chert.
6	“ 34 “	Black bituminous limestone.	Composed of congeries of shells.
7	“ “ “	Blue limestone, in thick regular layers.	
8		Mackinac limestone.	Very porous and much shattered.

Rocks as seen forming the coast of Lake Huron.

	Township.		
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, containing pyrites.
5	28 “	Thunder bay limestone.	Beds of limestone and grey clay or shale, containing abundant fossils.
6	30, 31 “	Black bituminous limestone.	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 out crops the rocks would appear to have a bearing nearly north 70° west, and south 70° east, which line of bearing corresponds with the out crop 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 un conform ably 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 unctuous 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 lakes 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 layers 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; Delthyrus speciosa, Calymene bufo, Gorgonia, Millepore, Catenipora stellata, Cyathophyllum dianthus, Calamapora spongites, Pentremites pyriforrnis.

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 congries 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 Blumembachii, Atrypa aspera and prisca, Delthyrus 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, Euomphaulus 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 contains 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 soar 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 Rabit;" 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 fifteen 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 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 slighty 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 stratifyed 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 building 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, Ceriopora 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, analagous 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 limestone 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 part 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 geological 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 formations, *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.

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. Alluvions, ancient, recent.
B. Tertiary clays.
C. Coal measures.
   - Upper coal and shales.
   - Lower coal and shale.
   - Included sandstones.
   - Limestone stratum.
D. Sub-carboniferous sandstones.
E. Clay and kidney-ironstone formation.
F. Sandstones, of Point aux Barqes.
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 consist 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 disruptured 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 boulders of that material occur. Limestone pebbles and boulders 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, imparts 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 part 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 number 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, these 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 circumstance 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 sub-strata. 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 features 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 associated 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 overspreads 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 bounding 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 limerock 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 boulders, 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 outcrop 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 northerly, 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 and 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 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 20 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 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 will, 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 Lepidodendron, Stigmaria and Calamites.

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 sand-rocks 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.

	Thickness.
Diluviums and tertiary clays,	1 to 100 ft.
Brown or grey sandstone,*	20
Argillaceous iron ore, in thin included beds,*	1
Coal strata, alternating with friable slaty sandstone and thick beds of black shale and slate;* in the whole probably,	30
Red or variegated sandstone, (Clinton and Ionia counties,	Undetermined.
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,)	
Coal and black bituminous shale, (Jackson, Ingham, Shiawassee, and Genesee,	20
Blue, compact, slaty standstone, (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 sandstones*, excepting in some of the uppermost strata, are generally fine grained and of a yellow color. Some strata of the latter

*Counties of Clinton and Eaton.

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 shaly 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 or 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, bold 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 gyperous 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 slate now under consideration, there is a well characterized black, bituminous slate. This rock makes an outcrop much farther 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 southwestern part of our state. The overlying tertiary clays conceal a great part of this formation.

The character and economical adaptation 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; Calymene and Asaphus, Cyathophyllum, Productus, Terebratula, Spirifer and Dethlyrus, Bellero-phon, Atrypa, Strophomena, Orthocera, Encrinus, 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 given on page 130 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.
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 ft.
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 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 125, as constituting the terminating rock of the coal basin. At this point, several of the next succeeding series of sand-rocks 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.

		Thickness 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,	2⅜	140⅜
20	Gypsum, with vein of salt water,	6¾	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,	1¼	180¼
27	Clay rock, free from saline matter,	10¾	191
28	Hard sandrock, very compact and of dark color,	7	198
29	Soft sandrock, nearly colorless,	18	216
30	do 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 rock," and they are thus shown to furnish a brine superior in strength to that of many of the salt wells of Ohio, and winch, 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 supply 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 Michigan 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, described on page 131 of this report, and a more extended notice will be found in the geological report of 1840, pages 25 and 86.

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 15 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 at which this ore occurs, see geological report of 1840, pages 28, 60 and 100.

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 through parts of Kent, Ionia and Genesee counties. (See further statements under pages 126 and 127 of present report.)

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 $300,000 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.

GYPSUM. 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 1 acre to 100, 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 financial difficulties, we are rapidly advancing in wealth, and are becoming awakened to the means of which we find ourselves possessed, for successfully competing with older states, in the departments of agriculture, commerce and manufactures. With lands among the richest in the world, well watered and advantageously situated for market, with water power abundant, and with an extent of coast and facilities for water transportation unequalled by any other inland state, and added to this, a population possessing a large share of that character for enterprise which distinguishes their countrymen, nothing will tend more to give full efficacy and permanency to these advantages, than to make more perfectly known the value of our mineral resources. Our state is now sufficiently advanced to be able to avail herself, properly and with certainty, of the advantages alluded to, and there is every reason to believe, that these will not longer fail to command attention, and that the results will equal the most sanguine anticipations.

BELA HUBBARD,
Assistant Geologist

REPORT
Of S. W. HIGGINS, Topographer of Geological Survey.

Detroit, January 24, 1841.

To DOUGLASS HOUGHTON, *State Geologist:*

SIR—In fulfillment of your instructions, I have, in the present report, brought together such observations relating to the magnetic variation in this state, as will, I trust, assist hereafter in affixing data to important facts. Further developments will require a prolonged period and additional observations. But the readiness with which the direction of magnetic lines may be ascertained, by the help of the solar compass, will render the labor and hazard of error a thousand fold less than any former method, and it is hoped that this compass will supercede everywhere, the necessity of depending alone upon the needle.

A great desideratum is obtained in having an instrument that will decide between antagonist forces, and indicate the inflections of magnetic lines, and determine mathematically, their amount.

From what has been advanced, an opinion is drawn in favor of magnetism being diffused throughout the particles which compose the mass of the earth, and against that of a magnetic nucleus at its centre. The modifications in the magnetic lines on the peninsula, are seen to be abrupt and irregular, where there are no indications of ferruginous matter, and in the absence of mountainous chains, equally as where mountains do exist.

But this subject when considered in connection with others, assumes no less importance. The changes which are silently and gradually progressing in the arrangement of the materials of the earth, are partly due to magnetic and electro-magnetic powers; other powers may co-operate in the production of general results, but the first are known to be active where there are metals and ores, and to these may probably be referred the arrangement and filling of mineral veins.

In an economical point of view, the level tracts and marshes in our state may be considered of great importance. Though the expense of clearing new lands is trifling, particularly our openings and plains, compared with the heavy timbered lands of the east, yet to drain the marshes and convert them into arable land, is still less expensive than either. There is little doubt of the success of operations in progress, by which many of them are becoming permanently dry, while others will require artificial aid. In either case large and valuable portions of the richest soil are reclaimed.

There appears to be throughout the state, a singular connection between the marshes and the openings and plains; where the one is found the other is usually associated with it, while the timbered lands are comparatively free from either large or numerous marshes. The course of policy for the preservation of the timber on the openings, which must inevitably in time become lessened in quantity, while its value increases, is to adopt those modes which will most speedily recover the tracts under consideration, and thus prevent the waste of timber which cannot be replaced.

In the report which follows, and in which I have alluded to the above subject with others, I did not feel at liberty to extend my remarks further than a detail of facts.

VARIATION OF THE MAGNETIC NEEDLE.—*General law relating to magnetism—causes of the pertubations of the needle—experiment—opinion concerning local attraction—mile applicable in explanation of the needle's attraction on the peninsula—general correctness of the observation in the public surveys-example—conditions by which it is demonstrated—description of the line of no variation—its course independent—no correspondence in exterior lines-—similar system of curves at Great and Little point aux Sable*—BURT'S SOLAR COMPASS—*Professor Loomis' report on annual changes in magnetic meridians—diffusion of magnetism, &c.*

The general law regulating the forces of magnetism, with its direction and intensity, has been untiringly studied, until by certain tests, it has at last been discovered that palpable effects are produced by the magnet on all substances whether organic or inorganic, and there seem to be only two ways of accounting for the phenomena: "either that all substances in nature are susceptible of magnetism, or all possess particles of iron or some other magnetic metal, from which this property is derived."

The obvious pertubations of the needle, as seen in all situations at times, arise from many small causes combined, and which, so far as they exert their force, influence the greater power of terrestrial magnetism, whereby it becomes propo-tionably feeble, as these combinations are multiplied. Atmospheric changes operate still further, and in a more sudden manner, to effect the needle; but the first causes mentioned are the most perplexing, and surveyors have attributed to local causes that which is found to be inherent in all substances.

The following single experiment will evince how far local causes are concerned in general. If a small needle be constructed of any substance, and suspended between two magnets, it will be found to fie itself in a line in the direction of the poles of the magnets, and the number of oscillations in a given time, will usually determine in different needles, the quantity of matter susceptible of magnetism in each; thus an important discovery has been made by means of this active principle, whereby is detected the least insensible traces of iron, when all other tests have failed.*

The opinion then, is an erroneous one, that mineral must always be present in masses, to cause the aberrations of the needle. This is not necessary, nor is it the fact; for

those minerals which are deeply buried can have no influence, inasmuch as their influence decreases inversely as the squares of the distance, and it may be said that the needle is wholly indeterminate in their neighborhood in respect to them, “since the resultant of magnetic forces being then vertical,” or nearly so, or nothing, “the horizontal element would be nothing.”

If it is true, as has already been abundantly proved, that magnetism, electricity, and gravitation are governed by the same laws, and that they decrease in the ratio of the squares of their distances from attracting bodies, it becomes difficult to define what is meant by “ local attraction,” in the common acceptation of the term, unless it be granted that the regions where it has been met with so commonly, abound in ores, or metallic substances to a great extent, or that it has been the misfortune of the surveyor to come so nearly in contact with mineral masses, above or near the surface of the earth, as to occasion the utter temporary loss of the polarity of the needle.

It may be laid down as a rule, applicable hereafter in explanation of most of the deviations of the needle, which occur in the central and western portions of the state, (there being but few rocks in *situ* that appear on the surface, and those lime, slate and sand rock, and the geological structure of the peninsula, being such as to preclude all opinion of there being ores or metals, or any kind of minerals, except bituminous coal, marl, and the like, further than what is found in all alluvial and mountainless countries, and there being an utter impossibility of any masses other than what may be erratic, capable of producing any great effect;) that as the direction of the needle is the effect of a principal terrestrial force, its deviations arise

*Professor Farrer.

only from those smaller secondary forces which we have said are inherent in all substances.

Many facts might be adduced in verification of the above supposition, from the thousands of observations which have been made during the course of the surveys of the public lands in the state. Entire lines have been measured from the southern to the northern boundary of the peninsula across its whole breadth on true meridians, and these lines have again been intersected by others running east and west, at right angles, each line having the magnetic variation recorded at intervals of every six miles, the points of intersection. Within the limits of these lines is included the whole area of the lower peninsula of Michigan, (and by an exact enumeration of the meanders of the coast, in the intervals between the terminations of these lines, is obtained with the greatest accuracy, the number of square miles it contains;) now from the collected observations, after rejecting those east of the principal meridian, mentioned in my report of last year as erroneous—and a few others that might be specified which are made to correspond to the measurement of fractional lines—an area of 41,304 square miles, is laid out with the accuracy of a map, and the magnetic meridians traced with the same facility as any other known and prominent feature; in fact we have a magnetic chart, indicating the declination of the needle, over this extensive region, on parallels of equal distances of six miles.

Let us pause here a moment to satisfy the inquirer, who may have doubted even the ordinary correctness of the observations, generally, obtained by the men whose duty it has been to establish the standard and other exterior lines in the survey of our state. To this end the two examples mentioned in another part of this report, will be sufficient, though as I have stated, others might, with equal propriety, be adduced. One of the examples consists of forty-nine townships, and the other of fifty townships.

These examples are all verified by actual measurement, and, as it was to be expected, one of them falls a little short, and the other has an excess, only of five links in a mile, above the convergence which all meridian lines have when run north. Now, if an error, the gross of which should amount to 15’, had been made in their observations, the result would be a departure from parallelism in the lines, of thirty-five links to a mile, whereas, the result exhibits an error of less than 2’ to a mile.

Now, it is obvious from the foregoing, that there must be one of two conditions, which has given precision to the examples we have adduced; either the magnetic parallels have become greatly diminished in intensity, and accommodated themselves to the plane of astronomical longitude, or care and skill have been exercised to modify the effects produced by them.

The latter condition is the true one, as we shall shortly demonstrate. We begin, then, at a point where the line of no variation passes out of Lake Huron, and first touches the south side of Drummond island. This island is one of the north-westernmost of the chain of the Manitous which divide the waters of the straits of Ste Marie. It first touches the island near the meander post on the shore, between ranges 7 and 8 east, in township 41 north, and is the tangent point to a curve of 4½ miles radius which it then makes on the island, the western extremity of the curve touching again the south shore of the island in the middle of the next township, in range 6 east; whence a reversed curve of 81 miles radius, approaches closely to the corners and one-fifth of a mile south of fractional township 41 and 42, ranges 5 and 6 east; thence on a course south 85° west, 6 miles, intersecting township line 41 between ranges 4 and 5, near the meander post south shore of the island; which is another tangent point, to a curve, whose radius is 31 miles. Along this curve, at the distance of one mile, is the western end of the island, and at the meander post for fractional township 41 and 42, range 4 east; thence crossing the channel to the opposite side nearly, the curve terminates between Round island and the main land of the upper peninsula, one-fourth of a mile from the shore; thence another reverse curve of 21 miles radius,

just sweeps along the edge of the shore, northward of Pointe de Tour, the western termination of the curve being in a lake, on the south-west corner of township 42 north, range 3 east; thence again the curve is reversed, whose radius is 2½ miles, crossing the south boundary of the same township, 1¾ miles from its western boundary; whence the curve is again reversed, with a radius of 2¾ miles, passing off the coast into Lake Huron again, passing over one of the small islands near Massacre island; thence ascending, it re-crosses the south boundary of township 41 north, in range 2 east, between sections 33 and 34; thence curving north-westerly, with a radius of 6½ miles, it crosses the town line between ranges one and two east, 1¾ miles from south boundary; still slightly curving northwardly, on a course of 12 miles, it crosses north boundary line of township 43, range one east; thence two miles it intersects Monusco bay, and curving westerly, leaves the water, and crosses the south-east corner of town 45, range one east, three-fourths of a mile from corner post, into town 45, range 2 east; thence curving with, a radius of 6⅓ miles, enters,' at the mouth of the Miscota Sawgee river, the Canoe channel of the straits of Ste Marie, and crosses it about one mile above the Nebish rapids in that channel, touching the most westerly point of Great Sailor's Encampment island, and keeping the western and northern shore, with a curve whose radius is 8 miles; here its course is again reversed, and beyond this we have no sufficient data to pursue it farther.

It is believed, however, to pass directly on to the south-west point of Sugar island, keeping along its westerly side, and crossing again the straits of Ste Marie on to the main land, at the forks of the Montreal channel and Great Hay lake, five miles east of the Saut de Ste Marie; thence irregularly over the granite formations, and in conformity to the littoral features of Goulais and Batcheewauanung bays, touching Michipicoten harbor; thence, leaving the eastern end of Lake Superior, it has been said that it becomes forked, taking the circumference of Hudson's bay, or that the variation is the same on the eastern and western sides of the bay.

We have now followed it from Drummond to Sugar island, through its actual and determined course, leaving nothing to conjecture; and we remark, that for that distance, it is as well determined as any other ascertained line.*

This line, before touching Drummond island, where we first commenced with it, may with almost equal certainty be traced down along its southern course in, and to the foot of Lake Huron; although, for the reason that it is confined to the lake, we may not always ascertain its distance from the shore.

The course it would now take, in the diminished part of the lake, approaching the straits of Mackinac, would be somewhat analagous, it is presumed, to that in the straits of Ste Marie. This fact is proved from observation, first on the island of Mackinac, on the west, and along the north-east and east shore of the peninsula, south of and opposite Drummond island. It makes a large curve, which approaches the end of the lake, without touching Mackinac, and receding from it, descends south-easterly to the termination on the coast, of the town line between ranges four and five east, in town thirty-six north, where the variation is 1° 55' east. The same variation is found at the termination of town line thirty-four north, ranges six and seven east; thence east, eight miles, at Presque Isle, it is imperceptible. On Thunder bay point, it is 45' east, the line of no variation passing between the light-house on the outermost Thunder bay island, four miles from the shore, and this point; its course thence is to the outlet of the lake, near Fort Gratiot, where it crosses into Upper Canada.

From the fact that the line of no variation passing through a part of our state, we are in some measure better able to determine the rationale of another system of curves found elsewhere on the peninsula, particularly on its western side, at the Great and Little Pointe aux Sable, where a greater inten-

*The hour should be noted as 10 o'clock, A. M., for observations on this line.

sity is observable on approaching Lake Michigan from the east.

Under the ordinary ideas of magnetism, it would not have been believed that a line so curved as we have described, could have existed, without ascribing its irregularity to some corresponding cause of local force.

Although the upper peninsula of Michigan differs from the lower, in regard to its geological features, the conclusion might be drawn that at the line of junction of the rocks of the Riviere Ste Marie, as described in your third annual report, where it is well defined as at, and through the outlet of the lake, the magnetic lines would be deflected, somewhat with the line of bearing of these rocks, in a distance of thirty miles; but its course on the contrary appears to be independent of them, crossing them at right angles, and without regard to their character.

Another peculiarity is, that corresponding curves, exterior to the line of no variation, on either side, bear no comparison. At the head of Great Sailor's encampment island, at the distance of two miles west, the variation is 1° 10' east; and opposite the middle of the same island, at one mile east of the line, it is 40' west; at five miles, 1° west, and at six miles 1° 10' west; one mile south of Monusco bay, the distance of one and quarter miles east of it, the variation is 1° west; five miles west, 2° 35' east only, and the curve mentioned as again entering the lake between towns two and three, as well as the curve which passes around the edge of the shore above Pointe de Tour, have no variation at their centres, but on approaching either way, east or west, variation increases to 30', and then again decreases to 0, on touching the line of the curve.

The same peculiarities are observed on the western side of the lower peninsula, particularly at Great and Little Pointe aux Sable, where the intensity increases, and the

curves, though larger, exhibit as little conformity. It is evident that the needle "hauls to the land," to use a nautical phrase, for at these points, the increase of variation amounts to 3° in thirty miles, exceeding 6° at the points, while the increase is but 1° for the whole breath of Lake Michigan; the variation being but 7° in Wisconsin, on the opposite shore.

The instrument used in ascertaining the particulars we have been stating, is one totally different in its principles and construction from the common compass, and is not even dependent for its accuracy on the needle. It was invented by Judge Burt, of Macomb county; and the Messrs. Burts have given me the results of observations made by them with this instrument, during most of the last summer. The needle is used with this compass only when the sun is obscured by clouds; when the sun shines, the needle is screwed fast, and the time then consumed in obtaining the true meridian, is not longer than that ordinarily taken by a needle to settle, while it is infinitely more correct.

I had intended to have given a description of this valuable invention, but to do this clearly, without an accompanying drawing, was found impracticable. It is called the "solar compass," and consists chiefly of three arcs, one of which is graduated to the ecliptic, the other to the complement of latitude, and the third to the sun's declination, whereby, if the latitude be known, the others are known, viz: the sun's declination, and the apparent time, and consequently the magnetic variation; or if the sun's declination only be known, then the latitude, and the others are known; or if the time be known, the others can be ascertained by an almost instant adjustment.

We have not only now been enabled to adduce facts confirmatory of the general principles of terrestrial magnetism, but to enter considerably into detail on the subject of magnetic variation. A variety of reasons seemed to require this, the principle of which was, the definite course obtained of the line of no variation, and the consequent illustration of other lines on either side of it being also irregular; demonstrating a system of curves, and a series of distinct and separate centres of attraction. This has been effected over no very limited space, and is free from all that might be considered empirical.

It is believed that in accuracy and fullness of detail, these observations exceed all that has been hitherto attained, nor am I aware that the line of no variation was ever before traced continuously for any great distance, or that other observations have been taken, than at those points where it has been crossed by the surveyor or mariner.

It has been pretty well determined by professor Loomis, of Western Reserve college, Ohio, that the "present annual changes of variation, caused by the retrograde motion of the needle, which commenced everywhere as early as 1819, and in some places as early as 1793; is about 2' for the southern states, 4' for the middle and western states, and 6' for the New England states." This is true in general of the magnetic lines in this state where they are at a distance from the line of no variation, as at Detroit. Here the decrease or amount of retrograde motion is 4 4-10' annually; the line of no variation has been quite stationary, at least for the last eight years, at points where it was known at that period. While, therefore, we observe a greater intensity, as we approach nearer to the line of no variation, we likewise observe the distance to increase between the lines of equal variation, and while the first is stationary the latter is retrograding.

While the parallelism which takes place in needles, proves that the magnetic force of the terrestrial globe may, like that of gravitation, act in parallel lines, we see also an exception. The lines of gravitation are always perpendicular to the surface of the sphere, while the lines of magnetism, which like gravitation, never cross each other, are composed of every variety of curve.

Though the diffusion of magnetism be general, it is by no means equal. It is found at the equator and at the poles, an interposed space equal to the earth's radii, and for this space no loss is apparently felt in its force, and it is not more difficult to conceive an exerting force through this, or a greater interposed space, than that the hand should communicate motion to a stone, with which it is demonstrably not in contact.

If then magnetism be a real power, at what distance does it terminate? can we give it an inferior level, and determine its final bounds, connected with solar light and heat? does it not emanate from, and is it not governed by that great central source, the sun, which controls the more palpable and grosser materials of which the planetary system is composed, which effects every change either in the interior or exterior of this globe, and to which every element is subject, and by which are conducted in silent processes, all changes and revolutions, since time began?

DIURNAL VARIATION.

The following table of diurnal variation was sent to me by Hon. William A. Burt, who is in the constant practice of keeping a meteorological table in connection with his observations on the magnetic variation; the results are the same as noticed in my former report, though not then in detail. These observations were made in lat. 42° 43', N., long. 5° 24' 30" west, from Washington.

Table of Diurnal Variation, taken in Macomb County, Michigan.

July, 1839.	Thermometer.			Weather.		Magnetic Variation.			
Day.	5½, A. M.	1, P. M.	6½, P. M.	A. M.	P. M.	Winds.	5½, A. M.	1, P. M.	6½, P. M.
13	60°	79°	62°	Clear.	Light showers,	W. S. W.	1° 42′	1° 28′	1° 42′
14	59°	72°	67°	do	Flying clouds.	N. W.	1° 42′	1° 26′	1° 33′
15	at 5, 53½ at 6, 58	73°	64°	Cloudy.	Light showers.	N. W.	1° 32′	1° 28′	1° 28′
16	55°	71°	66°	do	Some cloudy,	W.	1° 38′	1° 28′	1° 30′
17	52°	80°	69°	Clear.	Clear.	W. N. W.	1° 30′	1° 28′	1° 30′
18	55°	85½°	83°	do	do	W.	1° 41′	1° 28′	1° 35′
19	56°	89°	82°	do	Flying clouds.	S. W.	1° 40′	1° 28′	1° 35′
20	63°	80°	74°	do	Cloudy.	S. S. W.	1° 40′	1° 25′	1° 35′
21	70°	82½°	77°	do	do	S.	1° 42′	1° 28′	1° 30′
22	72°	86°	75°	Cloudy.	Some cloudy.	W.	1° 40′	1° 28′	1° 35′
23	65°	88°	77°	Clear.	Clear.	E.	1° 41′	1° 23′	1° 36′
24	72°	86°	77°	Rain.	do	W. S. W.	1° 43′	1° 25′	1° 35′
25	69°	83°	80°	Clear.	do	N. W.	1° 41′	1° 15′	1° 32′
26	66°	88°	79°	do	Cloudy.	W.	1° 40′	1° 23′	1° 35′
27	69°	80°	76°	do	Showers.	W.	1° 41′	1° 30′	1° 37′
28	64°	86°	80°	do	Clear.	W.	1° 42′	1° 24′	1° 30′
29	66°	87°	78°	Cloudy.	do	W.	1° 41′	1° 21′	1° 30′
30	69°	90°	79°	Clear.	Showers.	W.	1° 41′	1° 25′	1° 38′
31	62½°	76°	72°	do	Clear.	W.	1° 40′	1° 24′	1° 33′
August 1	48°	79°	76°	do	do	W.	1° 40′	1° 24′	1° 28′

Note.—July 19, at 12 h. 30 min. P. M., variation 1° 10'; at 12 h. 45 min., var. 1° 15'; at 1 h., var. 1° 28'. July 24, at 6 h. 10 min. P. M.? shower commences, var. 1° 85'; at 6 h. 40 min., shower past, var. 1° 25'. July 27, at 5 h. 45 min. P. M., shower rising, var. 1° 47'; shower past, var. 1° 37'.

COUNTY SURVEYORS—*law respecting them—Judge Burt's compass—magnetic meridians—disappearance of original lines.*

From the statute* regulating the duties of county surveyors, it becomes indispensible to possess themselves of one of Burt's solar compasses; for it is made their duty to be acquainted, before entering upon a survey, with the absolute variation of the needle, at the time and place where the survey is to be made, and to note the same upon their certificates, and no returns are either lawful or can be received as evidence in any court, without it. It may be supposed that this might be dispensed with, when it is known that the surveyor in the sub-division of a section, must be governed by the section and quarter section posts already established, and that the business of dividing a section, therefore, is merely intersecting these posts with his line, without the power to change them when wrong; and when smaller divisions are required, of taking equal distances between them, whether the full complement of acres be wanting or otherwise.

But though most surveyors have a meridian line for their own accommodation, generally in their immediate neighborhood, from which they can determine the magnetic changes, yet when their duties require them in opposite parts of a county, where the variation not unfrequently differs a degree, it is obvious that time must be devoted to an observation of some star to obtain the variation, if it be a clear night, or if otherwise, the survey must be suspended until a more favorable time. Besides all this, his pay is fixed at a stated price per mile, and that price barely a compensation. Now, either to make the business desirable, and at the same time to fulfill the conditions of the law, he must have a ready method of getting the variation, or must spend his time in so doing, without an equivalent for his labor; and while the law remains as it is, no instrument besides the solar compass can enable the surveyor, with profit, completely to fulfill the intent of the statute.

This question is of no less importance now, than it will be in future, when all traces of the original lines shall have been lost, which is the case already, wherever the county has become settled and roads or fields have been opened along the boundaries of section lines.

*Part first, title second, chapter third, section sixty-nine, revised statutes. In all surveys made as aforesaid, the course shall be stated according to the true meridian, and the variations of the magnetic meridian shall also be stated, with the day, month and year.

Sec. 70. The surveyor and his deputies may demand and receive for their services, the following fees, to wit: for each mile actually run with the compass, and measured with the chain, three dollars: *Provided*, That the necessary chainmen and markers be furnished by the surveyors or his deputy, at the request of the parties requiring the survey, but if the chainmen and markers are furnished by the party for whom the survey is made, or if the chainmen and markers be not necessary, then the surveyor and his deputies shall receive for each mile run, seventy-five cents, &c.

AREA OF THE LOWER PENINSULA OF MICHIGAN—*former maps and descriptions, erroneous—definite information now obtained.*

We have now the means of ascertaining, with the utmost degree of accuracy, the precise area of the lower peninsula, an accuracy characteristic of the plan pursued where the general government has the control of the surveys. These surveys afford the greatest facility in determining the boundaries and extent of every portion over which they have been made, from an eighty acre lot to a whole territory; and such has been their progress within the last three years, that there remains only the small fraction of thirty-six townships unsubdivided; but these being mostly in the interior, present no difficulty in determining at once the exact number of square miles contained within the boundaries under consideration. I have with extreme care, multiplied together every fraction, and find the whole amount to be 41,304 square miles or 26,434,560 square acres.

In giving the above estimate, we cannot avoid the opportunity of confronting its results with the compilations of draftsmen and geographers, who, in relation to the peninsula, have heretofore, in the main, copied such estimates as have fallen in their way, whether right or wrong. But little care has been exercised, even by those who ought to have been better acquainted with the errors which have always characterized not only the maps, but the descriptions of the peninsula. It is to be hoped that the period of such

errors is now past, and that while most existing publications become obsolete, they will be replaced by correct ones; for it is not too much to say that now, not only correct, but precise and definite information can be obtained, and wherever a dependence shall be placed upon former maps and descriptions, so far will their numerous and universal mistakes be the means of leading into important errors.

ELEVATION AND DEPRESSION OF THE WATER IN THE GREAT LAKES—*the maximum for 1838, 1839, and 1840—lowest stages of water of longer continuance than the higher stages—-evaporation—semi-annual alternations—effect of winds—the apparent tides fortuitous—reaction of the waters—table of elevation and depression for 1840.*

The last year is the second since the unusual elevation of the waters of the lakes; since which time there has been yearly a remarkable coincidence in the ratio of their subsidence, the more unlocked for, when taken in connection with the causes which tend to equalize the amount of falling water, in the form of rain, snow, and dew, with the constant action of evaporation.

In bodies of water like these lakes, slight changes in the seasons produce visible effects, in as much as they have no equalizing under-currents.

The quantity of rain must have been much less, and the evaporation more, than for many years past, to have produced the decrease mentioned below. This decrease amounts in the first year to one quarter of the total rise, and in the second to one half, making the proportion each year as thirty-three to forty-four nearly.

The maximum of August, 1838, was five feet three inches above that of 1819; that of 1889, three feet eleven inches; and that of 1840, two feet seven and one-half inches. The ratio of decrease, therefore, between the highest water in 1838 and 1839, is one foot four inches; and between the highest water in 1839 and 1840, one foot three and one-half inches.

Its rate of decrease is much more rapid than that of its increase from 1819 to 1838. In 1830 it was only two feet above the level of 1819; in 1836, three feet eight inches; having risen one foot eight inches in six years. In 1837, it was four feet three inches; increase, seven inches; in June, 1838, five feet; increase, nine inches; and, in August of the same year, five feet three inches. Having been nineteen years in attaining the maximum of five feet three inches, and only two years in reducing that height one-half, or to the average year of 1833. Thus the rapidity of its decrease in two years, equals the increase of five years.

I have not been able to ascertain whether the decrease of former years was thus sudden, or whether the period of the minimum, or lowest stage of water, continues for any great length of time; it is quite probable, however, that it does, and that the overflowing of the lands caused by the maximum rise, is but temporary, and only for one year, whence immediately commencing its decrease, it arrives very soon at its former standard, and remains there with little variation. Indeed, this is the more probable, from the example of the last three years, and from the appearance of long and undisturbed processes in the growth of trees and vegetation, with the formation of permanent channels in the interim, as well as the security felt by those who have erected buildings and planted orchards formerly, upon those lands which were inundated.

The diminution in a given quantity of water, exceeds by evaporation, all the supplies which it receives from rain, that is the average amount of falling water, is equal per year to 33 inches; evaporation will reduce it to 44 inches, when fully exposed to the sun and air. One season of extreme drouth would, upon the expanse of these lakes, produce an extreme depression, while the contrary would have the effect of producing a corresponding rise. It cannot be a matter of so much astonishment that such expanded areas of water, subject to such influences, should be greatly effected; the wonder is, that they do not oftener present greater fluctuations than they do, the equal and almost unvarying stage at which we find them, is due to the uniformity of the seasons, and the systematic order in which nature is conducted in all her works.

The semi-annual alternations observable in summer and winter, arise from other and well known causes. In summer, the supply is unchecked, and the consequence is, an increase to the height of 30 inches, or thereabouts; when in winter, these supplies are again checked, a consequent depression follows. Measurements to ascertain exactly these semi-annual fluctuations, have never been thought necessary. Besides, it is not uncommon for ice, in large bodies, to collect at the outlets of the lakes, and, for the time, prevent the usual discharge, and a lower stage of water, is the consequence, than otherwise would be. When this occurs in the chain of lakes, as it frequently does at the outlet of Lake Huron, in connection with a west wind, as in 1824 and 1831, it diminished the depth-of the Detroit river, opposite the city, to over ten feet, widening the beach more than twenty rods, and making it practicable, (except in the immediate channel,) to cross without danger, on foot, from the American side, to Isle au Cochons or Hog Island; and a further proportional decrease took place in Lakes Erie and Ontario, while the pent-up water flowed back into Lakes Huron and Michigan. For these reasons, and the want of uniformity in the temperature of the winter months, the minimum height is not to be depended upon.

Besides all this, the effect of winds sometimes acts in favor, as well as against, the other irregularities. The geographical position of the lakes is such, as that, allowing them to prevail from the same point, at the same time over them all, (which is, by no means, always the case,) they produce a variety of results. A west wind forces the water of Lake Erie into the Niagara river, at the same time, the waters from the foot of Lakes Huron and Michigan are forced into the straits of Mackinac, and

these again are met by the waters of Lake Superior, through the straits of Ste Marie. Hence the straits which connect Lakes Huron and Erie, have all the indications of a tide, though irregular as to time, as well as to the amount of its elevation and depression, and it has often both rose and fell in about the same proportion, and sometimes in the same period, as the lunar tides in those rivers which empty into the ocean. But whenever these tides take place, either in the lakes themselves or in the straits connecting them, they are fortuitous, and are the results of accidental disorder, common throughout the lake region.

Another feature may be observed of the lakes, different in nothing from the *ground swell of the ocean*,—the reaction of the water—after having been pressed by the wind for a few days or hours in one direction.

The most favorable points for noticing this re-action, is at an inlet or bay; Lake Superior, which has the largest surface, presents the most marked traits. Here, while the explorations by the geological corps were in progress, the past season, at the mouth of Grand Marrais river, which empties into a bay one mile wide and two miles long, having an outlet of a quarter of a mile wide into the lake, was observed the returning waters from the west, in wide undulations. The effect upon the smooth surface of the bay was a gentle elevation, which arose to one foot or more for a period of fifteen minutes, then subsiding, again returned at equal intervals of time, until the lake, after a lapse of a few hours, resumed its natural level.

Table of elevation and depression in the waters of the Lakes, compared with that of June 1, 1819.

		Ft.	In.	Ft.	In.
1838. August 21,	Highest stage of water,	3	8	5	3
1839. January 1,	Decrease,			1	7
July 31,	Highest stage,	3	2	5	11
1840. January 30,	Decrease,				9
July 4,	Highest stage,	2	1	3	7½
1841. January 1,	Decrease,				6½

DETAIL OF THE ELEVATION AND DEPRESSION FOR 1840.

			Ft.	In.				
1840. January 30,	Height of water,							9
April 25,	Increase,		1	5	2	2		
May 9,	"	Rain and wind from N. E., fluctuations 15 to 18 in.			2	3½		
" 19,	"	Same,			2	1½		
June 6,	"	Wind west, season dry and hot,			2	4½		
July 4,	"	Light showers, weather same as last observation,			2	7½	2	7½
" 29,	Decrease,	Much rain in June and July, on Lake Superior,			2	4		
September 1,	"	Season dry, little rain,			2	2		
" 13,	"	"			2	1½		
" 20,	"	Wind west, river fell suddenly,			1	9		
October 1,	Increase,	Heavy rain last 24 hours,			1	1		
" 12,	Decrease,				1	9½		
" 29,	"	Moderate,			1	9		
November 10,	Increase,	do			1	10½		
" 24,	Decrease,	Freezing, wind moderate from west,			1	6		
December 10,	Increase,	Ice made in river in considerable quantities,			1	6½		
" 21,	Decrease,	River blocked up by ice, no wind,			1	4½		
1841. January 1,	"	River nearly closed, wind moderate from west,				6½		6½

MARSHES—*their origin—once inhabited by the Beavers—their enlargement and diminution—other causes of their production—without timber—their uses—marl—peat—rich soil—cause of the subsidence of the water on them—instances of their becoming dry—causes still in operation—irreclaimable marshes.*

It is perhaps a matter of less difficulty than is generally supposed, to account for the existence of most of the marshes that so abound in this and other portions of the west. We may consider them as level tracts, so continuous often as to be but little broken for many miles, and which expand, or become narrow as the base of the hills and higher grounds, approach or recede; while the latter seem to stand as distinct and sharply defined as islands, whose shores are fringed by a line of timber, and whose foliage waves over the tall grass beneath, and which borders the very margin of this timbered belt, at times receding like deep indented bays, and again projecting in detached islands, and peninsula points, not unlike the meanders of an actual arm of the sea or lake, the level grassy surface being substituted for their waters.

Most of the marshes, however extensive, were once the habitation of the beaver, and were nothing more than expanded and shallow lakes of water. The stream that is now found universally to flow through them, was anciently at a lower level, which is sufficiently indicated when the depth of vegetable mould is penetrated and the former surface exposed. This depth is found to vary from one to many feet.

From the well known habits of the beaver, we may suppose their first labor was to raise a dam sufficiently high to protect them from attacks by land, and as the bottoms of the lakes became filled up by the decay of grass and roots, an additional elevation of the dam became necessary, and this gave a greater area to the lakes, which continuing to spread, the adjacent land whose relative level could be but little above the ordinary banks of the stream, was overflowed, leaving those islands, bays, and peninsula points we have alluded to, to give an indescribable beauty to the landscape.

A process of enlargement or diminution of the marshes, is constantly going on according as the original cause is either operating or has ceased; the latter is the case within, and to a great extent around, the neighborhood of permanent settlements. The beaver is nowhere to be found, excepting at the sources of Thunder bay river, and some other minor streams, on the lower peninsula; but Mr. Burt informs me that he found them within twelve miles of the coast north of Mackinac, in considerable numbers, where they had newly inundated the country to the depth of several feet.

Another cause of the stoppage of the streams, is the falling of timber across them, which becomes permanently fixed by the superincumbent pressure of the waters.

A long series of years, if not ages, must have elapsed to produce the filling up of these ponds by the decayed vegetation, and the destruction of so large a body of timber as that which once covered the ground they occupy, little or no vestige of these forests remaining, even of a fossiliferous character.

The benefit of these marshes to the country, consists not altogether in their picturesque and verdant appearance, or in the rural charm with which nature clothes them, so far from being practically useless, they, in a great measure have, to this day, been the pasture grounds of the domestic herds, which otherwise could not have been supplied in the first settlement of the country. Their first use has been to sustain, by their spontaneous crops, the dependent husbandman, placing him beyond the care and labor of opening new fields for his supplies.

Another value, which will hereafter be better known and appreciated, is derivable from the immense beds of marl, so universally found in them; with its uses, as a cement and manure, thousands are already acquainted. It is well known to be peculiarly adapted to our soil as a manure, and its quantity is inexhaustible.

Another characteristic production of the marshes, is the peat with which they abound; this may in future be found useful as a fuel, and may supply the place of that article when other sources are exhausted.

Nor need I here announce, what is so well known, (and which results from the fact of the composition of the soil, being made up wholly of decayed vegetation,) their surpassing richness, or that when, by artificial drains, or otherwise, they have been made arable, the experiment of planting and sowing for years, has attested them the most valuable and enduring lands in the state. So much is this the case, that their acquisition by those who understand them best, is more eagerly sought for than the richest of the woodland.

Numbers have yearly become dry, so as to be brought under cultivation, which have heretofore been known only as wet meadows, and where their yielding oozy muck could with difficulty be made to support the weight of a man, they have now no other water upon them than the original stream, and that no longer spreading over the whole surface as formerly, but confined to its proper channel.

The causes which will ultimately have a tendency to drain the great portion of them, is slow in its operations, but nevertheless, is sure. The operation may be expedited by artificial means; either, by straightening the usual serpentine course of the streams, or by enlarging their outlets, or which is the most effectual method, by removing the embankment, or beaver dam. These may in almost all cases be found by examination, though they are in a measure concealed, from the long period. of their standing, and the materials of their construction, having become overgrown and covered with rank grass and mould, accumulated through long periods of years.

The law of fluids-—the property of water to preserve its level—the natural and uniform effects when opportunity can be given for its operation, in level and sunken districts, will drain the superfluous waters from a higher to a lower level, leaving the surface dry. Thus, as I am informed, parts of the extensive meadows on the river road, in the southern towns of Shiawassee county, for miles, have the last year produced for the first time, crops of wheat, which, under my own observation, three years ago, were too wet to allow of crossing upon them; and in the adjoining townships, in the northern parts of Livingston county, small lakes have altogether disappeared. On the farm of Gen. Van Fossen, two of these lakes contained about three-quarters of an acre each, and were intended expressly for stock water for his cattle; these and several small marshes in the same county, have all since become fields. The marshes, in these instances, were all drained by the natural decay of old dams, or the wearing effects of the waters, in deepening the channel, and thus returning to their ancient level.

Further instances might be noticed, occurring in several counties in the state. In Branch county, several former marshes have actually emerged from a depth of two feet below the surface of the water. In these cases, the relative level has so changed within about seven years, as to be at present at a height of two feet above the water.

Here a second cause has been operating with the first, and which has given a greater rapidity in producing the effects we have mentioned, that is, the preservation from fire of the crops of wild grass; for if this is allowed to fall and decay, the continued accumulations formed by it, will have a tendency to alter and raise the level yearly, and but a short period of time will be necessary to complete the process.

Trees of a deciduous growth can never be supposed again to grow upon them, and hence they will always have the appearance that *natural prairies* present, with the advantages of a uniformly rich soil, which all natural prairies have not. They will likewise necessarily always receive the wash of the higher grounds.

Suggestions in relation to the cause of the late gradual decrease of the waters of the great lakes, in connection with the disappearance of these smaller lakes and drying of the marshes, have been offered, attributing both to the changes in the seasons only, so that a recurrence of circumstances hereafter that shall produce a rise similar to the one of 1838, in the great lakes, will also, it has been supposed, produce a similar submergence of the marshes, and fill again the small lakes. But I apprehend there is no connection between the causes which have acted on the one and those which have effected the other. It is true that the three thousand interior lakes, especially those of any considerable magnitude, have had their ebbs and flows in the same ratio and at the same time and from the same causes as the great lakes, but it should be remembered that no new instances of marshes being formed, have been discovered, but on the other hand, when the waters of the lakes were rising for years, and were at their maximum, an equal progressive subsidence was taking place in the waters of the marshes.

The number of irreclaimable marshes is comparatively few, and their areas are circumscribed to the dimensions of the lake which originates them, and to the basins which enclose them. In the first case the lake is central and cannot be approached; the vegetation which had taken root in their margin, has been so often re-produced, as to contract the actual dimensions of large lakes, and confine the remaining open space of water to a small extent. This is in consequence of a floating, buoyant covering, fixed by the fibres of roots, which, having been first supported by and around the shore, has, in deep water, no other support than what the surface of the lake itself affords. Hence, where these

lakes become entirely covered over, as in Sanilac, Cheboygan and Presque Isle counties, and in some other instances, to a greater or less extent, the weight of a man causes a depresssion and a wave-like and trembling-motion to some distance round. The surveyor, who is often compelled to cross them, well knows the feelings of insecurity they create. It may not be said of them, as was said by some travellers from London, on their journey to the north, who, on arriving at Dumfreshire, in Scotland, concluded, from the appearance of the mountains there, *that the world was finished no farther*, and returned quietly home.

These subterranean lakes are nothing less than immense reservoirs of water; their coolness and purity exceed those whose surfaces are exposed, and being fed by springs also serve as fountains to streams that rise in distant places.

S. W. HIGGINS,
Topographer to Geological Survey,

GLOSSARY.

Including the technical terms used in this report.

Alluvial. The adjective of Alluvium.

Alluvion or Alluvium. Recent deposits of earth, sand, gravel, mud, stones, peat, shell banks, shell marl, drift sand, &c, resulting from causes now in action. This term is generally applied to those deposits in which water is the principal agent.

Alum rock. Rocks, which, by decomposition, form alum.

Amorphous. Bodies devoid of regular form.

Amygdaloid. A trap rock which is porous and spongy, with rounded cavities scattered through its mass. Agates and simple minerals are often contained in these cavities.

Anthracite. A species of mineral coal, hard, shining, black and devoid of bitumen.

Anticlinal. An anticlinal ridge or axis is where the strata along a line dip contrariwise, like the sides of the roof of a house.

Arenaceous. Sandy,

Argillaceous. Clayey.

Augite. A simple mineral of variable color, from black through green and gray to white. It is a constituent of many volcanic and trappean rocks, and is also found in some of the granitic rocks.

Avalanche. This term is usually applied to masses of ice and snow which have slidden from the summits or sides of mountains. It is now applied to slides of earth and clay.

Basalt. One of the common trap rocks. It is composed of augite and feldspar, is hard, compact, and dark green or black, and has often a regular collumnar form. The Palisades of the Hudson show the columnar aspect of trap rocks. The giants' causeway is cited as an example of basaltic rocks, and the columnar structure is there very strikingly displayed.

Bitumen. Mineral pitch, which is often seen to ooze from fossil coal when on fire.

Bituminous Shale. A slaty rock, containing bitumen, and which occurs in the coal measures.

Blende. Sulphate of zinc. A common shining zinc ore.

Bluffs. High banks of earth or rock with a steep front. The term is generally applied to high banks forming the boundaries of a river or river alluvions.

Bog Iron Ore, Ochre. A variety of ore of iron which has been deposited by water. Chiefly in low, wet ground.

Botryoidal. Resembling a bunch of grapes in form.

Boulders. Erratic group. Lost rocks. Rocks which have been transported from a distance, and more or less rounded by attrition or the action of the weather. They lie upon the surface or loose in the soil, and generally differ from the underlying rock in the neighborhood.

Breccia. A rock composed of angular fragments cemented together by lime and other substances.

Calc Sinter. A German term for depositions of limestone from springs, and waters which contain this mineral in solution.

Calcareous Rocks. A term synonymous with limestone.

Calcareous Spar. Crystalized carbonate of lime.

Carbon. The combustible element of coal.

Carbonates. Chemical compounds containing carbonic acid, which is composed of oxygen and carbon.

Carbonic Acid. An acid gaseous compound, incapable of supporting combustion, and deleterious to animal life. It is common in caves and wells, and many incautious persons lose their lives in consequence of descending, without first ascertaining its presence by letting down a lighted candle. Man cannot live where a candle will not burn freely.

Carboniferous. Coal bearing rocks. This term has been applied to formations belonging to an ancient group of secondary rocks which contain coal. The term is now used in a more enlarged sense, and may be applied to any rocks containing coal.

Chalybeate. Impregnated with iron.

Chert. A siliceous mineral, approaching to chalcedony, flint and hornstone. It is usually found in limestone.

Chlorite. A soft green scaly mineral, slightly unctuous.

Chloritic Slate. Slate containing chlorite.

Clinkstone. A slaty feldspathic or basaltic rock, which is sonorous when struck.

Cleavage. The separation of the laminae of rocks and minerals in certain constant directions. They are not always parallel to the planes of stratification, but are often mistaken for them.

Coal formation. Coal measures. These terms are considered synonymous, and refer to the great deposit of coal in the older secondary rocks, which has been called the "independent coal formation." There are, however, deposits of carbonaceous matter in all the geological periods, and several of them might also be called coal formations.

Conformable. When strata are arranged parallel with each other, like the leaves of a book, they are said to be conformable. Other strata lying across the edges of these may be conformable among themselves, but unconformable to the first set of strata.

Conglomerate, *Crag*, or *Puddingstone*. Rocks composed of rounded masses, pebbles and gravel cemented together by a siliceous, calcareous, or argillaceous cement.

Cretaceous. Belonging to the chalk formation.

Crop out and *out crop*. Terms employed by geologists and mining engineers, to express the emergence of rock, in place, on the surface of the earth at the locality where it is said to crop out.

Crystaline. An assemblage of imperfectly defined crystals, like loaf sugar and common white marble.

Delta. Alluvial land formed at the mouths of rivers.

Denudation. A term used to express the bare state of the rocks over which currents of water have formerly swept, and laid the rocks bare, or excavated them to form valleys of denudation.

Deoxydize. To separate oxygen from a body.

Detritus and *Debris*. Broken and removed portions of rock which have been operated upon by waters or the atmosphere; frequently transported by currents to great distances.

Dykes. A kind of vein intersecting the strata, and usually filled with some unstratified igneous rock, such as granite, trap or lava. These materials are supposed to have been injected in a melted state into great rents or fissures in the rocks.

Diluvium and *Diluvion*. Deposits of bowlders, pebbles and gravel, which many geologists have supposed were produced by a diluvial wave or deluge sweeping over the surface of the earth.

Dip. Where strata are not horizontal, the direction in which their planes sink or plunge, is called the direction of the dip, and the angle of inclination, the angle of dip.

Dolomite. A magnesian limestone belonging to the primary class. It is usually granular in its structure, and of a friable texture.

Dunes. Sands raised into hills and drifts by the wind.

Earth's Crust. The superficial parts of our planet which are accessible to human observation.

Embouchure. From the French, signifying mouth or entrance, (of a river.)

Eocene. The strata deposited during the oldest of the tertiary epochs, as, for example, the Paris basin.

Estuaries. Inlets of sea into the land. The tides and fresh water streams mingle and flow into them. They include not only the portion of the sea adjacent to the mouths of rivers, but extend to the limit of tide water on these streams.

Exuviae. In geology, fossil remains.

Fault. A dislocation of strata, at which the layers on one side of a dyke or fissure have slid past the corresponding ones on the other. These dislocations are often accompanied by a dyke. They vary from a few lines to several hundred feet.

Feldspar. One of the simple minerals, and next to quartz, one of the most abundant in nature.

Ferruginous. Containing iron.

Fluviatile. Belonging to a river.

Formation. A group of rocks which were formed during a particular period, or which are referred to a common origin.

Fossils. The remains of animals and plants found buried in the earth, or inclosed in rocks. Some of these are but slightly changed, others are petrified and the organic replaced by mineral matter; some have decayed and left the impression of the bodies, while others have been formed by mineral matter deposited in the cavities left by the decay of the organic body. These last are called *casts*. The term petrifaction is applied to those cases, in which organic matter has been replaced by mineral substances. The form and structure of the original body both remain. In casts, the exterior form alone is preserved. Fossils are also called organic remains.

Fosiliferous. Containing organic remains.

Galena. An ore of lead composed of lead and sulphur.

Garnet. A simple mineral, which is usually red and crystalized. It is abundant in most primitive rocks.

Gneiss. A stratified primary rock, composed of the same materials as granite, but the mica is distributed in parallel layers, which will give it a striped aspect.

Geode. *Geodiferous*. Geodes are small cavities in rock, generally lined with quartzose or calcareous crystals.

Geology. A science which has for its object to investigate the structure of the earth, the materials of which it is composed, the manner in which these are arranged, with regard to each other; and it considers the action of all natural causes in producing changes, such as the effects of frost, rain, floods, tides, currents, winds, earthquakes and volcanoes.

Economical Geology refers to the applications of geological facts and observations to the useful purposes of civilized life.

Granite. An unstratified rock, composed generally of quartz, feldspar and mica, and it is usually associated with the oldest of the stratified rocks.

Graywacke, Grauwacke. A group of strata in the transition rocks; but the term has been so indefinitely applied, that other names will probably be substituted.

Greenstone. A trap rock composed of hornblende and feldspar.

Grit. A coarse-grained sandstone.

Gypsum. A mineral, composed of sulphuric acid and lime, and extensively used as a stimulant manure, and for making stucco and plaster casts, &c. It is also called Plaster of Paris.

Hornblende. A mineral of a dark green or black color, and which is a constituent part of greenstone.

Hornstone. A siliceous mineral, approaching to flint in its character.

Hydrography. A science which considers the waters of the globe, principally as relates to navigation, tides, currents, soundings, charts of coasts, &c.

In situ, in place. In their original position where they were formed.

Kidney Ironstone. A variety of ore of iron which receives Its name from the somewhat kidney shaped masses in which it occurs. It accompanies the rocks of the *carboniferous group*.

Laminae. The thin layers into which strata are divided, but to which they are not always parallel.

Lacustrine. Belonging to a lake. Depositions formed in ancient as well as modern lakes, are called lacustrine deposits.

Landslip. It is the removal of a portion of land down an inclined surface. It is in consequence of the presence of water beneath, which either washes away the support of the superincumbent mass, or so saturates the material, that they become a slippery paste.

Line of bearing, is the direction of the intersection of the planes of the strata with the plane of the horizon.

Linear survey. A plan of surveying adopted by the United States government, by which the public lands are divided into rectangles, by straight lines.

Lignite. Wood naturally carbonized and converted into a kind of coal in the earth.

Littoral. Belonging to the shore.

Loam. A mixture of sand and clay.

Magnetic Meridian. A great circle passing through or by the magnetical poles of the earth; to which the *compass needle*, if not otherwise hindered, conforms itself. This "line of no variation," is not stationary, but shifts eastward or westward of the true meridian, during a term of years.

Mural Escarpment. A rocky cliff with a face nearly vertical like a wall.

Mammillary. A surface studded with smooth small segments of spheres like the swell of the breasts.

Mammoth. An extinct species of elephant.

Marl. By this term an argillaceous carbonate of lime is usually implied. By custom, its signification is much more extended, and means mineral substances, which act as stimulating or fertilizing manures. There are clay marls, shell marls, and various others.

Marly Clay. Clay containing carbonate of lime.

Mastodon. A genus of extinct fossil animals allied to the elephant. They are so called from the form of the grinders, which have their surfaces covered with conical mammillary crests.

Matrix. The mineral mass in which a simple mineral is imbeded, is called its *matrix* or *gangue*.

Mechanical origin, Rocks of. Rocks composed of sand, pebbles or fragments, are so called, to distinguish them from those of a uniform crystaline texture, which are of chemical origin.

Metamorphic Rocks. Stratified division of primary rocks, such as gneiss, mica slate, hornblende slate, quartz rock, &c, and which may probably be regarded as altered sedimentary rocks.

Metalliferous. Containing metals or metallic ores.

Mica. A simple mineral, having a shining silvery surface, and capable of being split into very thin elastic leaves or scales. The brilliant scales in granite and gneiss are mica.

Micaceous. In part composed of scales of mica.

Mica Slate. One of the stratified rocks belonging to the primary class. It is generally fissile, and is characterized by being composed of mica and quartz, of which the former either predominates, or is disposed in layers, so that its flat surfaces give it the appearance of predominating.

Miocene. One of the deposits of the tertiary epoch. It is more recent than the *eocene*, and older than the pliocene.

Mollusca. Mollucous animals. "Animals such as shell fish, which, being devoid of bones, have soft bodies."

Mountain Limestone. "A series of limestone strata, of which the geological position is immediately below the coal measures, and with which they also sometimes alternate."

Muriate of Soda. Common salt.

Naphtha. A fluid, volatile, inflammable mineral, which is common in volcanic districts, and in the vicinity of the salt springs of the United States.

Native Metals. Those portions of metals found in nature in a metallic, or uncombined state, are called native.

New Red Sandstone. "A series of sandy and argillaceous, and often calcareous strata, the prevailing color of which is brick-red, but containing portions which are greenish grey. These occur often in spots and stripes, so that the series has sometimes been called the variegated sandstone. The European, so called, lies in a geological position immediately above the coal measures."

Nodule. A rounded, irregular shaped lump or mass.

Ochre. See bog iron.

Old Red Sandstone. "A stratified rock, belonging to the carboniferous group of Europe."

Oolite, oolitic. "A limestone, so named, because it is composed of rounded particles, like the roe or eggs of fish. The name is also applied to a large group of strata, characterized by peculiar fossils,"

Organic Remains. See Fossils.

Orthoceratite. The remains of an extinct genus of molluscous animals, called Cephalopoda. The orthoceratites are long, straight, chambered shells.

Out-crop. See *Crop out*.

Out-liers. Hills or ranges of rock strata, occurring at some distance from the general mass to the formations to which they belong. Many of these have been caused by denudation, having removed parts of the strata which once connected with outliers with the main mass of the formation.

Oxide. A combination of oxygen with another body. The term is usually limited to such combinations as do not present active acid or alkaline properties.

Palaeontology. A science which treats of fossil remains.

Peat. A product resulting from the accumulation of vegetable substances, found in marshy places, in a partially decomposed and sometimes compact state. Peat may be *fibrous, ligneous, &c*.

Pisolite. A calcareous mineral, composed of rounded concretions like peas.

Pliocene. The upper, or more recent tertiary strata. This group of strata is divided into the older and newer pliocene rocks.

Petroleum. A liquid mineral pitch. It is common in the region of salt springs in the United States.

Porphyry. A term applied to every species of unstratified rock, in which detached crystals of feldspar are diffused through a compact base other mineral composition.

Productus. An extinct genus of fossil bivalve shells.

Plastic Clay. One of the beds of the Eocene period. The plastic clay formation is mostly composed of sands with associate beds of clay.

Primary rocks. Those rocks which lie below all the stratified rocks and exhibit no marks of sedimentary origin. They contain no fossils, and are the oldest rocks known. Granite, hornblende, quartz and some slates belong to this division.

Pudding Stone. See *Conglomerate*.

Pyrites. A mineral, composed of sulphur and iron. It is usually of a brass yellow, brilliant, often crystalized, and frequently mistaken for gold.

Quartz. A simple mineral, composed of silex. Rock crystal is an example of this mineral.

Rock. All mineral beds, whether of sand, clay, or firmly aggregated masses, are called rocks.

Sandstone. A rock composed of aggregated grains of sand.

Schist. Slate.

Seams. "Thin layers which separate strata of greater magnitude."

Secondary Strata. "An extensive series of the stratified rocks, which compose the crust of the globe, with certain characters in common, which distinguish them from another series below them, called primary, and another above them, called tertiary.

Sedimentary rocks. All those which have been formed by their materials having been thrown down from a state of suspension or solution in water."

Selenite. Crystalized gypsum.

Septaria. Flattened balls of stone, which have been more or less cracked in different directions, and cemented together by mineral matter which fills the fissures.

Serpentine. A rock composed principally of hydrated silicate of magnesia. It is generally an unstratified rock.

Shale. An indurated clay, which is very fissile.

Shell Marl—Fresh water Shell Marl. A deposit of fresh water shells, which have disintegrated into a grey or white pulverulent mass.

Shingle. The loose water-worn gravel and pebbles on shores and coast.

Silex. The name of one of the pure earths which is the base of flint quartz, and most sands and sandstones.

Silicious. Containing silex.

Silt. "The more comminuted sand, clay and earth, which is transported by running water."

Simple Minerals—Are composed of a single mineral substance. Rocks are generally aggregates of several simple minerals cemented together.

Slate. A rock dividing into thin layers.

Stalactite. Concreted carbonate of lime, hanging from the roofs of caves, and like icicles in form.

Stalagmites. Crusts and irregular shaped masses of concreted carbonate of lime, formed on the floors of caves, by deposits from the dripping of water.

Stratification. An arrangement of rocks in strata.

Strata. Layers of rock parallel to each other.

Stratum. A layer of rocks; one of the strata.

Strike. The direction in which the edges of strata crop out. It is synonymous with *line of bearing*.

Syenite and *Sienite*. A granitic rock, in which hornblende replaces the mica.

Synclinal line and *Synclinal axis*. When the strata dip downward, in opposite directions, like the sides of a gutter.

Talus. In geology, a sloping heap of broken rocks and stones at the foot of many cliffs.

Tertiary strata. "A series of sedimentary rocks, with characters which distinguish them from two other great series of strata—the secondary and primary—which lie beneath them."

Testacea. "Molluscous animals, having a shelly covering."

Tepid. Warm.

Thermal. Hot.

Thin out. Strata which diminish in thickness until they disappear, are said to thin out.

Topography. The description or delineation of the varieties of surface, and whatever else relates to the general exterior character of a country.

Transition Rocks. A series of rocks which lie below the secondary and next above the primary, and are so called because they seem to have been formed at a period when the earth was passing from an uninhabited to a habitable condition. They contain numbers of characteristic fossils.

Trap—Trappean Rocks. Ancient volcanic rocks, composed of feldspar, hornblende and augite. Basalt, greenstone, amygdaloid and dolomite, are trap rocks.

Travertin. "A concretionary limestone, hard and semi-crystaline, deposited from the water of springs."

Tufa Calcareous. "A porous rock, deposited by calcareous waters on exposure to air. and usually containing portions of plants and other organic substances incrusted with carbonate of lime."

Tufaceous. A texture of rock like that of tuff.

Tuff or *Tufa*. "An Italian name for a volcanic rock of an earthy texture."

Unconformable. See conformable.

Veins. Cracks and fissures in rocks filled with stony or metallic matter. Most of the ores are obtained from metallic veins.

Vein-stone. That mineral matter with which the ores or metallic contents of a vein are associated.

Zoophytes. Coral sponges and other aquatic animals allied to them.