GEOLOGICAL SURVEY OF MICHIGAN.

UPPER PENINSULA
1869-1873
ACCOMPANIED BY AN
ATLAS OF MAPS.

VOL. I.
PART III.
PALÆOZOIC ROCKS.

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PUBLISHED BY AUTHORITY OF THE LEGISLATURE OF MICHIGAN.
UNDER THE DIRECTION OF THE
BOARD OF GEOLOGICAL SURVEY.

NEW YORK
JULIUS BIEN
1873

TO THE HONORABLE BOARD OF GEOLOGICAL SURVEY OF THE STATE OF MICHIGAN:

Gentlemen—I have the honor to lay before you the results of my investigations in the geology of the eastern portion of the Upper Peninsula of Michigan, which work was placed in my hands by the Honorable Board during the past two years.

All the facts reported upon, including the chemical analysis of quite a number of rock specimens, are derived from my own personal labors and observations. I have avoided, as much as practicable, expanding the bulk of the report; and have paid no more than the absolutely necessary attention to other branches of natural history, which, although very interesting, are not strictly comprehended under the word geology, and to which I could not make any personal contributions of value. A great portion of this material would have been a mere copy of the published records of others; and I think the public does not care so much for a compilation, as for an actual increase of our knowledge by carefully made observations, elucidating unknown or imperfectly understood features in the construction of the earth's crust.

For this object I have zealously worked. How far I have succeeded in the effort the reader may judge; and I shall feel well satisfied if he finds the picture I give worth attentive study, without having it surrounded by a borrowed glistening frame, composed of a collection of items from almost every branch of human knowledge.

Very respectfully yours,
C. ROMINGER.

INTRODUCTION.

BY the Legislative Assembly of 1871, the continuation of a geological survey of the State of Michigan was determined upon, in such a manner as to divide the work into three districts, each of which was to be investigated independently by different parties.

The third district, intrusted to me, comprises the Lower Peninsula, and the eastern half of the Upper Peninsula, or that portion which Is not included in the iron and copper regions. Its surface rock is exclusively composed of members of the palæozoic series; while In the other two, older crystalline and metamorphic rocks prevail.

On the Lower Peninsula only a partial reconnoissance tour has been made through *Little Traverse Bay* region.

The principal part of the time has been spent in the Investigation of the Upper Peninsula, of which the Board of the Survey desired to have a complete report at the end of this year.

GEOGRAPHICAL LIMITS AND SURFACE CONFIGURATION OF THE DISTRICT.

THE Upper Peninsula of Michigan comprises an area of about 16,000 square miles, excluding the several islands belonging to the State, which add to this sum 300 square miles more.

To the north it is bounded by the waters of Lake Superior, to the south by the Lakes Huron and Michigan; the east end is bounded by the river St. Mary, which cuts from the main body three larger islands—Sugar island, St. Joseph's island, and Drummond island; the first and the last of which belong to the State; St. Joseph is Canadian land.

The western, or more accurately speaking, the southwestern boundary line between the Upper Peninsula of Michigan and Wisconsin territory, is given by the bed of the Menominee river, flowing into Green bay of Lake Michigan, and by the Montreal river emptying into Lake Superior, which bounds the remaining western portion of the Peninsula.

The so defined land lies between the 45th and 49th degrees of northern latitude, and 83° 45' and 90° 93' of longitude west of Greenwich.

An air line drawn from the mouth of the Menominee river to the mouth of the Montreal river is about 175 miles long; from the mouth of Montreal river to the north end of Keewenaw point, a similar line measures 150 miles; and a line drawn from Marquette to the mouth of the Menominee river amounts to about 100 miles.

These three lines inclose the Iron and Copper Districts; only the smaller portion of this area is overlaid by strata of the palæozoic series, which on the remaining eastern portion of the Peninsula, exclusively compose the surface.

This remaining portion extends about 175 miles from west to east, and is about 50 miles in width from north to south.

The surface elevation of the two western districts exceeds considerably that of the eastern district; the highest points of the eastern portion do not go beyond 400 feet, while in the two others some mountains attain a height of 800 feet, and a few a height of 1,400 feet above the lake level.

The character of these western districts is irregularly mountainous. The eastern end of the Peninsula represents an undulating high plateau, sinking in gradual descent towards the south, and more rapidly falling off towards the north. Its watershed lies much nearer to the northern than to the southern margin, and consequently, the rivers emptying into Lake Superior are generally small in comparison with those entering Lake Huron and Lake Michigan. The headwaters of these rivers take their origin from numerous lakes and marshes dispersed over the plateau. None of them are navigable for anything larger than a canoe, on account of the frequency of rapids and cascades; particularly those of the north side, where almost every creek precipitates its waters over mural exposures of the Lake Superior sandstones. Nevertheless, these rivers and creeks are of high economical importance, by affording in the spring season, when the waters are high, ample power for floating the logs from the interior down to the numerous saw-mill establishments sprung up at the mouth of almost every larger watercourse, whose branches reach back into the pine lands.

The whole eastern Peninsula is an unbroken forest, having, except the lumbermen, no other inhabitants than some solitary trappers in the winter time; while, during the summer season, the fishermen take their temporary abode along the shore. Only a few of them have squatted down, and remain there all the year. Besides these there are a few migratory Indians.

GENERAL PRELIMINARY REMARKS ON GEOLOGY,

The object of the subsequent report is to give an explicit description of the above indicated portion of our State, regarding its soil, the different rock-beds composing its surface, and the various minerals associated with them. It intends to explain, as far as science will allow, the process by which all these materials were formed, and in what relation they stand to each other. It seeks to point out the different uses to which all of them are applicable in the economy of the human race, and means to aid in the understanding of the great unalterable law, which governed creation in the past, as well as it does in the present time.

In order to accomplish this in a plain and comprehensive way, I find it necessary to disregard those readers, who are already well informed, and for the benefit of those who are not so well informed, to preface these remarks by a short exposition of some elementary geological principles.

Every person is naturally inclined to inquire into the nature of things surrounding him ; and one of the most obvious objects for such inquiry are the different rocks, strewn in fragments over the surface, or buried in the ground in massive blocks, or in well stratified ledges. Without being geologists, we observe granites and other rocks of crystalline structure, we notice slates, shales, sandstones, limestones, coalbeds, iron ores and other mineral substances, under various conditions.

We find, sometimes, a variety of these rocks indiscriminately mixed, in rounded water-worn fragments; at other times they exhibit a certain regularity in their position, and succeed each other in a fixed order, their layers piled up, one upon another, like the leaves of a book.

Usually, the stratified rock-beds are in horizontal position, but frequently also, we find them inclined, or standing vertical, or even reversed or twisted, in all imaginable curves; ripple marks present themselves on the hardened stone-faces, as plain as those formed under our eyes by the play of waves on the shallow sand-banks of our lakes and rivers; unmistakable shells, corals, and other animal or vegetable remains are imbedded in the stone-mass, sometimes in such profusion as to constitute the principal body of the rock. All these and many other geognostical facts, present themselves to our daily observation, and there are few who are not deeply interested by them, and seek for explanations how all this originated, and how and when things assumed their present condition and form. It is the science of Geology which attempts to answer these questions.

With the increased accumulation of geognostical facts, we become more and more enabled to bring isolated observations into a system; to see the connections in which one phenomenon stands with another, and to

deduce and recognize therefrom the rules and laws which are guiding the terrestrial development.

Much has been achieved by these efforts to disclose the earth's history, but much more yet has to be learned, before we can have a clear comprehension of all the successive changes which our globe has undergone, and of which indelible traces are left to record the past. Beginning to make deductions from these our indicated daily observations, we find that the first mentioned crystalline rocks are the lowest ones we know of in the earth's crust which we have directly penetrated to the small depth of only 3,000 feet, but of which, natural outbursts and fissures have laid bare to our eyes successive layers of rock-masses, representing a depth of 80,000 feet and more.

The variety of these crystalline rocks is great; they occur most frequently in bulky masses, as if once in molten condition; not so often in regularly stratified layers. From the existence of volcanoes, from the gradual steady increase of temperature as we go down into the interior, the hypothesis has been made that the globe was once in molten condition, and that these crystalline rocks are the cooled crust, inclosing a still fluid nucleus, at a comparatively insignificant depth.

An opposite opinion to this contends for the aqueous origin of these crystalline rocks. One of the several objections brought against the igneous theory by the so-called Neptunists, is the frequent occurrence of minerals intermingled, or in close juxtaposition, within the crystalline rocks, which in a melted condition of the mass, according to our chemical knowledge, could not have existed without combining with each other, or in some other way decomposing. The real truth is, that rocks of crystalline structure can form in both ways, and that in some instances the facts indicate an igneous origin, in others, crystallization out of an aqueous solution.

Above the crystalline rocks, if we make an ideal restoration of the series,—which, in nature, is often interrupted by elimination of one, or of a long series of successive strata,—a complex of rocks succeeds, which, by its regularly stratified condition, bears evidence of its sedimentary origin, but which has become more compact and subcrystalline in structure than unaltered aqueous deposits generally are.

These are designated as *metamorphic rocks*, suggesting that, after their deposition, they were subjected to a metamorphosis.

Of what kind the influence was, which produced this alteration, is not accurately known. It has been supposed that the melted crystalline rocks, while breaking through these sedimentary strata, communicated to them a degree of heat sufficient to produce the metamorphism; and, indeed, the altered rock masses frequently look as if they had been subjected to a process of partial melting. We should expect, in such cases, to find the most intense metamorphism in immediate contact with the crystalline rocks; but this is not the case always; we frequently find the sedimentary beds in contiguity with the crystalline rocks, only slightly altered, while on the other hand, sometimes a high degree of metamorphism is observed in a series of strata, too far remote from the focus of heat to allow a transmission of any high degree to it, to such a distance.

The Neptunists, of course, explain the metamorphism of the rocks as dependent from the solvent action of the water, or suggest the co-operation of only a low degree of heat, and of a high atmospheric pressure.

The metamorphic rocks are followed by a long series of rock-beds, which are all of sedimentary origin; many of them contain the remains of sea animals, and other traces of organic life.

If we had to depend alone on the visible order of stratification, and on the much more uncertain lithological characters, identifications of beds from remote localities would be difficult, and sometimes never could be made; but, by the organic remains we find included in them, we are enabled to determine with a considerable degree of precision their relative age.

In the examination of this long series of rock-beds, we find that certain animate forms have existed and flourished during certain periods, then disappeared, to give way to other new forms, which in their turn made room for subsequent new types of creation; and this coming and going of new forms is so often repeated that, according to our conception, an immense time must have elapsed while all these numerous animate forms came into existence, lived and disappeared.

By comparing the different subsequent faunas imbedded in the rock series of one place with those of a series from another place, we find that contemporaneous beds generally contain the same or similar animal forms, besides some others, which are peculiar to each locality. This gives us the ready means of investigating the stratified fossiliferous rock-beds of all parts of the world, and of assigning to them the correct place and comparative age which they have in the series of deposits. Nowhere on the globe, an uninterrupted series of all the sequence of strata and rock formations can exist. The ancient ocean which made the deposits, frequently changed its place, and in spots which emerged from the water no deposits could accumulate. Consequently, all the ocean deposits made during the interval of their emergence were wanting there, and if afterward a subsidence of the same spots took place, the newly-formed deposits would come to repose on beds of perhaps widely different, much older age, with elimination of a more or less considerable mass of strata, which in other localities separate them. Oceanic or other aqueous deposits have originally always a horizontal, or nearly horizontal position, but we find over extended districts, such deposits uplifted in every degree of inclination; we find them actually tilted over, or bent and distorted in wonderful serpentine flexures. In these disturbances we have a very palpable cause with which

to explain the frequent changes in the ocean basins, to which allusion has just been made.

Even the relative time in which such disturbances occurred can be determined by observing the strata which were implicated in the process of upheaval and distortion, and by noticing those which immediately followed without being involved in the dislocating revolutionary motion.

Whether the upheavals were produced by the expansion of gases developed in the interior of the earth, and bursting out in volcanic eruptions, or by the slow contraction of the cooling earth's crust, or by the pressure of unequally distributed weight over the not entirely unyielding surface, or by other causes, are questions foreign to our present purpose, and therefore we may leave them with the few hints thus far given.

A number of other deductions can be made by wisely using the data we have found. From the nature of the deposits, and even from the fossils they contain, we draw conclusions as to the depth or shallowness of the water which deposited them; we trace the extent of ancient ocean shores by the same means; we determine by fossils whether it was fresh or salt water which made the deposit, and bring a great many other similar questions to satisfactory solution by attentive combination of what sometimes seem to be facts of small importance.

This preliminary exposition of the mode and means by which we construe a part of the earth's history, I consider sufficient to bring to the general reader of the report a fair understanding of all that is to be described in the following pages, devoted to a special description of the surface deposits of the Upper Peninsula of Michigan.

SYSTEMATICAL ENUMERATION AND DESCRIPTION OF THE STRATA COMPOSING THE EASTERN PORTION OF THE UPPER PENINSULA OF MICHIGAN.

The reports of the New York geologists have generally served, in American geology, as the basis for comparison, and in all the later geological descriptions of other States, their nomenclature and divisions of the fossiliferous strata in principal groups, have been unanimously adopted, and are also here used as the rule.

The *Palæozoic Series*, including all the deposits from the earliest time in which indubitable organic remains were discovered up to the close of the carboniferous period, is, in the New York reports, divided into the following principal groups:

I. LOWER SILURIAN.

1. Potsdam sandstone.
2. Calciferous sandstone.
3. Chazy limestone.
4. Trenton limestone, including Birdseye and Black river limestones.
5. Hudson river group, including Utica shales; by western geologists also called Cincinnati group.

II. UPPER SILURIAN.

6. Medina sandstone, a more local development in New York State.
7. Clinton group.
8. Niagara limestone.
9. Onondaga salt group.
10. Helderberg group, the upper division of which is connected with the next superimposed Devonian system.

III. DEVONIAN SYSTEM.

11. Hamilton group.
12. Chemung and Portage group.
13. Catskill group.

IV. CARBONIFEROUS SYSTEM.

14. Subcarboniferous limestone.
15. Coal measures.

The Michigan district under consideration is composed of the older portion only of the above tabular series, commencing with the Potsdam sandstone, and forming an uninterrupted series up to the Devonian period, of which the upper Helderberg limestones are the highest member developed. Of later deposits nothing is known to have existed in this region before the large drift accumulations took place which now envelop almost the whole surface, and restrict the outcrops of the older formations to very limited areas.

The greatest regularity prevails in the disposition of the Palæozoic strata. They seem not to have suffered from any subsequent disturbance, and have retained their

original horizontal position, with a slight dip southward, in which general direction the ancient ocean appears to have gradually receded.

We find the older strata exposed in a belt, extending from west to east, and forming the north shore of the Peninsula; moving southward from there, we successively step over newer strata, which follow each other in imbricating order, until, at the south shore, on St. Ignatz Point, or at the island of Mackinaw, we stand on the limestone beds of the upper Helderberg group.

Not all the single subdivisions made in the systematical description of the New York series can be recognized, but the principal groups are identified without difficulty. To the description of each of these a separate chapter will be devoted; but, first of all, the superficial deposits called *drift* and *alluvium*, which compose by far the greatest portion of the surface of the district, deserve our attention. From their nature and composition, the character of the vegetation in a great measure depends. From the vegetation we draw conclusions as to the agricultural characteristics of a place, and in these, the principal value of a country rests.

SUPERFICIAL DEPOSITS.

Under the name of Drift, in geology, are included immense masses of loose, rounded or water-worn rock fragments, and of finer comminuted materials, which are spread over a wide and long extended belt of country in certain latitudes of the North American and European continents.

It is an established fact that these deposits were once transported in the general direction from north to south. We find the drift material in part composed of rocks which are not found in any of the neighboring districts, but which are known to exist at variable distances north of these deposits, exhibiting the same details of structure, color, and composition, so that no doubt can remain as to the origin of the fragments.

In addition to this, the whole wide area over which the transportation of this material took place, bears unmistakable marks of the mechanical effects which the moving debris exerted on the underlying strata.

Whole formations of more perishable rock-beds, which stood in the way of the moving detritus, were broken up, mixed with the intruding masses, and carried away from their old resting-places by irresistible force.

The projecting inequalities of harder and more unyielding rock-masses were ground smooth, or deep furrows were carved into their surfaces, which exhibit yet, with exquisite distinctness, innumerable fine parallel scratches, by which this grinding and carving were effected. All these scratches point in one constant direction from which the force acted, and which varies very little from a north and south direction. In certain single instances the resistance offered by some obstacle was so strong, that the moving rock stream was deflected, and, in such a case, the local drift scratches may run in any other direction.

These phenomena are the same that have been recognized in connection with the moving rock-masses of the glaciers in Switzerland, and in other Alpine regions.

The accumulated materials of the drift, frequently like the moraines of glaciers, have no stratification, and are a heap of confused rubbish, inclosing boulders and rock fragments of such huge weight and dimensions, that the propelling power of waves and water currents, unquestionably under ordinary circumstances, was not adequate for the performance of the work.

The hypothesis of glaciers and icebergs having been the transporting mediums of the drift deposits, in consideration of these facts, is now almost universally adopted by geologists; but notwithstanding its plausibility, a great many circumstances connected with the drift formation remain still unexplained by it, and we have no definite conception of the causes which could produce glaciers of such stupendous extent. A considerable portion also of the drift deposits are not heaps of rubbish, but well stratified beds of clay, sand and gravel, exhibiting with plainest distinctness the action of waves and water currents in their deposition.

It has been said this stratified drift was the product of subsequent floods, which sifted and rearranged the materials in their present regular beds. No doubt a large portion of the drift has been rearranged and worked over by later floods, the terraces, so frequently observed around the shore line and along some river valleys of the Upper Peninsula, are confirming this suggestion. In various elevations above the lake level we see these terraces in stair-like succession ascending to the height of eighty feet, and it is probable that within comparatively recent time the waters of the lakes stood high enough to cover the whole Eastern Peninsula, and may have modified the surface; but it is equally evident that much of the stratified drift observed there, and in many other places, was originally deposited prior to the time in which the terraces were formed, and the last finishing touch was given to the configuration of the country, as we see it at present.

Much of the non-stratified coarser boulder drift, which resembles moraines, is found in the narrower channels of Lake Superior and of Lake Huron. Many of the small Islands in these channels are composed exclusively of such coarser material, and shoals, paved with larger drift blocks, extend far out into the lake, endangering navigation.

The non-stratified condition of the drift in these cases is directly the result of later floods acting on the drift, which before may have been well stratified. By the action of the water, the drift barriers, separating the lakes into different levels, were broken through and all the lighter particles washed away, the current pushing with increased velocity through the newly-made outlet, and dropping on the way the heavier rock fragments and

larger pebbles which we find now directly resting on the rock beds of older formations. Also, in other localities of the Upper Peninsula, on the top of higher hill elevations, composed of older rock beds, we find frequently only heavier drift boulders and scarcely any finer comminuted material spread out over the surface, which seem to be the remnant of former larger deposits. The non-stratified drift is consequently not all to be brought in connection with moraines of glaciers, and In a great many of the better exposures of the peninsula the drift is found in well-stratified layers, in which constantly a lower deposit of an impalpably fine rose-colored clay, of almost shaly structure, can be distinguished, and an upper arenaceous and gravelly portion, containing larger boulders.

These lower clay beds are exposed in the bed of Carp river in St. Martin's bay, on Manistique river, on Menominee river, Ford river, Escanaba river, and on Lake Superior shore near St. Mary, on Taquamenon river, at Sable Point, and in many other places, where they rest immediately on the older rock formations. Usually seams of gravel are intermingled with the clay deposits, or single pebbles are dispersed through the mass. On South Manitou island the lower clay beds are more sandy than elsewhere. In the districts underlaid by limestone, the clay contains a more or less considerable admixture of carbonate of lime; only in a few instances, however, the proportion of the admixture is so large as to make it unfit for pottery ware. The experiments I made with several specimens of the clay gave satisfactory results; it dries without cracking, and by burning furnishes a tough, light-yellowish colored ware, which is not fusible in moderate fire.

In the sandstone districts of Lake Superior, the clay is quite free from calcareous parts, and deserves the attention of manufacturers. From Sugar island and from St. Mary, limited quantities have been shipped to iron furnaces, to be used as ordinary clay, but the experiment is worth trying, if a proper mixture of the clay with coarse quartz sand, would not have the qualities of a good fire clay.

The thickness of the clay deposits is very variable in different localities. In the land slides on both sides of the lower part of Taquamenon river, and in the hills south of St. Mary, it is not less than sixty feet, in other places on the Lake Michigan side it is often not over ten feet.

The upper arenaceous portion of the stratified drift, is composed of alternating sand and gravel beds, with occasionally intermingled larger boulders and subordinate seams of clay.

The frequent occurrence of discordant stratification, makes the strata very irregular, and no general rule in the succession of the sand and gravel layers can be recognized; their deposition was governed by local influences of very changeable nature.

In the sandhills of Sable Point and on Point Iroquois, the aggregate thickness of this upper part of the drift formation is 300 feet. This seems, however, to be the maximum, and in most other places it is found to be less.

Over extensive areas, the drift material forming the surface is an almost pure fine quartz sand of very sterile character, congenial only to the growth of pine trees. Other districts are underlaid by the more gravelly and argillaceous portions of the drift, which form a productive soil, covered by a rich vegetation of hard-wood timber. The geologist can form here reliable conclusions on the nature of the superficial deposits, from the character of the forest trees, before he examines the soil, and the insufficient denudation of the strata in the interior of the Peninsula, makes the indications given by the vegetation frequently a welcome help to him.

The coarser gravelly constituents of the drift, and the larger boulders, represent an immense variety of rock formations and mineral species. The older granitic, syenitic and gneissoid rocks are never missing, diorites are also abundant of all shades, from the coarsest crystalline structure to the aphanitic condition, quartzites, jaspers, conglomerates, from the Huronian group, and amygdaloid and porphyritic rocks of the copper bearing series; blocks of iron ore or of metallic copper are occasionally interspersed, and quite common are also limestone and flint pebbles, containing well-preserved fossils of the Niagara group, and many Devonian species, which found their way from distant arctic regions to the shore of Lake Superior.

A very important part of the drift pebbles is taken up from the detritus of the neighboring and immediately underlying formations, which by their multitude and less worn angular form betray the proximity of the mother rock.

So we find the drift, reposing on the Lake Superior sandstones, full of sandstone blocks, and smaller fragments; further south, Trenton limestone, with its characteristic fossils, is very common. In the Niagara belt, the Niagara limestone almost excludes every other rock species, and the same thing is repeated within the limits of the Helderberg group.

Organic remains, contemporaneous with the drift period, are remarkably rare. In all the numerous exposures of undisturbed drift on Lake Superior, I did not see a single animal or vegetable fossil; but in the loose alluvial deposits, by which our present time is insensibly linked with the drift era, vegetable and animal remains are copiously imbedded.

In many of the larger river valleys, as, for instance, in the valley of Manistique river, extensive deposits of sandy argillaceous mud, mixed with vegetable debris, and interstratified with black peat-like beds of almost entirely vegetable composition, are met with. We find imbedded in them large trunks of the cedar, the birch, and other forest trees of the present day. Giant trees of the same species now grow and flourish in the soil of these deposits. The woody fibre of their buried ancestors of the cedar tribe is as well preserved as if only a few years had passed since their entombment. The bark of the

birch trees looks yet as white as snow, while the more perishable wooden nucleus has almost entirely disappeared.

A similar recent deposit of vegetable débris and tree trunks of ten feet thickness, is shown on the shore of Lake Superior, in the drift bluffs of Sable Point, about two miles west of Grand Marais harbor. To a superficial observer, this deposit seems to make part of the drift; the vegetable matter reposes immediately on the lower clay beds of the drift formation. But a more careful examination reveals clearly the discordant position of the carbonaceous deposits to the adjoining strata of the drift. The vegetable substances evidently accumulated on the bottom of a deep smaller lake basin, which was excavated in the drift, and subsequently covered up by the sand falling in from the sides, until the whole of it was filled up, and made even with the surface. By the encroachment of the Lake Superior on the shore, a cross-section of this former basin was exposed in the lake bluffs, and by the perfect similarity of the covering sand layers with the adjoining sand deposits, this carbonaceous wedge, cropping out from the base of the apparently unbroken continuation of a drift bluff, seventy feet high, is very apt to deceive.

Another alluvial clay deposit, containing many vegetable debris, and large numbers of sweet water shells, planorbis, physa, cyclas, and also some helices, is exposed in the bed of Carp river in St. Martin's bay. A similar much more extensive deposit, on the Lower Peninsula, near Little Traverse bay, forms the whole bed of Pine lake, a sheet of water sixteen miles in length.

The practical value of these alluvial vegetable deposits is very small; they are mixed with too much sand and argillaceous particles to become good fuel.

In the marshy meadow lands of the Peninsula an abundance of peat is stored away for future use, and is in constant process of formation. The large demand for fuel in the production of iron has already induced a company in the iron district of Marquette to make use of the peat, and, as it appears, with satisfactory results.

BOG IRON ORES OF THE UPPER PENINSULA.

Among the more recent superficial deposits, the bog iron ores are of high practical interest. A number of localities in which bog iron ore was found were long since pointed out in the maps of the linear surveyors of the State.

In the late preliminary report of the former State geologist inexhaustible quantities of this ore were said to exist on the western tributaries of Manistique and of Taquamenon rivers, and for that reason I have given particular attention to the investigation of these districts.

Nearly all of the springs contain small quantities of iron in solution, which they deposit, if by escape of carbonic acid, or by other chemical action, the solvent power of the water for the iron should fail. The waters of all the rivers of the Peninsula are freed of the iron which they hold in solution, by passing through the extended swamps, from which the rivers originate, and the small continuous secretion of iron particles, in favorable spots, gradually increases to masses of such extent as to constitute valuable ores for the manufacture of iron. Such large deposits are, however, of rare occurrence. Usually, we find the surface coated with a crust of ochraceous mud, or the superficial sand is infiltrated and sometimes cemented into a hard sandstone band by the ferruginous matter, or concretiary lumps and nodules of a purer hard ore are sprinkled thinly over the ground, and frequently adhere to the root fibres of fallen trees. Spots of this kind, noticed by the woodmen and the surveyors, have been carefully indicated in the maps, and seem to show that the whole centre of the Peninsula is carpeted with bog iron ore; but the quantity of the ore here alone determines its value, and not its quality. Only in very few places the ore deposits are important enough to give favorable hope for mining operations.

Among all the bog iron ore deposits, which came under my observation, I found one of the best localities on the head-waters of the Taquamenon river, which I am going to describe.

Between the head-waters of Two Hearted river and the west branches of Taquamenon river, a swampy, almost treeless, high plateau spreads out, on which, for many square miles, not a trace of bog iron is to be seen, until finally, at the southeast margin of it, the stagnant ditches of the plain collect into a tortuous channel with slow current, which, before it enters the timbered lands, is surrounded by a grassy marsh, about sixty acres in extent. Over this spot the bog iron ore is dispersed in small irregular patches, which are clear of all vegetation, excepting a few low bushes. The total of the surface occupied by the ore can be estimated to be three acres; the greatest observed thickness was fifteen inches, but in other places it was not more than two inches, and its average thickness I would not estimate over six inches. Beyond these limits, no more ore is found in this locality.

The ore is evidently of a rich quality, but I have not found the time yet to make an accurate chemical analysis of it. Numerous other localities for bog iron, which I saw, were of no greater extent than the described deposit, and most of them much inferior to it. Also, the frequent descriptions of bog iron ore deposits given to me by the woodsmen did not indicate the existence of any more favorable spots for the ore in this district.

Taking into consideration the remoteness of these places from all passable roads, and the easy exhaustibility of such limited areas, I am of the opinion that at present little practical benefit can be derived from these mineral stores, which perhaps in the future may become valuable, after the country gets more inhabitants, and is traversed by railroads, or even only by common roads.

MAGNETIC IRON ORE SAND.

In certain localities on Lake Superior and on Lake Michigan, the beach is found thickly covered with black, magnetic iron ore sand, which has been washed out of the drift sand by the action of the waves.

The separation of the iron ore from the quartzose sand is in streaks almost perfect; other portions would require purification by artificial washing to make it fit for the melting furnace. The quantity of the ore sand is sometimes so considerable that shiploads of it could be gathered with very little expense.

HELDERBERG GROUP.

Below the drift, the next youngest of the deposits, composing the Upper Peninsula, are the limestones of the upper Helderberg group.

Their surface extent is limited to the triangular landspur, inclosed between Point aux Chênes, Point St. Ignatz and Grosspoint, in St. Martin's bay. The islands of Mackinaw, Boisblanc, and Round island are likewise composed of the same strata, which continue southward across the straits, and form a wide belt around the north end of the Lower Peninsula. The present report, however, is specially devoted to the description of the Upper Peninsula, and the Helderberg strata of the Lower Peninsula will be left out of consideration.

The thickness of this group, within the indicated district, amounts to about 250 feet. In New York State, and particularly in the eastern part of it, it has a much greater development, in which two principal divisions, an *upper* and a *lower* one, are well marked. The lower division is known to extend through Pennsylvania, Maryland and Virginia, to Tennessee. It has been recognized in southern Missouri and southern Illinois, and in the northeast part of the continent; it is largely developed in the promontory of Gaspe. Directly west from the Helderberg mountains, from which the name of the formation is derived, this lower division soon disappears, and has also in the adjoining Canadian districts, and in our State not been clearly recognized.

It is the upper division of the New York series which is represented by the strata of Michigan. The identity of the compared strata is fully demonstrable by the identity of their faunas; but a detailed parallelism between the successive layers in the different places cannot be established.

A very peculiar brecciated lime rock is considered to be the lowest stratum of our Helderberg formation in the Upper Peninsula. It is composed of a great variety of calcareous, dolomitic, cherty and calcareo-argillaceous rock fragments, mixed and thrown about through the re-cemented rock mass. A great portion of the brecciated material is distinctly recognizable as the fractured beds of the immediately underlying formation, and frequently larger rock masses, composed of a series of successive ledges, which have retained their original position to each other, are scattered through the breccia.

The lower part of the breccia rarely contains fossils; near its upper termination, fossils sometimes becomes very abundant. None of these are peculiar to the breccia; the same species continue to exist during the time in which the upper undisturbed series of the group was deposited.

The picturesque scenery of the island of Mackinaw is produced to a great degree by the bold escarpments of this brecciated rock along the shore line, and a similar character is imparted to the landscape on the landspur of the mainland of the Peninsula, as far as this formation extends. It retains, however, not uniformly, this brecciated character; in a number of places it can be observed that the bold rock masses, in their horizontal continuation, gradually are replaced by regularly stratified, less disturbed beds of dolomites, or dolomitic limestones, alternating with shaly or marly layers.

Along the lake shore, between St. Ignatz Point and Point aux Chênes, repeatedly the precipitous walls of the breccia rocks disappear, and the hillsides assume softer, more rounded forms, on the same level, in which a continuation of the vertical rock walls would be expected. In other instances, the powerful denuding agencies of the drift period have swept away the softer, well-stratified portions, but could not destroy the more compact brecciated limestones, which now stand like obelisks, in isolated masses along the margin of the hills, or project in strong relief from their declivities, forming arches, caverns, and other specimens of natural architecture which, from popular imagination, in many instances have received fantastical local names.

The disturbing influences which occasioned the brecciated structure of the Helderberg strata were not confined to this small northern area. Similar effects, referable to the same period, can be observed on several of the islands on Lake Erie, where the lower rock beds are of a decidedly brecciated character. Also the Helderberg strata, exposed in the village of Rock Island, Illinois, are partially in brecciated condition.

The upper division of the Helderberg series in the Upper Peninsula, is made up by uneven bedded limestones, and by cherty and argillaceous layers, attaining an aggregate thickness of about 100 feet, on the island of Mackinaw, where it forms the summit elevation on which old Fort Holmes was situated. The larger portion of the island has been denuded from these higher beds during the drift period, of which thousands of granite boulders and other rocks were left behind, strewn over the rolling plateau, formed by the brecciated limestones, whose beds offered more resistance to the destructive forces. During this process of denudation, portions of the upper series were undermined, and occasionally tumbled downhill into open clefts between the breccia rocks, escaping in this way further destruction. An instance of this kind can be observed in ascending the wagon-road to the new fort. A large crevice in the breccia is seen

there, replenished by a wedge of vertically standing beds of the upper fossiliferous limestones. Similar conditions are found on the triangular spur of the mainland, where several conspicuous hilltops are formed by the upper fossiliferous beds of which, at the foot of the hills, larger dislocated masses fill out the ravines.

Fossils are very abundant in this upper division and in the subjacent terminal strata of the brecciated limestone. I have stated already the conformity of the fauna in this whole upper complex. Many of the fossils seem to have been fractured and waterworn before they were inclosed by the calcareous sediment; some are compressed, and by the process of petrifaction, the finer structure of many of them has been partially obliterated. Most of the fossils are calcareous, or only partially silicified.

On comparison with the fossils of the corniferous limestones of Canada West and of the Sandusky limestones, we find the same forms in either of the deposits, testifying their equivalency.

In the following list all the species I found are enumerated:

Several species of *Stromatopora*, of which I have prepared descriptions and magnified photographic views, are not published yet.
Zaphrentis gigantea, M. Edw.
" prolifica, Billings.
Clysiophyllum Oneidaense, Billings.
Cyathophyllum rugosum, M. Ed.
Heliophyllum, not described species.
" exiguum, Billings.
Chonophyllum magnificum, Billings.
Phillipsastræa Verneuilli, variety with larger cells.
Eridophyllum Simcoense, Billings.
Cystiphyllum Americanum ?
Syringopora Hisingeri, Billings.
" Maclurei, Billings.
" nobilis, Billings.
Alveolites squamosus, Billings.
Cladopora labiosa, Billings.
" expansa, nov. spec.
Favosites hemisphericus, in many varieties, with larger and smaller cells and with variable development of perfect or compound diaphragms.
Favosites Canadensis (Fistulip. Canad., Billings).
" tuberosus, nov. spec.
" turbinatus, Billings.
" epidermatus.
Michelinia convexa, M. Edw.
And several Bryozoa.

Of shells are found:

Atrypa reticularis.
Centronella glansfagea.
Pentamerus aratus.
Stricklandinia elongata.
Strophodonta hemispherica.
" demissa.
Spirifer divaricatus.
Conocardium trigonale.

Of Trilobites: fragments of Dalmannia, of Phacops and of Proetus crassimarginatus.

The value of this limestone formation for building purposes is very limited; the upper strata are thin and not even-bedded, full of silicious veins and nodules of hornstone; the lower brecciated rocks are too heterogeneous and subject to rapid decay.

In construction of the fort the brecciated rocks have been used, but the dilapidated, rough appearance of its walls are little apt to recommend them for such purposes.

Some beds are adapted for the manufacture of quicklime, but at present only the small demand for local consumption has been supplied from them.

The marly and argillaceous constituents form a large proportion of the group, and their mixture with the superincumbent arenaceous drift material, make a very congenial soil for agriculture. By the extent of cultivated lands in this region the limits of the formation are pretty well defined.

To the west, the barren drift sand covers the surface; to the east, the broken, rocky surfaces of the Niagara group have offered to the farming settler no inducements and have remained in their primitive state of wilderness; while along the hillsides facing the lake, from Mackinaw to Point aux Chênes, many a friendly house and verdant clearing attract the attention of the voyager sailing by.

Below the brecciated limestone a series of light colored, thin, and even-bedded dolomites follow in descending order, interstratified with softer marly layers; but these succeeding lower strata are so intimately connected with the brecciated limestones, that often only an arbitrary division line can be drawn between them.

The base of the breccia, in a great proportion composed of the fractured lower strata, merely differs from them by the disturbed condition of its materials, and not by lithological characters. If in places, as has been stated above, the breccia limestone loses its brecciated character, and forms regular beds, it is almost impossible to distinguish an exact geological level.

On the east side of Mackinaw island, well-stratified, light-colored dolomites, in beds of 6 or 8 inches thickness, form an outcrop right above the water line, and are directly overlaid by the brecciated limestone.

In approaching the southeast corner of the island, in the cliffs called *Robison's Folly*, these dolomites are seen on a higher level; further on, west of the Mission House, the whole elevation of the hillside is composed of these well-stratified dolomites, in somewhat thinner ledges and interchanging with softer marly layers. The breccia rock has receded here from the margin, and seems to be partially replaced by the marl and dolomite beds, but a little distance east of the new fort, its massive rock walls come to the front again, forming a conspicuous vertical cliff, on which the southeast corner of the fort is built.

This spot offers a splendid opportunity to study the relations of the dolomites to the superincumbent breccia

rock; the gradual transition of the shapeless, massive portions of the rock, into regularly stratified beds, making the horizontal continuation of the former, is here plainly laid open to the observer.

The shore line between St. Ignatz Point and Point aux Chênes repeatedly presents similar exposures. The lower well-stratified dolomites form a terrace often or twelve feet elevation, from which, a small distance away from the lake border, the vertical walls of the breccia limestone ascend, or on which a softer rounded hillside is built up, by a succession of regularly bedded dolomite and marly strata, replacing the breccia.

Very characteristic for this dolomite formation, in its whole extension, are tabular leaflets of calc-spar crystals, pervading certain ledges in every direction; seen edgewise, the crystals appear in acicular form. In many instances the spar crystals subsequently have been re-dissolved, and the empty spaces present themselves as narrow slits in the rock.

In one locality I found in the same strata, apiece of dolomite,

representing a pseudo-morphose of a rock-salt crystal, one and a half inches in diameter. It has the shape of a quadrangular pyramid, with parallel striæ concentrically arranged over the facets, as in coarsely crystallized culinary salt.

In fresh fractures, the dolomite has a fine crystalline grain, but its weathered surface has a rough, absorbent, and mealy aspect, and as decay goes on it softens to an easy friable aggregate of microscopic, rhomboidal crystals.

Within the same horizon of the series, in which the acicular spar leaflets are most common (and this is in the upper beds of the dolomites, which frequently, also, enter into the composition of the breccia), a few species of fossils are found, which are highly interesting.

One is a large *Leperditia*, which I identify with Liperditia alta of Hall; another is *Spirifer modestus* (Hall). Both are casts which sometimes, in great numbers, cover the surface of the slabs. Except those, I only could find the indistinct cast of a *gasteropod*, and another cast of a *cyathophylloid star-coral;* all my hunting for *eurypterus,* which would be expected here, was in vain.

Leperditia alta and Spirifer modestus are known as lower Helderberg species. On such a meagre representation of a rich fauna, I would hesitate to base conclusions regarding the age of the formation; but taking also into consideration the stratigraphical sequence, surmounted above by well-characterized upper Helderberg strata, underlaid below by beds of perfect lithological resemblance to the Onondaga salt group, we may safely take the intermediate beds as contemporaneous with the lower Helderberg group.

The thickness of this dolomitic rock series, as far as exposed, I estimate at sixty feet; an accurate determination of it is impracticable. Its upper limits have been described as connected with the brecciated limestones by insensible gradations, and its connection with the gypsiferous beds below, is, for the most part, hidden in the depths of the lake or under drift accumulations.

The dolomites are generally too thin bedded to be of much practical use for building purposes and for quicklime; the large percentage of magnesia degrades the product.

A chemical analysis of a specimen from the exposures on the east side of Mackinaw, close to the water level, gives

Carbonate of lime.....	55 per ct.
" " magnesia..	41 "

The remainder is iron, alumina and bituminous matter.

A specimen of the upper fossiliferous Helderberg limestones from Blanchart's farm gave on analysis:

Carbonate of lime.....	68 per ct.
" " magnesia.....	22 "
Siliceo-argillaceous residue, insoluble in muriatic acid.....	8 "
Iron oxyd and alumina hydrate ..	2 "

ONONDAGA SALT GROUP.

In the bed of the lake, near Blanchart's farm, not many feet below the outcrops of the just described dolomites, green and red variegated marls, alternating with more massive ledges of a calcareous rock, are seen. Near Little Point aux Chênes, and on the lowlands joining the shore to the west of it, similar variegated marls with beds of shale and dolomitic ledges form the surface rock. Interstratified with these are nodular concretionary masses, and narrow bands of gypsum. The gypsum there is principally composed of a white granular plasma, through which larger brown colored crystals of gypsum are disseminated; some of it occurs also in seams composed of transversal, silky, shining fibres.

The dolomites, interstratified with the gypsum, are much more mixed with silicious and argillaceous matter than the higher dolomite beds. A specimen from the gypsum quarries of Point aux Chênes had the following composition:

Carbonate of lime	46 per ct.
" magnesia.....	14 "
Alumina and iron oxyd hydrate ..	10 "
Siliceo-argillaceous residue, insoluble in mur. acid.....	30 "
Boiling solution of carbonate of soda dissolved out of this residue three-tenths of its weight.	

Many years ago quarries were opened near Point aux Chênes for this gypsum, but are abandoned now. From

the appearance of the quarries I infer, that the beds of the gypsum were too irregular, and too much of worthless material had to be handled, in order to gain it; perhaps another reason for the suspension of the work is the remoteness from the market, while the same, and I suppose a better article, is found abundantly right in the centre of the district, for which it is in demand.

The same variegated marls, as seen near Point aux Chênes, are found again underlying the St. Martin's islands; their surface is principally composed of drift material. I was informed that large white gypsum blocks are sometimes found on the beach of the islands, and a locality on the larger St. Martin's island was described to me, in which the gypsum could be seen in place, but I did not succeed in finding the spot, although I spent a whole day in hunting for it. In the bottom of the lake, twelve miles east of Mackinaw, in the circumference of Goose island, extensive patches of snow-white gypsum can be seen at the depth of eight or ten feet; the island itself is a low gravel bank, and does not show any rock exposures.

In the bed of Carp river in St. Martin's bay, half a mile above its mouth, the water runs in rapids over rock ledges, which in all probability represent the lowest beds of the gypsiferous formation. The river bank is composed of six feet of yellow sand; next below are five feet well-stratified, impalpably fine rose-colored clay; then follows a stratum of gravel two feet thick, which forms the base of the drift formation. Immediately under this gravel are ash-colored dolomites, mottled and shaded with red. They segregate in uneven rugose layers of six or eight inches in thickness, and are interstratified with thin seams of shaly and marly substance; numerous cellular cavities, filled with calc-spar and occasionally with sulphate of baryta, are seen in the rock, which has a fine-grained, somewhat earthy fracture. The strata, of which six feet are exposed, have a gentle dip to the southeast, which would bring them under the variegated marls of St. Martin's island. In the opposite direction, the first rocks met with are the Niagara limestones. The immediate contact of the two formations is, however, nowhere to be seen.

The lithological characters of this complex of strata, and their position below the Helderberg group, and above the Niagara limestone, have been to all geologists satisfactory evidence in identifying them with the Onondaga salt group of New York. Salt springs, which make this formation in New York so very important and valuable, have not been found in this district, and are not likely to be found where nearly all we have of the formation lies in the bottom of the lake, and for this same reason its thickness cannot definitely be ascertained in this region.

The Dolomites in the bed of Carp river are composed of:

Carbonate of lime	53 per ct.
" magnesia	44 "
Hydrated iron oxyd	1 "
Insoluble matter, consisting of crystals of sulphate of baryta and bituminous substance	2 "

The variegated marls of St. Martin's island give on analysis:

Carbonate of lime	41 per ct.
" magnesia	22 "
Iron and alumina hydr	7 "
Insoluble residue, mostly silicious sand	30 "

NIAGARA GROUP.

With exception of the small area, in which the Helderberg and the Onondaga groups have been described as forming the surface rock, the whole south part of the Peninsula is composed of a series of dolomitic limestones, which prove their contemporaneous age with the Niagara group, not only by numerous characteristic fossils, but also by the immediate continuity which they keep with the typical rocks of the Niagara falls.

A belt of this formation strikes from Niagara river northwestward to Cape Hurd on Lake Huron, and from there continues through the Manitou islands to Drummond's island, only interrupted by a few narrow channels of the lake.

Drummond's island is the eastern end point of the north part of our State. A small belt of its northern end only is composed of older sedimentary rocks; the remainder is all built up by the ledges of the Niagara limestone.

All the numerous islands in the south part of the bay between Drummond's and St. Joseph's islands, the south end of St. Joseph, Lime island, Round island in the St. Mary's river are underlaid by Niagara rocks, but the most part of their surface is boulder drift. On the mainland of the Peninsula, the northern limits of the formation are to a great extent conjectural.

Without considering the almost universal deep drift covering, which hides the rock beds, the uninhabited condition of the country, and the extensive swamps and impenetrable timberlands spreading over the ground make it almost impossible even to penetrate into the interior. Far less success can be expected for a geological exploration, which, however, was in many instances attempted. But to travel with such impediments for many successive days, and to return without having been able to accomplish the desired object, is a severe disappointment.

The Niagara rocks seem to extend as far north as the south shore of Manusco bay; no outcrops of rock ledges can be seen there, but the rock fragments intermingled

with the drift material are mainly Niagara limestone, containing Pentamerus oblongus, and other fossils. Of the Hudson river group, which one would naturally expect to find there, not a single pebble is to be seen.

The north boundaries of the western extension of the group approximatively coincide with the centre of the Township Tier 44. In approaching Millecoquin's river, which is over fifty miles west from Manusco bay, the Niagara limestones reach further north, and are observed in outcrops as far as the north shore of the largest one of the Manistique lakes in the centre of the Town Tier 45. From there, the limits of the formation descend again in a southwest direction, pass at a distance of several miles north of Indian lake, a tributary on the west side of Manistique river, and finally run out near the mouth of Sturgeon river, in Big Bay de Noquette.

A line drawn from the mouth of this river, and prolongated until it strikes the west side of Green Bay peninsula, will indicate the direction in which the Niagara formation continues southwards. The Peninsula, and all the islands east of this line, are composed of Niagara rocks; west of it we find only older strata.

After having delineated the extent of the formation, I proceed to give the results of its special investigation and study in different localities of the district.

Commencing at the east end of the State, at Marblehead off Drummond's island, we have undoubtedly the best section which is offered anywhere to start with.

This promontory, forming the northeast end of the island, has an elevation of about 100 feet above the lake. Its sides are steep, with occasional perpendicular rock escarpments; the strata slowly dip southwards, and consequently, on the north side of the hill deeper strata come to the surface; their dip is, however, by no means so uniform that by comparing dip and distances reliable conclusions on the thickness of the formation could be derived. Undulations in the strata are frequently observed.

The summit of Marblehead hill is formed by light-colored, uneven-bedded, crystalline dolomitic limestones; their moderately thin ledges are pervaded by numerous silicious veins and nodules of hornstone, and inclose a great number and variety of silicified fossils, particularly corals. I collected from these beds:—

Halysites esharoides, Syringopora verticillata.
Syringopora, similar to S. compacta of Billings.
Heliolites interstinctus, Heliolites elegans?
Lyellia Americana, Strombodes pentagonus.
Several forms of Cyathophylloid corals, Favosites favosus.
Favosites Niagarensis, Favosites venustus, several species of Alveolites, and of Cladopora, and likewise of Stromatopora.

Of shells I found: Atrypa recticularis, Pentamerus oblongus, and a large Euomphalus, the two latter of which are generally only imperfect casts.

The thickness of these beds at the spot is about twenty-five feet; the lower ones are much less fossiliferous than the upper. Next below follows a massive, light cream-colored, obscurely stratified dolomite of coarsely crystalline grain, and projecting in perpendicular rock walls from twelve to fifteen feet high. It is filled with casts of Pentamerus oblongus, their form almost obliterated to indistinctness; or merely the cavities once containing them, and now lined with calc-spar or quartz crystals, are preserved. In the same imperfect condition, Favosites and Stromatopora are abundantly dispersed through the rock mass.

At the foot of these walls other more thinly and regularly stratified dolomite ledges of finer grain, and containing no fossils, are seen in the thickness of four or five feet. The subsequent lower strata are hidden by talus.

Some distance sideways, it may be at a ten feet lower level, a downward continuation of the section is most plainly given in a quarry, which once had been worked there, but is now abandoned.

The top of the quarry, which is about thirty-six feet above the lake, is formed by dark gray-colored, highly crystalline limestones, with silicious veins and containing many fossils. Stromatopora is most abundant; besides this, Halysites esharoides, several kinds of Favosites, Alveolites, Syringopora, Cyathophylloid Corals and Crinoid stems are found. Somewhat lower the crystalline lime-stones become mottled with lighter silicious spots, and at the depth of six feet from the top the crystalline structure changes into a dull, more earthy-fracturing rock of lighter yellowish color, the fossils decrease in numbers, and gradually are absent.

From there, to the depth of fifteen feet, light-colored, yellowish white, earthy-fracturing limestones, of laminated structure, continue in layers of variable thickness, which easily decay and fall into angular fragments after some time of exposure. The next lower eight or nine feet are again of crystalline structure and darker gray color, separating in beds up to two feet in thickness, while the lowest portion of the quarry exhibits again more earthy-fracturing beds of distinctly laminated structure. The sole of the quarry is about eight feet above the level of the lake.

The thicker beds in the lower portion of the quarry, including the darker colored crystalline ledges, furnish a building material of fair appearance, but the weather seems to affect them injuriously, and the name of marble is ill-adapted to them; they have neither the lively colors of marble, nor are they susceptible of a fine polish. A small distance north of the quarry, after a short interruption of the exposures, a continuation of the section through the next lower strata can be observed by following the shore line, where successively the deeper layers are brought to light by the gentle southward dip of the whole formation. At the same time, the level of the lake intersecting the outcrops allows one to observe minutely the different undulations to which the strata are subject. The next succeeding rock-beds, below the sole

of the quarry, are dark gray, bituminous dolomites, of nodular, very unhomogeneous structure. Seams of black carbonaceous matter wind themselves through the rock mass; other beds are stained with large white blotches of chert. They contain a good many fossils, principally Stromatopora and Favosites, also Halysites, Saphrentis, Orthoceras, and other remains are found, but not very well preserved.

After intersection of about ten feet of the last-mentioned strata, six or seven feet of flaggy layers follow, in various shadings of color, and of uneven nodular surface.

Next below are three feet of ash-colored, fine-grained limestones, in beds of from four to eight inches, some of which are full of fissure-like cavities, penetrating them in all directions, which, according to their shape, are the empty spaces once occupied by re-dissolved tabular spar crystals. Similar limestone specimens have been described from the lower strata of Mackinaw. Underneath these, eight feet of regularly bedded limestones, of yellowish gray color, and of dull, earthy, uneven fracture, continue the series. They inclose druse cavities filled with calc-spar or quartz, and contain the casts of an Avicula, not unlike Avicula rhomboidea of Hall, a Nucula-like bivalve, a Rhynchonella, Leperditia, and a tuberose form of Favosites. Some of the thicker beds have been quarried on a small scale, but the rock does not seem to resist the weather very well. The next succeeding rock is a dark gray-colored bituminous limestone, of unhomogeneous nodular structure; the nodules are coated with a black cuticle of bituminous shaly matter; its thickness is five feet, composed of uneven layers. Fossils are not rare, but poorly preserved; those found are Favosites, Leperditia, Rhynchonella, of apparently the same form as those in the strata above; besides these, casts, similar or identical with Murchisonia subulata ; some Nucula-like bivalves and a fragment of Orthoceras have been found.

Finally, light-colored absorbent limestones, separating in thin slabs, with uneven conchoidal surface, make the end of this section; their exposed thickness is ten feet. Some of the layers are harder, giving a ringing sound under the hammer; others softer and easy weathering, in angular fragments. The lowest layers are darker, and full of ramified, fucoid-like maculæ, the only distinct fossil I noticed in them is a Leperditia.

By this time we have followed the shore to within one-quarter of a mile from Pirate harbor, in Sitgreaves bay, and the rocks are lost under the drift, or disappear in the bottom of the lake.

On the opposite side of the bay, only about one and a half miles distant, the shore is literally covered by hard, compact, loose limestone slabs, containing silicious concretions, part of which are evidently obscured specimens of Stromatopora; also the cast of a large orthis was found.

I could not find an outcrop of these layers; but the abundance and unworn condition of the loose slabs leave no doubt about their close proximity *in situ*. The lake bottom at this spot is formed of a different kind of rock bed—a blue arenaceous limestone, with intercalated shales, which, by the immense number of chaetetes stems they contain, indicate the upper part of the Hudson river group; while the loose limestone slabs, which undoubtedly form the next layer above, in lithological characters, more resemble the dolomites of the Niagara series, on the other side of the bay.

Further west, on the islands at the north end of the channel between Drummond's and St. Joseph's island, similar hard dolomitic rocks are exposed, in which the casts of a large orthis, similar to Orthis Occidentalis, are the only recognizable fossils. A critical consideration of these beds, and the lower members of the above given section through the Niagara rocks, I postpone for a subsequent chapter.

On the west side of Drummond's island other interesting sections of the Niagara group are observed on Quarry Point, and in another locality about one mile north of it, in Town 42, Range 6 east, Sections 18 and 19, where, also, quarries have been opened.

In the latter place, the quarry itself comprises twenty-five feet of strata; its sole is about sixteen feet above the level of the lake, and its upper edge forty feet below the highest hill elevation, which is formed by massive dolomite ledges, containing numerous casts of Pentamerus. The next lower beds are not well exposed, but from about ten feet above the margin of the quarry, down to its sole, all the ledges are remarkably even, and of more or less distinctly laminated structure. The upper beds, in and above the quarry, are generally not thick enough for a building stone; they have been used to supply the limekilns erected in front of the quarry. The lower ten feet above the sole bed are in layers from twelve to thirty inches thickness, which break in fine, square-edged blocks; the coarser grained ledges seem to be preferable; the middle bed exhibits the before-mentioned laminated structure in a high degree, and not only may be split in this direction in slabs of any desired thickness, but unfortunately also separates in such laminæ after a short exposure to the winter frosts. This is probably the reason why quarry and limekiln were both abandoned several years ago. Some of the coarser grained blocks left in the quarry have withstood during this time the effects of five or six winters, and are sound yet; but these beds alone would scarcely remunerate for the necessary expense and labor to get at them. The blocks of laminated structure left there may, by the stroke of a small hammer, be shattered into innumerable thin slabs, like roofing slate.

From the bottom of the quarry, down to the edge of the water, the dolomite, retaining the same lithological characters, continues in thinner ledges, and disappears then in the lake channel.

Throughout this lower complex of strata, scarcely any fossils are noticed; only a few calyces of a Zaphrentis could be seen projecting from one of the layers in the quarry.

The rock beds of the Niagara group allow a subdivision in three well-marked sections. It is exclusively a limestone formation. The lower section is always very regular and even-bedded, composed of comparatively thin layers of a fine crystalline grain, or with a dull, more earthy fracture. In composition, most of the strata are dolomites; only a few layers are found to be a pure limestone. Fossils are rare in it. The middle division is made up by more massive highly crystalline dolomite ledges, which usually contain a large number of the casts of Pentamerus oblongus, and some ill-preserved corals. The third upper division is a series of thin, uneven layers, with intermixture of much silicious matter with the dolomite mass, and of seams and nodular concretions of hornstone. In this upper division, also, the greatest abundance of fossils is found.

The south part of Drummond's island is exclusively composed of the two upper divisions. Their outcrops are not in high bluffs, as on the north and west side; the southern dip of the strata brings the rock ledges down to the water level, which crown the hill-tops at the northern end.

Only a few of the rock cliffs have an elevation of 20 feet; the higher background of the south shore is formed by the drift hills, densely overgrown with forests.

At the southeast side of the island, the massive rock masses of the middle division form the surface rock of the flats adjoining the lake. The rock could be easy quarried there, and is of sufficient durability for ordinary rough constructions; but for such uses there is little demand in this region, and for finer masonry the structure is too seamy and unhomogeneous.

The upper thin-bedded, fossiliferous strata have no economic value, but the profusion of fossils imbedded in them excite the highest interest of the palæontologist.

The environs of the old English fort, in Whitney bay, have long been celebrated for their abundance of beautifully preserved silicified fossils, particularly corals; but this much-hunted place has been largely spoiled of its treasures by frequent visitors, and no new ones are brought to the surface, since the industrious settler, and with him the plough, have retired from this once flourishing military station.

On the opposite side of the St. Mary's river, along the hill-sides of Point Detour, the numerous drift terraces, surmounting each other in succession, are almost exclusively composed of the broken-up confused layers of the upper Niagara limestone, which in spots are seen yet retaining their undisturbed position on top of the Pentamerus limestone, which composes the body of the hills, and is in several places denuded from its drift covering.

In this accumulation of rubbish, fossils are crowded in astonishing numbers, far surpassing the Drummond island localities. Here is scarcely any room left for the rock mass; it is all one heap of silicified corals, and a part of them preserved as perfectly as if the animal only had recently ceased to live in the corallum.

The fossils found in this locality are enumerated in the subjoined list:

Favosites favosus.
Niagarensis.
venustus.

These three forms are the closely allied representatives of a peculiar type in the Favosites tribe, by which peculiarity Hall was induced to separate them from Favosites, under the name of Astro-cerium.

Spinules, projecting in longitudinal rows from the interior of the tube walls, and a similarly spinulose or granulose surface of the transverse diaphragms, with more or less developed syphonal depressions in their circumference, are characteristic of all the three species; but these characters are so variable, that we find all degrees of transition; from almost smooth, only slightly granulose, tube cavities to such as are decorated with rows of long projecting spines. The marginal depressions of the diaphragms may give the tubes the appearance of a star-cell, while in other portions of the same specimen scarcely any such depression is perceptible. The convexity of the diaphragms is a distinctive mark of Favosites favosus from F. Niagarensis or Gothlandicus; but we find all gradations from convex to perfectly level diaphragms, represented in the specimens. If we consider the size of the tubes, which appears to be an excellent character for distinction of species, we are lost altogether. We find specimens having all the particular qualities of Favosites favosus, with tubes six millimetres wide, and of every possible Intermediate size, down to specimens with only 11/2 millimetre tube diameter. This latter small-tubed form connects the species Immediately with the still more minute form of Favosites venustus, which is only a miniature edition of Favosites favosus.

The almost unlimited variability in the size of the calyces, in specimens which otherwise are perfectly alike, is observed in all the Zoantharia tabulata, and in the majority of Zoantharia rugosa.

Other Favositoids found in this locality are:

Favosites reticulatus, M. Edw.
Cladopora multipora, Hall.
laminata, n. sp.
Several species of Alveolites not nearer determined.
Two species of Thecia and one of Striatopora.
Halysites catenulatus, in all possible gradations of tube size and chain mashes.
Syringopora verticillata, Goldf.
similar to compacta, Billings.
and several other not accurately determined forms of Syringopora.
Heliolites interstinctus, Waheenb.
megastoma, McCoy.
Lyellia Americana, M. Edw.
papillosa, nov. spec.

Strombodes pentagonus, Goldf, in a great variety of forms with larger and smaller calyces.
Strombodes mamillaris, Owen.
Zaphrentis Stockesii, M. Ed.; and several other not determined forms of Zaphrentis.
Omphyma verrucosa.
Amplexus Shumardi (Cyathoph., M. Edw.); and a great many other forms of Cyathophylloid corals, to be subordinated in the genera Streptelasma, Heliophyllum, Eridophyllum, Cyathophyllum and Cystiphyllum.
A species of *Columnaria*, and a *Tetradium*, are of particular interest, as not known before to occur in the Niagara group.
Chaetetes and other Bryozoa are not very common.
Stromatoporas, in many different forms, are among the most abundant fossils in the formation. In a not published manuscript I have described and figured one form as *Stromatopora minuta*, another as *Str. vesiculosa*.
Except the Corals and Sponges, only a few other fossil forms are found. They are: Atrypa reticularis, Pentamerus oblongus, a peculiar Stricklandinia, Orthis flabellulum, a large Euomphaloid shell, and casts of other gasteropodes.
Several forms of the problematic fossil Huronia, and of Discosorus conoideus are found quite frequently; and Crinoid stems, common everywhere where fossils are, are not missing.

From Point Detour westward to the mouth of Pine river, almost continued outcrops of the middle, rarely of the upper fossiliferous division of the Niagara group, offer themselves in the low landspurs or in the islands and shoals surrounding the shore. Some distance back from the shore, where the land makes its first terrace-like ascent, a string of low rock bluffs can be all the way followed, but the higher elevations are all covered by the drift.

The rock character remains uniformly the same; it is a hard crystalline dolomite, in massive ledges, full of irregular, impurer silicious seams. The dissolving action of the lake water on the exposed rock-faces excavates the purer limestone portions, and the more resisting silicious seams project in high relief.

Fishermen frequently bring up such eroded pieces with their nets, and admire them as curiosities, comparing them with all sorts of natural objects, which similarity frequently only can be seen by persons gifted with a livelier fancy than naturalists generally have.

By some explorers, the above-mentioned rock bluffs, exhibiting about fifteen feet of the massive beds of the middle Niagara division, have been noticed in a locality in Town 42, Range 1 east, Sect. 21 ectr., and the discovery of a *great marble quarry* was announced. After careful inspection of this place, I express my opinion to the numerous inquirers about the locality in the following short sentence: It is a good common building stone, not better than in any other locality, where the central ledges of the Niagara group are exposed, and a great deal more out of the way than many others.

The islands of the Cheneau group are all underlaid by a nucleus of this rock formation, but in most of them it is totally enveloped with boulder drift and with debris of the fractured rock ledges.

In the hills surrounding Pine river and the upper branches of Carp river off St. Martin's bay, the massive pentamerus rock frequently comes to the surface, but it offers no peculiarity which would require a separate description.

Going further west, along the shore of Lake Michigan, for a space of fifteen miles, nothing but bluffs of drift sand are encountered, after having passed the Helderberg outcrops from St. Ignatz Point to Point aux Chênes,

In the shoals of Manitou payment, the Niagara rocks make their first appearance again, and continue from there, with only short interruptions, to form the surface rock of all the low lands and projecting spurs along the lake shore, as far as Summer island, at the entrance of Big Bay de Noquette.

The hills coming up to the shore or ascending further inland are built up by drift deposits, and only in deep ravines and the channels of creeks, could an erosion down to the rock beds occasionally be observed.

Epouffete Point and the surrounding low lands are only four or five feet above the water level; the exposed ledges are very rugged, cellulose dolomites, containing quite numerous ill-preserved fossils or casts of them. Most common are Pentamerus oblongus, Halysites esharoides, and Syringopora verticillata.

In the surroundings of Millecoquin's river, beds somewhat higher in the series, and containing more and better preserved silicified fossils, underlie the first drift terrace, having an elevation of about twenty feet above the lake. Most of the drift material is only the shattered fragments of the ledges in place, mixed with a few erratic boulders and gravel. The river is the outlet of a lake, situated on top of the drift plateau, whose elevation above Lake Michigan I estimate to be about 100 feet; its distance from it is six miles. In the creeks entering Millecoquin lake, and in the bed of its outlet not far from the lake, the rock ledges of the Niagara group, containing Pentamerus, Catenipora, and Favosites, are exposed under drift banks of 30 and 40 feet height.

Travelling from Millecoquin lake, in a northwest direction, to the Manistique lakes, we pass over undulating drift hills overgrown with splendid hard-wood forests. In the beds of creeks, or along the slanting hill-sides, the Niagara limestone frequently comes to the surface, well characterized by the usual fossils, Pentamerus, Halysites, Favosites, and other corals. The same rock is exposed on the west shore of South Manistique lake. The environs of North Manistique lake exhibit also outcrops of limestones in the northwest corner of the lake, not far from the exit of Manistique river.

The rock there is a light-colored gray dolomite, in uneven beds, generally not over five or six inches thick, enclosing some fossils; I found Zaphrentis, Favosites, a Leptæna similar to subplana, a Conularia, and Crinoid joints. The Conularia differs from the Trenton and Hudson river group species; the other few and imperfectly preserved fossils are not sufficient to entitle to any conclusions on the age of the strata, but Favosites are not known to occur in any lower position than the Clinton group, and the rock character is so similar to the well-identifiable Niagara limestones of the neighborhood, that I feel inclined to consider the age of these limestones as upper Silurian. The limits of the Hudson river group cannot be far off from there, pebbles containing Ambonychia radiata, Murchisonia bicincta, and other Gasteropodes similar to Murchisonia gracilis, are not uncommon along the beach, but an outcrop I could not find; heavy drift deposits form the principal part of the lake borders.

In the interior of the Peninsula very few opportunities are offered to see extensive sections through the strata, and my companions were not woodsmen enough to risk a further advance, so I returned to the lake shore.

West of Millecoquin's river, the Niagara rocks are not well disclosed before reaching Seul Choix Point, where the massive dolomites project from the lake in a string of reefs, and form the surface rock of the low landspur, in places overlaid by the thin-bedded more fossiliferous upper strata. The fossils, which in the eastern localities usually are found silicified, are here and in the more western outcrops partly calcareous, rarely exhibiting structure as well preserved as in the silicified specimens. Halysites esharoides, Syringopora verticillata, Strombodes pentagonus, Zaphrentis Stockesii, several species of Favosites, of Alveolites, Cladopora, and of Stromatopora are found in great abundance; also several species of Huronia, supposed to be the siphuncules of Orthoceratites, but probably of altogether different nature.

Two miles west of Seul Choix Point, which is a very important fishing station, the rocks have disappeared again from the shore under a belt of low barren sand hills, thrown up by the present lake, and perhaps with co-operation of the gales acting on the loose sand and transporting it in the air. Subsequently, in some low marshy headlands and in the shoals of the lake, the rock beds are found again denuded. After entering the mouth of Manistique river, I had for the first time after leaving Drummond's island, a good deal more extensive section of the Niagara group laid open before me.

At the saw-mill, a dam is erected on the rock ledges over which the river used to run in a small cascade.

From the water-level below the dam, to the level above, twelve feet of strata are exposed. Lowest is a hard crystalline blue and yellowish spotted dolomite, above it are two feet more of similar strata, which contain numbers of Stromatopora and Pentamerus oblongus, also a specimen of Discosorus conoideus was found.

Above follow four feet of a hard brittle limestone, weathering white, but interiorly of a bluish color. It splits in slabs of uneven surface, and has a conchoidal fracture. On the surface of the beds Pentamerus oblongus, long stems of crinoids, and fucoid remains of two different kinds are seen. One of them resembles closely Fucoides caudagalli, also specimens of Dictyonema gracilis and of Favosites are inclosed in the rock.

About a quarter of a mile east of the river, in a ridge of sixty feet elevation, and extending alongside of the river for many miles up stream, a continuation of the section is exposed. Above the rock ledges, supporting the dam, similar beds continue for several feet, then follows a coarsely crystalline, unhomogeneous, easy weathering dolomite, containing large numbers of half silicified corals and casts of Pentamerus. It forms the surface rock of a slowly rising belt around the hill, and its thickness cannot be accurately ascertained. Higher up the dolomite becomes almost entirely replaced by flinty layers, which contain a great abundance of silicified fossils, but also not in very good preservation. The following collections were made: Strombodes pentagonus, Halysites esharoides, Syringopora verticillata, Lyellia Americana, several species of Favosites, and of Stromatopora, Atrypa reticularis, a species of Rhynchonella, and fragments of Orthoceras. Of these flinty layers four or five feet are deposited.

Above them are four feet of compact dolomitic limestones of uneven bedding, laid open in a quarry, which furnished the stone to fill the cribs in the construction of the mill-dam. For other building purposes the stone would not answer. The upper part of the hill is formed by drift, and the top layers of the quarry are found polished by drift action. The bed of the river is, for many miles upwards, formed by flat rock ledges of hard dolomitic nature, over which the water rushes in rapid current. The rocky river bed continues up to Indian lake, whose east side is lined with cliffs from ten to fifteen feet in height, which belong to the Niagara limestone series, containing Pentamerus, Stromatopora, and in the upper beds many fucoid-like stems. On the east shore of Indian lake a tract of high land, overgrown with fine beech and maple trees, is inhabited by Indians, and the ruins of some larger log houses, erected there by the white men, indicate that in former times this was an important trading-post. Towards the north end of Indian lake, extensive marshlands are spread out, in which nothing, but here and there dispersed patches of rusty mud, or a small bog-iron deposit, attracts the interest of a geologist. Also, in ascending the west branch of Manistique river, up to the centre of Town 44, not a single rock exposure could be found; the river has carved its bed in the drift, which frequently forms embankments forty and fifty feet high. On the east side of the main river, a ridge of Niagara limestone strikes in a northeast direction through Towns 42, and 43, R. 14, and terminates on the west side of South Manistique lake.

The rock beds composing this ridge are partly even-bedded thick layers of a dull earthy fracturing limestone, partly in thinner uneven beds, more crystalline in structure. Fossils are rare, only fragments of Cyathophylloid corals and specimens of a Rhynchonella have been observed. Well-opened sections are not seen in this forest land where, before the sight of rock can be had, a thick blanket of moss has to be peeled off from their surface. By the owners of the saw-mill I was informed that the rock ledges extend from the river bed out in the lake for quite a distance. Step by step, with the increase of the depth, lower strata come out in the bottom, until, at forty-two feet, the rock beds disappear at once, and clay replaces them.

As we leave Manistique river, and sail west, the thin, hard, bluish colored limestone slabs, forming the upper surface ledges at the mill-dam, are found exposed in the shoals of the lake, on a land tongue in Town 41, R. 16, Sect. 22. A few compressed shells of Pentamerus were the only fossils found In them. In several places, west of this landspur, the proximity of the strata is indicated by accumulations of little water-worn, angular limestone slabs along the shore; but regular outcrops are only found after having passed Point of Barques. On Point of Barques, and east of it, two successive drift terraces are almost entirely composed of very fossiliferous larger rock fragments, the unbroken ledges of which cannot be far from the surface.

The lake throws out thin-bedded, blue-colored limestone slabs, filled with calcified or half-silicified fossils; the fossils in the limestone fragments of the superincumbent drift bluffs are all silicified, and, like the calcified specimens below, represent the same species, which have been enumerated as found in the upper Niagara division at Point Detour, on St. Mary's river. Some of them are very beautifully preserved.

In Town 39, R. 17, Sect. 17, the rock ledges project about one foot above the water, and underlie the lowlands along the lake, which are overgrown with mixed timber of small size. In Town 38, R. 18, Sect. 4, the rocks project about ten feet, in uneven slabs; the upper portions of which contain only a few Pentamerus shells; the lower beds, intermingled with more argillaceous matter, are rich in fossils, identical with those thrown out by the lake on the east side of Point of Barques. I suppose this to be the place called by Desor *Orthoceras Point.*

Huronia vertebralis is found there in numerous specimens, but, like the other fossils, not in very good preservation.

Onwards to Point Detour, which forms the eastern boundary of Big Bay de Noquette, the rock exposures continue almost without interruption, but the ledges do not rise much above the water level, and the whole country is very low land. At Point Detour the cliffs are about eight feet high, and are composed of the same crystalline, massive limestone beds which form Seul Choix and Epouffete Points. Casts of Syringopora verticillata and of Pentamerus oblongus, besides indistinct Stromatopora specimens, are almost the only fossils found there.

South of Point Detour, Summer island presents bold perpendicular rock walls around its circumference, which project much higher than the cliffs of Detour Point.

Little Summer island, situated north of the large island, is nearly all drift; on its northern end, and on a small island close by, the rocks are at the surface. As we sail into Big Bay de Noquette, the upper fossiliferous limestones are everywhere close under the surface in the low, rounded bluffs extending up to Elliot's harbor, only covered by a thin coating of drift.

On the north side of Elliot's harbor perpendicular rock walls begin to emerge from the water; at first only in cliffs of ten feet height. Further north, in quick succession, lower and lower beds come up under the gently southward dipping strata; and, after the short distance of only three miles, at *Burnt Bluff*, the perpendicular escarpments are already sixty feet high; above which, in a less abrupt manner, the series of rocks continues, or forms in places a second perpendicular escarpment of the same height; so that at Burnt Bluff an uninterrupted section, of at least 125 feet of strata, can be observed. The rock escarpments continue further north, without rising any higher. In an indenture of the coast line, perfectly surrounded by the high cliffs, an iron furnace has been erected, melting Lake Superior ores shipped from Escanaba. At Garden Point the rock walls are already considerably lower, and near the head of Bay de Noquette they are lost out of sight under the red clay banks and gravelly sand masses of the drift.

The lower fifty feet at Burnt Bluff are very evenly and thinly bedded dolomitic ledges of a smooth, fine-grained conchoidal fracture. Except the casts of a Murchisonia-like gasteropod, and some nodular masses of Stromatopora, I did not observe any fossils in them. Next above are succeeding more thickly stratified crystalline dolomites, containing numerous spherical lumps of Stromatopora. Within this horizon lenticular masses of snow-white granular calc-spar of the grain of Italian marble, but softer, are intercalated between the beds. At the same height, a band about two feet thick of a cellulose brecciated rock, with the rock fragments all incrusted by calc and dolomite spar of yellow color, is found. This band is shown in the whole length of the exposure; at Burnt Bluff it is about sixty feet above the water; in the bluffs a mile south of this place it is found down at the water's edge. The next higher strata, above the last-described series, are thick-bedded crystalline dolomites, alternating with thinly and unevenly bedded nodular limestone slabs. Several of the layers contain silicified corals; and, in the upper beds, Huronia vertebralis and Discosorus conoideus, with an abundance of casts of Pentamerus.

The summit of the perpendicular cliffs is formed by even-bedded limestone slabs, fifteen or twenty feet in thickness; and above them, in the receding portions of

the hill-top, still twenty or thirty feet more of silicious limestone ledges, with nodular seams of horn-stone, are found. All these layers contain a great number of silicified, but poorly preserved fossils, of the usual kinds found in this upper division of the Niagara group.

The lower even-bedded limestones at the iron furnace are used as flux in the melting process, and as ordinary building stone, as far as there is any demand for it in the locality. Neither there, nor in another neighboring place, did valuable building stones, worth trans-shipment, come under my observation. On the west side of the bay, near the mouth of Sturgeon river, the lowest beds seen in the section at Burnt Bluff seem to continue. Ledges of them are visible in the shoals surrounding the headlands on the north, and on the south side of the mouth of Sturgeon river. The rock specimens from both sides of the bay do not differ lithologically.

CHEMICAL ANALYSES OF DIFFERENT ROCK SPECIMENS FROM THE NIAGARA GROUP.

In all the analyses I selected homogeneous pieces, avoiding such portions in which visible impurities were intermingled.

Names and Localities.	Carbonate of Lime.	Carbonate of Magnesia.	Allumina et iron oxyhydrat	Residue Insoluble.	Remarks.
	Per cent.	Per cent.	Per cent.	Per cent.	
1. White crystalline dolomite from the middle division of the group from the Lake Huron shore, one mile east of Pine river.....	56	40	1	1.5	Insoluble residue, consisting of clear quartz crystals.
2. Light-gray colored dolomite from the middle division at Point Detour on St. Mary river.....	56	43	Traces.	1	
3. Dolomite forming the top stratum of the quarry at Marblehead, Drummond's island.....	62	33	2	3	Cloudy bituminous residue, with some quartz granules.
4. Upper part of Marblehead quarry of laminated structure with absorbent earthy fracture.....	54	39	4, most alumina.	2	Residue bituminous and silicious.
5. Lower beds of Marblehead quarry, Drummond's island.....	58	32	2	7	Residue siliceo-argillaceous.
6. Limestone from the section of Marblehead with *acicular cavities* (*vide* description above).....	95	1	2	2	
7. Limestone from the Marblehead section, 30 feet below the acicular limestone, described as nodular bituminous limestone, containing fossils.	94	2	1	2	Residue bituminous, and some quartz granules.
8. Lowest beds in the Marblehead section.....	52	35	2	9	Siliceo-argillaceous residue.
9. Loose slabs on the west side of Sitgreaves bay, immediately above the Hudson river group strata, Drummond's island..	52	38	3	6	Silicious residue.
10. Quarry point on the west side of Drummond's island. Quarry stone of laminated structure.....	60	32	1	3	Silicious residue.
11. Sole bed of the same quarry of more crystalline structure than specimen No. 10.....	59	38	1	1	
12. Lowest strata at Burnt Bluff of Big Bay de Noquette.....	56.6	39	1	2.5	

The white, lenticular, marble-like masses, imbedded between the lower strata of the Burnt Bluff section, in Bay de Noquette, are almost chemically pure carbonate of lime.

CLINTON GROUP.

Intermediate between the Niagara group and the Hudson river group, in the New York series, a complex strata is found intercalated, which is characterized by peculiar lithological features and by a number of peculiar fossils. These strata are known under the names Clinton group and Medina sandstone.

Also, in the last geological reports of Michigan, the Clinton group is mentioned as a distinct member in the series of strata in our State, and the lower thirty-two feet of Dickinson's quarry, on Marblehead, off Drummond's island, have been pointed out as being the upper portion of this group, and the beds exposed on the lake shore between this quarry and Pirate harbor, as the lower portion. In proof of this assertion, only three not nearer described fossils—an Avicula, a Murchisonia, and a Leperditia are mentioned, all of which, as far as my experience goes, are only found in the lowest portion of the section, while in the quarry, which altogether does not comprise much over thirty-two feet of strata, only Niagara fossils are found, or at least such kinds which are common to both formations. The three mentioned fossils are only imperfect casts, not allowing an exact determination, and scarcely justify important deductions to be based on their occurrence. But, allowing to these meagre representatives the importance given to them, the indicated limits of the Clinton group had to be lowered considerably. I do not doubt that a portion of the lower strata is contemporaneous with the Clinton group, because the lithological changes from the upper portion of the Hudson river group to the typical Niagara group are so gradual that no important alterations in the ocean bed can have taken place during all this interval, which would have caused the elimination of this group; but, for the same reason, I do not admit a division line to be drawn, at random where an uninterrupted continuity is indicated by nature. The Clinton and Medina groups of New York are evidently littoral deposits, in which the amount of sedimentary material is much greater, and in quality more variable, than in the deep ocean deposits, going on in quiet uniformity in the western countries. There was no cause for a sudden change in the fauna, while the local conditions near the shore altered frequently, and, consequently, also, a local change in the fauna was induced by these alterations.

A critical examination of the faunas of the Niagara group and of the Clinton group, demonstrates that a great many of the fossils of the Clinton group were living during the Niagara period, and those which were not are frequently found only in certain restricted localities, standing in some relation with the character of the rock, or are stragglers of the vanishing Hudson river group fauna; as, for instance, Orthis lynx. A further proof of the uninterrupted succession of deposits in this western country, from the end of the Hudson group period to the

Niagara time, I see in the continued existence of Halysites esharoides, and its different varieties, through all the concerned strata. A similar continuity of the successive deposits during this era, we learn from the descriptions of the Canadian survey of the island of Anticosti, where the richness of the fauna in all the different horizons is peculiarly favorable for making comparisons regarding the duration of each species of fossils. We find there the faunas of the Hudson river group and of the Niagara group intimately linked, the one gradually disappearing, the other slowly developing itself.

The summary result of my studies of the Clinton group in our State, in the States of Ohio, Indiana, and the more western States, is, that during that time, in which the littoral deposits of New York State, and their organic contents, frequently changed their character and were accumulating to mighty masses, contrasting with the deposits above and below, in the West, the deposits went on in slow uniformity, without any sudden changes in the fauna or in the deposited materials. In consideration of this fact, I see no reason why we should uphold here an artificial line of demarcation where nature has made none.

HUDSON RIVER OR CINCINNATI GROUP.

It has been mentioned, that in the shoals surrounding the mouth of Sturgeon river, on the west side of Bay de Noquette, ledges of limestone are seen, which are lithologically the same as the lower beds of the opposite shore, on Burnt Bluff. Further inland, about eight miles in direct line from the shore, we find the Sturgeon river running in rapids over ledges of a dark bluish-gray arenaceous limestone, containing Streptelasma corniculum, stems of Chaetetes, Crinoid stems, fragments of Isoteles gigas, Streptorhynchus filitextus, Murchisonia bicincta. The banks of the river are formed by drift deposits thirty feet high. In going up stream, we see the rapids continue, and successively other rock-ledges come to the surface, and form part of the river banks. These are of a darker, bluish-green color, more arenaceous, and interstratified with arenaceous marls. Of fossils, they contain a great many Chaetetes stems, and a coral named by Hall, Sarcinula obsoleta (more likely it is an Eridophyllum). The cavities of the stems have generally lost their organic structure, and are filled with calcspar, and occasionally with violet-colored fluorspar. Besides these, are found specimens of Halysites, in no way much differing from the Niagara species, fragments of Bryozoa, Isoteles gigas, Streptorhynchus filitextus, Crinoid stems. The exposed rock series amounts to about fifteen feet in thickness at this place. In a locality four miles higher up the river the same strata are met with again; the outcrops are so limited and disconnected that little of information can be collected about the structure and sequence of the strata, for which reason I returned from there to the mouth of the river, in anticipation of finding better opportunities along the shore line. I am informed that, twenty-seven miles from the mouth of Sturgeon river, twelve miles above the place from which I returned, other more considerable rapids with rock exposures, are found in the river, which probably are of older Trenton age.

The whole Peninsula, separating Big Bay from Little Bay de Noquette, is underlaid by the Hudson river group. Its east shore is low, and has few rock exposures, but numerous limestone blocks strewn along the beach, indicate, by the fossils they contain, the nature of the subjacent rocks. Leptæna alternata, Zygospira recurvirostra, Orthis testudinaria, Isoteles gigas, are the common fossils.

On a landspur four miles east of the lighthouse at the entrance of Little Bay de Noquette, in Town 38, Range 21, Sect. 8, six feet of uneven and thin limestone beds, interstratified with arenaceous shales, form an outcrop along the shore. They contain numerous stems of Chaetetes ramosus, Orthis testudinaria, Orthis lynx, Leptæna alternata, and other fossils. The interval from there to the lighthouse is filled out by a sandy, low drift beach. On the lighthouse point the rock beds emerge again, and from there, continued outcrops for ten miles up Little Bay de Noquette, line the west side of the Peninsular spur, and form conspicuous vertical bluffs of from 12 to 50 feet in height. At the lighthouse, the elevation of the strata above the water is only a few feet. The uppermost beds, not more than three feet in thickness, are light-colored silicious limestones, full of flint nodules, and inclosing a great number of fractured shells, of the same kinds as those found in the beds below, which are blue-colored argillaceous limestones, alternating with blue shales, and perfectly crowded with fossils. The whole thickness of the exposed strata, amounting to about 60 feet, is composed of these alternating beds of shales and limestones. At times the shales prevail over the limestone, other times the case is reversed.

Notwithstanding the immense abundance of fossils, well-preserved specimens are rare, and also the number of species is comparatively small.

The following list gives the names of the specimens found:

Streptelasma corniculum, rare.
Chaetetes ramosus, and other species, very abundant.
Protaræa vetusta, rare.
Tetradium cellulosum, rare.
Stictopora, spec, not determined.
Orthis lynx.
" plicatella.
“ testudinaria.
" occidentalis.
Rynchonella increbescens.
" small variety.
Zygospira recurvirostra.
Leptæna alternata, in a smaller and in a larger variety.

" sinuata.
Streptorhynchus filitextus.
Ambonychia carinata.
Modiolopsis modiolaris.
Avicula demissa.
Cyrtodonta, sp. not determined.
Indistinct casts of Gasteropods, and of Orthoceratites.
Isoteles gigas.
Crinoid stems, and a specimen of a sessile Conoid not generically determined.

The lowest beds seen in these outcrops are a less argillaceous kind of limestone slabs than those above, and are almost entirely composed of Chaetetes ramulets. In the bank, the upper argillaceous limestones appear solid enough to be used for a filling stone in the cribs of aquatic dams, and have been quarried for this purpose; but the experiment proved to be a failure; the rock rapidly decomposed into a soft pulp, and was swept away. Opposite Escanaba, the bluffs have attained their maximum elevation; further north they begin to get lower again, and two miles south of Squaw point all the older rock beds have disappeared under the drift.

About six miles further north, in Bill's creek, a branch of the Whitefish river, 12 feet of blue shales, and a few intercalated limestone beds form, for a short distance, the embankment of the creek.

The shales contain a large number of Lingula shells of suborbicular form, with delicate concentric lines of growth and a faint radial striation from the umbo to the periphery. The dimensions of some perfect specimens are two centimetres from the umbo to the front, and seventeen millimetres in transverse direction. Of other fossils there were only noticed compressed specimens of an Orthis, small casts of Gasteropods, and, quite abundantly, the small casts of a Nucula-like shell (Cleidophorus), covering the surfaces of the slaty laminæ, together with branchlets of a Stictopora and of a Trematopora. The intercalated seams of limestone are an agglomeration of Chaetetes stems. These outcrops are perfectly isolated. All the surrounding country Is covered by drift, their central position between the Trenton limestones of Whitefish river and the Hudson group of Bay de Noquette indicates them to be of lower position than the Hudson group strata exposed in the shore line of the bay. The similarity of these beds with the shades representing the Hudson river group in the lead regions of Illinois and Iowa is very obvious, and the differences existing between them and the more eastern strata would find their explanation in the somewhat older date of the western prevalently shaly deposits. South of Bay de Noquette, the continuation of the belt formed by the Hudson river group Is found on Wisconsin territory. It makes a few outcrops on the west side of Green Bay Peninsula. On the mainland, near the end of the Bay, on Duck creek, quarries have been opened in this formation, which furnish large blocks of a stone, which is worked into window sills, door steps, etc., but I notice too many argillaceous seams in the blocks, which must impair their durability. Some of these layers are very rich in large shells of Leptæna, Orthis occidentalis, Orthis lynx, etc. Of the eastward continuation of this belt of the Hudson river group, through the Michigan Peninsula, we have very little definite knowledge. I found in a few places of the interior rock fragments mixed with the drift, which contained Ambonychia radiata and other characteristic Hudson river group fossils, but a well-disclosed outcrop of the formation is not known to me east of Bay de Noquette, before reaching St. Mary's river. The absolutely regular geological construction of the east part of the Peninsula makes it certain that a belt of the formation traverses its centre, in the direction from west to east; but the drift has exclusive possession of the surface in this region, and the watercourses creeping over the swampy plateau of the centre have not dug their channels deep enough to reach the rock beds. No doubt a minute investigation of this strip of land would lead to the discovery of some favored spots, where glimpses of the rock beds could be caught, but this would require more than the labor of a whole working season, with no prospect of any practical or scientific acquisition, equivalent to the expense and the unusual difficulties connected with a travel, confined to the central portion of an uninhabited forest, where the remoteness, from all supplies is an impediment more serious than can be imagined by those who have not had experience of backwoods travelling.

The first disclosures of the Hudson river group, near the east end of the upper Michigan Peninsula, are found on the Canadian island St. Joseph; but also there, most of it, is covered up by deep drift deposits. Finally, along the north shore of Drummond's island, a series of good exposures allows the study of the formation. The rock differs little from the equivalent beds at Little Bay de Noquette; it is an argillaceo-arenaceous limestone of blue or greenish color, with intercalated beds of shale. If we take into account the beds seen twenty feet under water, in the lake bottom, an aggregate thickness of about fifty or sixty feet of strata comes to view.

The strata of these eastern localities likewise abound in fossils. Some are the same in the east and in the west, but one kind may be very common in one place while it is rare in the other, and a number of species are found only in the eastern localities, and there are inverted. For instance, at Drummond's island, Favistella stellata (columnaria), and a coral related to the genus Lyellia, and identical with Calapœcia of Billings, are found very abundantly, while not a single specimen of either of them is to be found at Bay de Noquette. Streptelasma corniculum and Rhynchonella increbescens are very common at Drummond's island, and only few small specimens of both can be seen in the west. At Drummond's island the following collections have been made:

Streptelasma corniculum (Zaphrentis Canadensis, Billings).
Columnaria stellata (Favistella of Hall).
Calapœcia Huronica.

Chaetetes, several species of it.
Stictopora, not determined.
Stromatocerium rugosum, in large laminated masses, but with very obscure finer structure.
Protaræa vetusta.
Crinoid stems.
Rhynchonella increbescens, large variety.
Zygospira recurvirostra.
Leptæna alternata.
Orthis lynx.
Orthis plicatella.
Orthis occidentalis.
Streptorhynchus filitextus.
Modiolopsis modiolaris, and a number of other indistinct casts of bivalves and gasteropods.
Various species of Orthoceras, one quite large kind of the type of Endoceras proteiforme, with large conical siphons of the shape of gigantic Belemnites. Others have small central siphons.
Isoteles gigas, and fragments of another kind of Trilobite.

The extent of the Hudson river group on Drummond's island is restricted to a strip of land a few miles in width, and its approximate demarcation from the Niagara belt will coincide with a line drawn from the fond of Vermont harbor, in Portaganissing bay, across the island, in southeast direction, to the centre of Sitgreave's bay. The interior of the island, through all this district, is a low swampy forest, in which no outcrops of any extent can be expected. The principal outcrops are confined to the different promontories on the northeast side of the island, between Sitgreave's bay and Reynold's bay. The rock beds are in stairlike offsets, extending far out into the lake, and can be seen yet at a depth of 30 feet; their dip is slowly southeast.

The economical value of the rock series is small. For building purposes, and for lime burning, the ledges are too argillaceous and sandy. A specimen of the calcareous shaly beds from Bay de Noquette gave, on analysis:

Carbonate of lime	36	per ct.
" magnesia	18	"
Alumina and iron oxydhydr.	4	"
Insoluble argillaceous residue, mixed with some quartz sand, and with iron pyrites	42	"

TRENTON GROUP.

This group has in its western extension a very analogous development, in lithological as well as in palæontological characters, with the Trenton strata of New York. It underlies a considerable part of the Upper Peninsula. A belt of it, coming up from the head of Green Bay, enters our State at the mouth of Menominee river, and forms the whole shore line, up to the head of Little Bay de Noquette. At Menominee, the belt has a width of 12 miles; at Escanaba, its extent from east to west is from 20 to 25 miles. Near Grand rapids of Menominee river, the river is left to the west, and the formation ascends with its western limit to the southwest corner of Town 42, R. 25. It is intersected by the Escanaba river, in the centre of the west side of Town 43, R. 24. From there it bends eastwards, crossing the Escanaba and Negaunee railroad a short distance north of Centreville, and comes up to a mile south of the north end of Town 45, R. 22. In an easterly direction its limits are found again near the outlet of Mud lake into Whitefish river. Further east, for a long distance, the formation has not been observed. At Carp river, six miles south of Waiska bay, on Lake Superior, for the first time, the Trenton strata are met with again, and a few ledges of it are seen on the top of the calciferous formation at West Anebish rapids; from there it strikes under the drift across Anebish island to the island of St. Joseph. The west side of St. Joseph's island does not show the formation, except in a large accumulation of drift boulders, composing the hills near St. Joseph's village.

On the east side of the island the Trenton strata are quite extensively exposed along the shore. An outlier of the Trenton limestone forms also the top of Encampment d'Ours island, and of several other islands in the north channel of Lake Huron, all of which are Canadian territory.

The southern limits of the formation, and its junction with the Hudson river group, are very imperfectly known. Even at the shore line, where fine outcrops of the two joining formations are to be seen on the opposite shores, the places of contact are either in the bed of the lake or hidden under the drift. In many localities, through the centre of the Peninsula, the Trenton strata can be identified from west to east, but the exact line of its southern boundaries is as little known as are the northern limits of the Hudson river group. Also in the eastern exposures on St. Joseph's island, the contact of the two adjoining formations has nowhere been observed.

In the bed of the Menominee river, below the mill-dam near its mouth, 10 or 12 feet of hard, crystalline, gray-colored dolomitic limestone form the surface. The uppermost beds are polished by drift action; otherwise the ledges are of a rough, uneven surface, containing, druse cavities lined with spar crystals. The rock is durable for ordinary purposes, but not homogeneous, and not in blocks sufficiently large to be useful for finer masonry. It contains some fossils, of which the following specimens have been collected: Lingula quadrata, Leptæna camerata, Streptorhynchus filitextus, Murchisonia major, Buccania expansa, Trochonerna umbilicata, Maclurea (large casts three inches in diameter), Conularia Trentonensis, Dictyonema (a species with very delicately-reticulated fronds expanding from a transversely-wrinkled hollow cylindrical stem, with a shining carbonaceous surface; also indistinct specimens of Chaetetes frondosus and Crinoid stems are included in the rock.

Above the mill-dam no more rock-ledges are visible before arriving at the next rapids, which are six miles above the mouth of the river. The outcrops there are all confined to the river bed; only few ledges project from the banks. The rock is a thin and uneven-bedded arenaceous limestone of blue color, weathering yellow, interlaminated with shaly seams. Numerous fucoid branches, similar to Buthotrephis succulens (Hall), stand out in relief from the surface of the ledges; the other fossils found are Orthis testudinaria, Streptorhynchus filitextus, Rhynchonella plena, ramulets of Stictopora, Phænopora multipora, Esharopora recta, and other Bryozoa, Schizocrinus nodosus (stems), Streptelasma corniculum, fragments of a Calymene. These appear to be inferior in position to the Trenton strata at the mouth of the river, and represent the middle horizon of the Trenton series. From this locality to the Grand rapids, a distance of 15 miles, no more rock exposures are seen on the river. At Grand rapids, the ledges of the calciferous formation are the surface rock, and will be considered in the following chapter. The Trenton formation keeps itself east of the Menominee river, but Cedar river, with all its ramifications, and Ford river for almost the whole length of its course, are within the Trenton area. Numerous good outcrops are noticed along these river beds, but the Escanaba river flows over exactly the same rock strata, and offers by far the best and most continuous sections through the whole series. I restrict myself, therefore, to an accurate description of the Escanaba section, to avoid tiresome repetition of one and the same thing.

At the mill-dam, one mile above the mouth of Escanaba river, the highest beds of the section make an outcrop in the east bank and in the channel of the river. The rock is in ledges from four to ten inches in thickness, partly an impure limestone with silicious seams, partly of crystalline dolomitic character. The following fossils are found in this place: Leptæna sericea, Leptæna alternate, Zygospira recurvirostra, Orthis testudinaria, Orthis pectinella, Murchisonia gracilis, Murchisonia major, Trochonema umbilicata, ConulariaTrentonensis, Echinoencrinites anatiformis, Poteriocrinus, similar to alternatus, Heterocrinus, similar to H. simplex of Hall, Chaetetes petropolitanus, and ramose forms of Chaetetes.

The more crystalline rock beds have been quarried in this place to supply local demands, but the rock is not clear enough of argillaceous seams to make a good building material. About eight feet of the strata form the exposure. A half a mile above the dam the same rock beds form the shallow river bed and its low banks. The strata dip slowly down in the direction of the stream, and by ascending the river the next lower strata are soon found at the surface, and, shortly after, they rise in the river banks into vertical rock walls twelve feet high. This second division is composed of thin-bedded nodular limestones, intermingled with irregular seams of argillaceous and cherty matter. They are called in Hall's report "*wedge-shaped limestones*," and form for several miles onward to the lower Falls, the surface rock of the river valley. Fossils are not abundant, but everywhere specimens of Leptæna sericea, Leptæna alternata, Zygospira recurvirostra, and fragments of Isoteles and of Orthoceras are to be found. The lower Falls, six miles above the mouth of the river, run over the ledges of this wedge-shaped limestone, making a descent of twelve feet in three offsets. The lower beds at the foot of the falls are thicker and more regular than those above. Underneath these, a series of shales, alternating with arenaceous limestone slabs, are denuded in the river channel, representing a third division of the section, characterized by its prevailing shaly constituents, and, in certain layers, by a great abundance of fossils, in numbers as well as in variety of kinds. The beds exposed below the Falls are not so fossiliferous, and contain only Fucoid branches and Chaetetes petropolitanus. Above the Falls the wedge-shaped limestones forming the surface soon to disappear under drift accumulations, which now make the embankments of the river for the distance of a few miles. The first rock ledges met with again, in ascending further up the river, are the wedge-shaped limestones, and above them more thick-bedded dolomite ledges stand out from the upper portions of the embankments. The strata are subject to frequent undulations, causing repetitions in the sections; but as we ascend the river the erosion steadily becomes lower. At the big bend of the river, in the south part of Town 41, Range 23, some thicker rock beds, full of silicious concretions are found at the base of the wedge-shaped limestones, and then follow, in the descending order, the before-mentioned alternating beds of shales and arenaceous limestone slabs, and remain for several miles onwards the surface rock of the valley. The thickness of these strata amounts to about thirty feet. In Section 17 of the above-mentioned township, the finest outcrops of the fossiliferous beds are found. The fossils are nearly all nicely preserved. An enumeration of them is given in the subjoined list:

Plants.—Paleophycus rugosus, Licrophycus Ottawaensis, and several other Fucoids.

Sponges.—Stromatocerium rugosum.

Corals.—Streptelasma corniculum.

Bryozoa.—Chaetetes petropolitanus, Chaetetes ramosus, and several other forms, of which one is interesting enough to be described here. It is of small mammiform shape, with conspicuous solid dots, formed by closed tubes and closed finer interstitial cells. These solid dots in some specimens project like warts, and are surrounded by a depressed polygonal area, which gives the surface a striking similarity with a compound star-coral. Perfectly identical specimens also occur in the Trenton limestone of Canada, near Ottawa river, and are preserved in the collections of the Geological Survey in Montreal.

Phænopora multipora. Phænopora n. sp.

Coscinium flabellatum, Stictopora ramosa, and two other not determined species; Ceramopora, n. sp.; Arthroclema pulchella, Billings.

Crinoids.—Schizeerinus nodosus, Comarocystites punctatus.

Lamellibranches and Gasteropods.—Nucula levata and casts of other bivalves; Murchisonia major, Buccannia expansa, Trochonema umbillcata, Cyrtolites compressus.

Brachiopods.—Leptæna sericea, Leptæna alternata, Streptorynchus filitextus, Orthis pectinella, Orthis testudinaria, Orthis tricenaria, Orthis lynx, Zygospira recurvirostra, Rhynchonella plena, Crania Lælia, Pholidops Trentonensis.

Articulata.—Isoteles gigas, Illænus Americanus, Cheirurus pleurexanthemus, Calymene senaria, Phacops callicephalus, Encrinurus sp. indic.

Cephalopoda.—Several imperfect specimens of Orthoceras.

The next lower beds presenting themselves in the section below the fossiliferous shales and limestones, are seven feet of light-colored subcrystalline limestones, with an absorbent earthy fracture, which are followed by a few beds of dark-blue crystalline limestone, filled with crinoid stems and the shells of a Cyrtodonta; and these are underlaid by a series of thin-bedded limestones, of uneven, nodular surface, and with silicious veins and concretions, which in appearance scarcely differ from the higher beds designated as *Wedge-shaped limestones*. They contain some fossils which do not extend into the higher beds; but many others of them are found In the lower as well as in the higher strata. In this lower wedge-shaped limestone the following fossils were collected: Columnaria alveolaris, Tetradium fibrosum, Streptelasma corniculum, Stromatocerium rugosum, Chaetetes in several ramose species, a tubular Bryozoon, described by Billings doubtfully under the name of Stromatopora compacta; Stictopora ramosa, Phaenopora multipora and another species, Orthis testudinaria, Orthis tricenaria, Streptorynchus filitextus, Atrypa bisulcata, Rhynchonella plena, Cyrtolites compressus, Pleurotomaria and casts of other Gasteropods, fragments of Orthoceratites, Asaphus, Illænus, and Leperditia Canadensis. The thickness of these lower wedge-shaped limestones is 15 feet, very nearly the same as the upper series has it; their principal exposures are at and below Oak falls, in a narrow canon with vertical walls 20 feet high, through which the river rushes with great velocity for the length of a mile. The next lower beds seen in the base of these cliffs are thick-bedded, hard crystalline dolomites, eight feet In thickness, and at the foot of the falls, which make a vertical descent of eight feet, still lower rock-beds come to the surface, of the thickness of six feet. These are limestones of a greenish ash color, with smooth conchoidal fracture, and full of silicious veins and nodular concretions, which, on the surfaces exposed to the dissolving action of the water, stand out in high relief. Some of the ledges are almost entirely composed of Cyrtodonta shells and their casts.

Three miles above Oak falls, another cascade of five feet is formed by the river; the rock ledges continue to be of the same geological horizon. Columnaria alveolaris, Tetradium fibrosum, and Stromatocerium rugosum, are here the most obvious fossils. Analogous lower Trenton strata are seen in numerous places upwards on the river. In Town 42, Range 24, Section 16, a light-colored brittle limestone, with smooth conchoidal fracture, and shattering in uneven slabs, contains specimens of Endoceres proteiforme, Ormoceras tenuifilum, Orthoceras multicameratum, Tetradium fibrosum, Chaetetes, Stictopora, Leptæna alternata, Rhynchonella plena, Cyrtodonta, Isoteles gigas, and other fossils. These beds are strikingly similar In rock character and in fossils to the upper brittle limestones of St. Joseph's Island, which hereafter will be described. In the north end of Town 42, the river begins to cut down into deeper dolomitic strata, which I consider to represent the calciferous formation. The greenish-gray limestones, containing many Cyrtodonta shells, and mentioned as the lowest strata seen at the foot of Oak falls, are found in this more northern locality, resting immediately on the above dolomitic ledges of the calciferous group.

The aggregate thickness of all the Trenton strata exposed in the section given by the Escanaba river I estimate at 100 feet. Frequent repetitions and interruptions in the section make an accurate measurement impracticable. East of the Escanaba river, on the height of the drift plateau, near Maple ridge station, and at Centerville, on the Escanaba and Negaunee railroad line, the Trenton strata come very close to the surface, and are repeatedly denuded, in the railroad cuts. Near Maple ridge a quarry has been opened to supply the foundation stones for the buildings of a newly erected Iron furnace at Escanaba. In the quarry about ten feet of the strata are denuded; they are of a crystalline dolomitic structure, but contain too many argillaceous seams to be recommended as building stone. The top ledges in the quarry are all ground level by drift action. Of fossils the following species were found in the rock: Murchisonia major, Leptæna sericea, Leptæna alternata, casts of Orthoceras, Conularia Trentonensis, Echinoencrinites anatiformis, Dictyonema growing out from a transversely wrinkled hollow cylindrical stern, and forming a fan-like reticulated expansion. These beds, like the analogous beds on the mouth of Menominee river and of Escanaba river, represent the highest portion of the Trenton group. The same strata form the bed of Day's river for several miles upwards from its mouth. The lowest ledges seen in the river are silicious limestones, which on their surfaces, exposed to the dissolving action of the water, are peculiarly excavated, so as to bring out the more resisting silicious portions in high relief. The upper more thin-bedded and more argillaceous ledges are covered with stems and disjointed heads of Echinoencrinites anatiformis, besides Leptæna sericea, Orthis testudinaria, Streptorhynchus filitextus, Rhynchonella plena? and stems of Chaetetes. The rock beds opened in the railroad cuts near Centerville are lower in the

series, and represent the shaly fossiliferous strata, below the wedge-shaped limestones of the Escanaba river section.

Whitefish river, with all its ramifications, lies within the Trenton area. The lower part of the river, below the mill-dam, has no outcrops of rock ledges. Above the mill-dam, the water, by its artificial retention, has overflowed the lowlands surrounding it, and expands into a long, narrow pond, two miles in length. Above this pond the water is found running in rapids over coarsely crystalline dolomite ledges, containing silicious veins and druse cavities filled with rock oil. Of fossils are found Crinoid stems grown into the rock mass, Orthis testudinaria, Leptæna camerata, Zygospira recurvirostra. The river appears to flow, for a long distance, constantly over rock ledges of the same kind, without cutting deeper into the strata. In various places, as high up as Town 43, Range 20, whenever I struck the river, I found it invariably flowing over the same kind of rock beds. The river valley is an impenetrable cedar swamp, and for this reason I had to follow the road over the adjoining drift hills, and only from time to time I found a chance to descend to the river. On the borders of a small lake, in Town 43, Range 20, Section 2, the bed of the river is formed by hard dolomitic ledges. In the drift deposits forming the banks of the lake, a large proportion of the material is made up by angular blocks of a dolomitic limestone containing a number of fossils, which indicate the upper division of the Trenton group, as represented in the bed of Day's river. Echinoencrinites is very common, besides Leptæna sericea, Orthis testudinaria, Orthis pectinella, Calymene senaria, Streptelasma corniculum, and various Bryozoa. On the west branch of Whitefish river, in Town 44, Range 21, the lower Trenton strata, containing fossils characteristic of the Birdseye limestone, are, in various places at the surface, and are likewise found higher up in the east branch, near its exit from Mud lake, whose basin is underlaid by the calciferous sandrock.

East of Whitefish river the swampy condition of the centre of the Peninsula prevented me from penetrating in this direction. The opportunities to study the rocks are too rare in such districts, and after having repeatedly experienced how small the results of such forced excursions are in comparison with the expense of time and money, I desisted from a detailed survey of this part of the interior, which would have required a whole season's work, and a larger body of assistants than I had to dispose of. Near the east end of the Peninsula I found the Trenton formation again in the bed of Carp river, south of Waiska bay, and in the hills striking from southeast to northwest, through the diagonals of Towns 45 and 46, Range 1 west. The light-colored limestones found there contain Crytodonta Huronica, Vanuxemia inconstans, Orthis tricenaria, Leptæna alternata, Crinoid stems, Streptelasma corniculum, and branchlets of Stictopora, and evidently represent the lower horizon of the Trenton group. At no great distance from these limestones, conglomeritic dolomite strata, with streaks of coarse-grained calcareous sandstone, come to the surface, which belong to the calciferous formation. In the west Anebish rapids the calciferous sandrock is overlaid by some ledges of an impure argillaceous limestone, containing Chaetetes petropolitanus, Stictopora, Streptorhynchus filitextus, Cyrtodonta, Murchisonia gracilis, and Orthoceras proteiforme, all fossils of the Trenton group. Anebish island is entirely covered by drift, and in order to get a fair opportunity to study the Trenton formation as it is in this eastern end of the State, we have to intrude on Canadian territory, where Instructive outcrops of the formation can be seen at the northeast shore of St. Joseph's Island, on Encampement d'Ours Island, and on several other smaller Islands In the north channel of Lake Huron.

The base of Encampement d'Ours Island Is formed by the quartzites and slates of the Huronian group, projecting with vertically erected ledges in bold cliffs from the shore, and in isolated knolls from the lake channel. On a part of the island these vertical ledges are overlaid by horizontal strata of a light-colored, soft, sometimes conglomeritic sandstone, attaining the thickness of 100 feet, or even more. In the northeastern portion of the Island this horizontal sandstone is conformably overlaid by a series of shales and limestones 60 feet thick, which betray their Trenton age by an abundance of characteristic fossils.'

The lowest beds of this limestone formation are prevalently arenaceo-calcareous shales of a dusky green or bluish color, and containing numerous fossils.

The middle strata are thin-bedded nodular limestones, with shaly intercalations, also of darkish color, like the strata below, and equally abounding in fossils.

The upper strata are light-colored brittle, limestones, with conchoidal fracture, splitting in uneven, wedge-shaped slabs by exposure or under the stroke of the hammer. They are likewise well stocked with fossils.

At a first glance the three indicated subdivisions of this series appear to be well defined by the occurrence of fossils peculiar to each section; but after hunting over the ground, one will learn that certain kinds of fossils in beds prevail over other kinds, but that only a small number of them are peculiar to a certain horizon, and that nearly all are to be found in any one of the layers from top to base.

The following collections were made:

1. *In the lower argillaceous beds:*

Rhynchonella plena, Leptæna alternata, small variety; Cyrtodonta Huronensis, Cyrtodonta subtruncata, Vanuxemia inconstans, Matheria tener, Pleurotomaria Eugenia, Orthoceras multicameratum, Orthoceras granulosum, n. sp.; Cyrtoceras, Stictopora ramosa, Chaetetes ramosus, small specimens of Columnaria, and a Bryozoon of nodose glandular form of a most delicate tubular structure, provisionally named by Billings *Stromatopora compacta*, to which genus the fossil has no relation.

2. *From the middle nodular limestones:*

Stictopora ramosa, Phænopora multipora and another not determined species. Chaetetes in ramose forms, Tetradium fibratum, Crinoid stems, Lingula quadrata, Leptæna alternata, Rhynchonella plena, Zygospira recurvirostra, Trochonema umbilicata, Pleurotomaria Eugenia, Cyrtodonta subtruncata and other species of Cyrtodonta, Orthoceras granulosum, Cheirurus pleurexanthemus, Phacops callicephalus, Bathyurus spiniger, Asaphus platycephalus, Leperditia Canadensis, Beyrichia Logani.

3. *From the light-colored upper limestones:*

Several forms of Fucoids, Paleophycus and Buthotrephis, Tetradium fibratum, Columnaria alveolaris, Chaetetes stems, Stictopora, Schizocrinus nodosus (stems), Orthoceras proteiforme, Orthoceras vertebrale, Orthoceras Huronense (Billings), Orthoceras of elliptical form with eccentric Sipho, Cyrtoceras Huronense, Cyrtoceras Isodorus, Leptæna alternata, Zygospira recurvirostra, Pleurotomaria subconica, Pleurotomaria rotuloides, Subulites elongatus, Subulites vittatus, Murchisonia bicincta, Belerophon bidorsatus, Ambonychia amygdalina, Modiolopsis gesneri, Vanuxemia inconstans, Cyrtodonta Huronensis, Cyrt. subtruncata, and other species, Asaphus platycephalus, Illænus crassicauda, Phacops callicephalus, Cheirurus pleurexanthemus, and Leperditia Canadensis.

The strata composing the Landspur forming the north-east end of St. Joseph's Island, are identical with those of Encampement d'Ours. They offer a still better opportunity for observing every single successive stratum of the series, fifty feet of which are laid open.

Lowest, partly below the water level, dark blue or greenish colored arenaceous limestones, interstratified with sandy shales, are seen to the thickness of six feet. They contain Fucoid branches and stems of Chaetetes, but the most obvious fossils enclosed are numerous well-preserved specimens of Orthoceras and of Cyrtodonta. I collected:

Cyrtodonta Huronica, Cyrtod. subtruncata, Vanuxemia incon-stans, Pleurotomaria Eugenia, Orthoceras proteiforme, Orthoceras multicameratum, Orthoceras granulosum, Orthoceras tenuifilum, Orthoceras vertebrale, several species of Cyrtoceras, and one species of Orthoceras, similar to multicameratum, with preserved shell, in which the difference of colors is yet distinctly perceptible. Reddish brown longitudinal stripes alternate with narrower uncolored interstices on the surface of the shell. A similar specimen, with much finer and narrower, but equally distinct, colored stripes, I found in the drift deposits of Ann Arbor.

The next layers above, six or eight feet in thickness, are nodular sandy limestone slabs, alternating with shaly and marly easy decomposing layers, of dark greenish or bluish color. Most conspicuous among their fossils are the immense numbers of Rhynchonella plena, almost entirely composing the rock mass. With them are found Leptæna alternata, small variety, Streptorhynchus filitextus, Orthis subaequata, Stictopora ramosa, Phaenopora multipora, Coscinium flabellatum, Chaetetes ramosus, Tetradium fibratum, (Stromatopora ?) compacta, covering whole ledges with its glandular nodules, and several forms of Fucoid branches.

The third succeeding group of strata in the ascending series are 10 feet of light-bluish gray argillaceous limestones, with smooth conchoidal fracture. They contain fucoid branches, Stictopora ramosa, Chaetetes ramosus, Streptelasma corniculum, Leptæna alternata, Zygospira recurvirostra, Cyrtodonta Huronensis, Vanuxemia inconstans, Ambonychia amygdalina, Modiolopsis gesneri, Ctenodonta nasuta, Illænus crassicauda, Asaphus platycephalus, Cheirurus pleurexanthemus, Leperditia Canadensis.

Above these limestones are a few thick ledges of a brown-colored, sandy-looking, tough dolomite, with large fucoid branches of fasciculated form (licrophycus) projecting from their surfaces in high relief; and after them follow light colored, brittle limestones, with smooth conchoidal fracture, which separate on exposure into thin, uneven, wedgelike, interlaminated slabs or smaller fragments. The top of the embankments, near the shore, is formed by these limestones, which have a thickness of about 12 or 15 feet. Their fossils are : Orthoceras (Endoceras) proteiforme, Orthoceras tenuifilum, Orthoceras Huronense, Orthoceras vertebrale, Cyrtoceras Huronense, Cyrtoceras isodorus, Lituites, and several other not determined Cephalopoda; Vanuxemia inconstans, Cyrtodonta Huronensis, Cyrtodonta Canadensis, Ambonychia amygdalina, Modiolopsis mayeri, Pleurotomaria rotuloides, Pleurotomaria subconica, Murchisonia bicincta, Subulites elongatus, Subulites vittatus, Belerophon bidorsatus, Leperditia Canadensis, Illænus crassicauda. Some distance back from the shore, on a little higher level, several feet of crystalline limestone strata are found deposited on the top of the just mentioned strata, which contain numerous specimens of Columnaria alveolaris, and of Tetradium fibrosum, besides some other fossils met with in the strata below.

Southeast of the location just described, along the shore of another promontory of the island, an outcrop of five feet of rock-ledges projects from the water, which in all probability are the next higher strata to the above given section. Their contact is not to be seen; the two outcrops are separated by a bay three miles wide, and on the shore their junction is hidden under drift deposits. Dark gray limestones, with a rough uneven surface, and containing numerous flinty concretions, form the outcrop. Of fossils, Receptaculites occidentalis is peculiar to these beds, and is found quite common. Other fossils of this place are: Leptæna alternata, Streptorhynchus filitextus, Orthis tricenaria, Orthis testudinaria, Rhynchonella plena, Pleurotomaria subconica, Lituites undatus, Leperditia Canadensis, Phacops callicephalus, Cheirurus pleurexanthemus, Illænus Conradi, Illænus crassicauda, Bathyurus, Streptelasma corniculum,

Chaetetes, Crinoid stems, and a great many fucoid branches spread over the surfaces of the rock ledges.

Four miles north of Drummond's island is Sulphur island, formed by a protrusion of the Huronian Quartzites, overlaid by fossiliferous limestones, without the intervention of sandstones, which separate the Quartzites from the limestones on Encampement d'Ours and on St. Joseph's island.

In the Canadian reports these strata have been identified with the base of the Hudson river group. Before making any suggestions on the age of the strata, I will describe the locality, and mention its fossils.

The Quartzite rocks in their present elevated position seem to have formed an island or submerged reef in the Trenton ocean we find now the rounded water-worn edges of the old Quartzite cliffs covered up by limestone beds, and the fissures between the erected ledges filled with angular fragments of the Quartzites and with rounded water-worn pebbles of granitic rocks, which were thrown into the fissures by the breakers, and subsequently cemented into a limestone breccia by the calcareous mud of the Trenton sea. The ledges of the limestone abut inconformably against the more abrupt rock-walls of the Quartzite, while they adapt their bedding to the moderately inclined surfaces, covering them like a cap and slanting off towards the lake, parallel with the inclination of the underlying surfaces. This dip does not seem to be produced by a subsequent elevation of the island, but is due to the surface attraction, which arranged the sedimentary molecules in laminæ parallel with the surface on which they were deposited. We see at least no signs of a subsequent dislocation of the contiguous rock-masses. During the Drift period a part of these limestone strata were broken up and swept away, or were mixed with the drift-masses, which now cover a considerable portion of the island. The lowest beds, seen to the thickness of eight feet, are dark blue arenaceous limestones, weathering rusty brown, or, in the proximity of the Quartz cliffs, have the nature of a coarse breccia. Fossils are very abundant, in particular Chaetetes ramosus and Chaet. petropolitanus, Stictopora ramosa, Phaenopora multipora, Stems of Glyptocrinus and Schizocrinus, Orthis tricenaria, Orthis pectinella, Rhynchonella increbescens. Less frequent are Orthis testudinaria, Orthis subæquata, Orthis subquadrata, Orthis lynx, Leptæna alternata, Streptorhynchus filitextus, Zygospira recurvirostra, Discina, Cyrtodonta subtruncata, Ambonychia suborbicularis, Columnaria alveolaris, Streptelasma corniculum, Stictopora recta.

Succeeding above are six feet of light-colored limestone ledges, mixed with much silicious matter and. deposited in irregular easily splitting beds like the wedge-shaped limestones of the Escanaba section. They contain large specimens of Orthoceras proteiforme, Chaetetes petropolitanus in larger hemispherical masses, Chaetetes ramosus, Leptæna sericea, Leptæna alternata, Orthis testudinaria, Rhynchonella increbescens and Streptelasma corniculum. Large blocks of this same rock are mixed with the drift, covering the hills near the village of St. Joseph, and are in places so densely crowded that they could be taken for regular outcrops of the formation. Besides the fossils mentioned in the Sulphur island strata, some other species are found in the blocks of St. Joseph. These are Receptaculites occidentalis, Orthis plicatella, Orthis pectinella, Illænus crassicauda, and fragments of a Calymene.

The next following higher strata of Sulphur island are compact, hard, somewhat arenaceous limestones of a dusky yellowish color, and in moderately thin beds. All their fossils are silicified. Leptæna sericea, Orthis testudinaria, Orthis lynx, Rhynchonella increbescens, Camerella hemiplicata, Streptelasma corniculum, and Crinoid stems, are the usual forms. The thickness of these upper beds is six feet.

Glancing over the complex of fossils found in the Sulphur island strata, we notice them all to be Trentonian forms. Many of them are likewise found in the Hudson river group, but the general similarity of the fauna is much greater with the Trenton group than with the Hudson river group. The place which I would assign to these strata in the series would be above the limestones of St. Joseph's island, containing Receptaculites occidentalis, and if this be correct, we would have not far to go to reach the lower limits of the Hudson river group. The difference of opinion, then, whether we connect these beds with the Trenton strata or with the Hudson river group, is of small importance. The continuance of so many Trenton forms through the Hudson group period, proves their intimate connection.

An isolated spot, covered with limestones of Trenton age, has, since 1847, been discovered fourteen miles west of the Bay of L'Anse. The exact locality is in Town 51, R. w. 35; the deposit extends through several sections, 13, 14, 23, 24. Dr. Jackson considered these limestones as of upper Silurian age, because he believed he recognized among the fossils Pentamerus oblongus, a decidedly upper Silurian fossil. But Prof. Hall, in examining the specimens collected by Foster and Whitney, declared all the fossils found there to be lower Silurian forms, and my own examination of the place and its fossils brings me to the same conclusion.

From a branch of Otter creek I ascended the hill range, capped with the limestones, from its northwest side. The foot of the hill is all drift on the surface, and even in the deeper ravines the sandstones, which must form the nucleus of them, make no actual outcrops on this side, but loose fragments of the red and variegated sandstones are plentifully mixed with the drift. As we come near the top of the elevation, the limestone is seen to form a long line of vertical escarpments around its upper circumference. The rock walls rise to the height of thirty feet, and at their foot, in the inclined plane, covered by talus, about twenty feet of limestone strata are found underlying, which gives to the series in this place a thickness of fifty feet. The strata appear to be very nearly horizontal.

After climbing over the top of the vertical cliffs I proceeded, still slowly ascending, in a southeast direction, until I arrived at the opposite declivity of the hill range, from whence an extended view over the country is to be had. The limestone ledges are found there dipping to the northeast, in an angle of thirty degrees, and sometimes greater. I could not find any positive facts explaining the causes which produced this inclined position of the limestones, but from all circumstances it appears to me more probable that there was an underwashing and sinking of the strata during the drift period, rather than an actual upheaval of earlier date.

The thickness of all the limestone strata together will not be much below 75 feet. Their general character is dolomitic, partly silicious.

Fossils are found through the whole series, but nearly all are obscure casts. Only in the upper strata well preserved silicified specimens are found. In the following list all the fossils found by me in the locality are enumerated.

In the lower ledges, casts of Bivalves and of Gasteropods are numerous, but not well enough preserved for determination; the same is the case with fragments of Orthoceras and Cyrtoceras. I have identified: Orthis occidentalis, Orthis testudinaria, Orthis similar to Pectinella, Orthis lynx, Rhynchonella increbescens, Leptæna alternata, Leptæna sericea, Lingula quadrata, Pleurotomaria lenticularis, Subulites similar to elongatus, Murchisonia major, Buccania, Ambonychia orbicularis, Cyrtodonta subtruncata, Nucula levata? larger than Hall's specimens, Streptelasma corniculum. The valve of a Brachiopod, similar to the dorsal valve of Orthis occidentalis, but with the hinge line extended ear-like, and exhibiting an internal septum like the ventral valve of a Pentamerus. A specimen of this kind may possibly have induced Jackson to mistake it for Pentamerus oblongus.

CHAZY LIMESTONE AND CALCIFEROUS FORMATION.

Below the well characterized Trenton strata, and reposing on the Lake Superior sandstones, we find, over the whole, extent of the Peninsula, a series of calcareous or arenaceo-calcareous beds, which hold the place of the Chazy limestone and the calciferous formation of the Eastern States. We cannot distinguish two different formations, with different faunas, in the West, where all the fossils ever found are three or four species of shells, and those generally in imperfect condition. But we can see a plainly expressed typical similarity between the fossils of the Eastern and Western localities. Also the lithological characters of the compared rocks are in perfect general correspondence, so that we can safely consider our Western strata as the equivalents of the two named groups of the New York system. The greatest observed thickness of the formation within the district is near 100 feet, but usually it is not found in so large a development.

Its general rock character is that of a coarse-grained sandstone, with abundant calcareous cement, in alternation with pure dolomitic or sometimes Oolitic beds. But sometimes the arenaceous character is less obvious, and the dolomites wholly prevail.

In the lower portions of the group, some beds are found in brecciated condition;—an observation which has also been made by Prof. James Hall in several other localities of the west. A special description of the different localities in which the formation was observed will make further general remarks superfluous.

Starting from the southwest portion of the district, we first meet this group at the Grand rapids of Menominee river. The rapids are nearly three miles long, and in the bed and the banks of the river a succession of about 25 feet of strata can be observed in the following ascending order:

1. The lowest seen rock is a white coarse-grained sandstone of different degrees of hardness, with interstratified seams of arenaceous shales. The surfaces of the ledges are plainly ripple-marked. Numerous angular limestone fragments and pieces of shale are inclosed in the upper sandstone layers. The sand granules composing the rock are small perfect quartz crystals, with glistening facets and sharp unworn angles. Mixed with the quartz crystals are numerous dispersed oolith globules. Portions of the sand-rock have scarcely any calcareous cement, and are easily friable; others are hard, and are rich in calcareous cement. Exposed thickness, five feet.

2. Hard dolomitic limestones and Oolite beds, mixed with a greater or smaller proportion of quartzose sand granules. Thickness, four feet.

3. Fine-grained argillaceo-arenaceous limestones, banded with red striped, or variegated with irregular red blotches, in thin and even-bedded layers of a dull, earthy fracture, glistening from the admixture of delicate mica scales to the rock-mass, which evolves a strong bituminous smell under the stroke of a hammer. Its thickness is three feet. I found some irregularly dentate, dark brown, leaf-like bodies in the rock, which are decidedly of organic origin.

4. Compact dolomites, partly arenaceous, partly of oolitic structure, two feet.

5. Nodular limestones of peculiar concentrically laminated structure, much resembling irregularly-contorted, nodular masses of Stromatopora; but the nature of the laminated masses is concretionary, and not organic, in its origin. Frequently, portions of the laminated rock are composed of differently-colored, alternating layers of chalcedony, equal in beauty with the nicest Band agates. Thickness, three feet.

6. Fine-grained crystalline even-bedded limestones, in thin layers, with argillaceous partings, four feet. hese disappear under the drift.

The next rock exposure in the river is twelve or fifteen miles further down stream, and exhibits the middle portions of the Trenton group. Also, up the stream, the rocks are soon lost from sight. At White rapids, sandstones similar to the lower beds at Grand rapids form the river bed, and in the river banks numerous blocks of the red blotched bituminous limerock, No. 3 of the Grand rapids section, are found mixed with the drift, indicating the extension of the limestone formation on the river for a good distance north of Grand rapids.

In the drift forming the embankments of Menominee river, above the Grand rapids, calcareous rock fragments have been found containing Trilobite remains, which belong to the Primordial fauna. It is most likely that these rock fragments belonged to the calciferous rock series, and not to the Potsdam group, as is generally supposed. I shall speak again of this subject farther on.

When describing the strata of Escanaba river valley, I closed the section with the greenish-colored silicious limestones containing many Cyrtodonta shells, which I assumed to be the lowest Trenton strata. In Town 43, Range west 25, Section 24, to which point my description extended, we see next inferior to the Cyrtodonta beds, dark grey-colored crystalline Dolomites. A part of them is in uneven slabs, containing numerous carbonaceous scaly fragments, which seem to be of vegetable origin. Other beds are of a more massive kind, and inclose thin seams of coarse-grained calcareous sandstone. Still lower, more light-colored crystalline dolomite ledges, mottled with yellowish-white more porous dots, succeed in the series. They form the surface-rock at the forks of the river, where the west branch enters the eastern trunk. Underneath these, follow even-bedded ledges of a light-colored earthy fracturing limestone, striped or dotted with irregular dark-red blotches, which are in all respects like the stratum No. 3 of the Menominee section. The lowest visible beds are brecciated limestones; the limestone fragments composing the breccia are of the same material with the cementing rock mass. The fragments are rounded on the corners and of a smoothened surface, as if mixed in semi-plastic, half-indurated condition, with the softer calcareous mud which forms the matrix of the rock. A green pigment of ferruginous composition frequently coats the limestone pebbles, and pervades in thin seams the remainder of the rock-mass.

The limestone pieces found in the drift of Menominee river and inclosing Trilobites (Dikelocephalus), are of exactly the same appearance with these brecciated strata. This brecciated limestone disappears under the drift, which forms the bed of the river for several miles further north, when we meet with the Granite. In the drift of the river bed, we find a great many angular arenaceous and partly conglomeritic limestone blocks, which contain well-preserved specimens of Lingula antiqua, and also casts of Ophileta levata. There is little doubt that these arenaceous limestones form the next succeeding stratum under the brecciated limestone, but I could not find the undisturbed rock-beds in contact. Eight miles northeast from this place, close to the 45th milestone, the Escanaba and Negaunee railway cuts through a low ridge, formed by soft friable sandstone. This ridge, which forms an isolated outlier on the drift plateau, is capped with calcareous sandrock ledges, representing the calciferous formation. The rock contains small cavities, which once seem to have been filled with organic contents, but I could not find a distinct determinable form. Further eastwards, on the headwaters of Chocolate river, the older strata are hidden under heavy drift deposits. On the heights surrounding the upper course of Laughing Whitefish river, the drift covering is only thin, and the calciferous sandrock, which crowns all the higher elevation in this district, is frequently seen at the surface. The calcareous sandrock, which is perfectly identical in appearance with the ledges covering the ridge cut through by the Escanaba railroad, contains here the casts of a small Pleurotomaria. The falls of the Au Train river, 12 miles east of Laughing Whitefish river falls, are entirely formed by beds of the calciferous formation, which here attain a thickness not far from 100 feet. After rushing over a series of rapids, and making a descent of 30 feet within a short distance, the river tumbles over an inclined plane, with stair-like projections, 40 feet deeper; other perpendicular falls from five to eight feet in height follow, and all the rocks exposed within this space are of highly calcareous nature; in some of them the arenaceous constituents are not more than 15 per cent, of the rock-mass.

Lower down, the softer whitish sandstone layers of the Lake Superior sandstone form the river bed for a while, but I did not notice the junction of the calcareous sand rock with the underlying sandstones in the narrow and sometimes inaccessible ravine through which the river hastens to lower levels. Fossils were not observed. Following the river above the Falls, backwards to its source from Mud lake, the rock beds of the calciferous formation are constantly found near the surface of the valley, which the river has carved through the drift covering of the high plateau of the Peninsula.

Also Mud lake, and the series of connected lakes and marshes from which Au Train river makes its exit on the north side, and Whitefish river on the south side, have their basins eroded through the drift down to the older rock beds. The level of the lakes lies from sixty to seventy feet below the top of the plateau.

In the preliminary report of the former State Geologist, the discovery of an ancient outlet of Lake Superior into Lake Michigan, was announced as existing in this locality. It is true, the waters of Au Train river and of the Whitefish river, take their source from a series of connected lakes and marshes, in which the watershed of both rivers is so little defined, that the direction of the wind may sometimes predispose the water to flow one

way or the other. This watershed lies, as has been mentioned before, in a valley eroded into the drift, to the depth of perhaps seventy feet, but the sole of this valley is at least 300 feet above Lake Superior, and the river has to descend in numerous cascades and rapids through a tortuous narrow ravine, before it reaches the lower levels of the indenture of the land, formed by Au Train bay.

If we suggest a former connection of Lake Superior with Lake Michigan through this narrow superficial scratch, we may as well at once go a little further with our suggestions, and let the waters rise a few feet higher than otherwise would have been necessary, and we have the connection perfect, the whole Peninsula is then under water.

The calciferous formation is traceable from the falls of Au Train river eastwards, to the highlands above Munising furnace in Grand Island bay, and from there to the heights south of Pictured Rocks, along the head-waters of Miner's river and Chapelle river. Near Munising furnace, the top ledges of the ravine in which the furnace is erected are formed by an arenaceous dolomite, which contains traces of fossils.

Only a small distance back from the margin, on the same little brook which precipitates itself into the ravine, the next sequent higher strata are opened in a quarry. These are thin bedded, blue colored calcareous sandstones, with shaly partings, and with indistinct fucoid-like relief forms covering their surface. They are charged with considerable admixture of iron pyrites, and for this reason are of little durability.

Four miles east of Munising furnace, on their coaling station No. 3, by well-digging and other artificial excavations, similar calcareo-arenaceous strata became exposed, which contain the casts of Pleurotomaria Canadensis in tolerably good preservation.

A part of the layers in this locality is a fine grained dolomite, very little contaminated with impurities; other layers are of oolitic structure; in the centre of every oolite granule is a small quartz grain.

The principal mass of the exposed ledges is of more sandy nature, and resembles the calcareous sandstones in the quarry above the furnace.

Similar fossiliferous limestones are reported to occur on the northwest portion of the summit of Grand island, but I did not visit the spot.

East of the Pictured Rocks, near the head-waters of Twohearted river and Taquamenon river, I had no opportunity to observe the calciferous formation, or indeed any outcrops of rocks at all. I met with the calciferous formation for the first time again south of Waiska bay, in a locality mentioned before, while speaking of the Trenton group. The brecciated character of the rock in this place was mentioned.

We find more extensive denudations of the calciferous formation in the West Anebish rapids. The rock there is a hard crystalline dolomite, in ledges of variable thickness, from six to twelve inches, and divided by vertical fissure cracks, crossing each other almost in regular right angles, into large quadrangular slabs. It appears to be a durable building stone, and could easily be quarried on the west shore of Anebish island, where it is not much covered up by drift, and sufficiently above the water level to be accessible for working. The fossils of this locality are crinoid stems, Rhynchonella plena, casts of Pleurotomaria Canadensis, and of a Subulites, besides stems of Chaetetes. On the east side of Anebish island the same kind of rock is accumulated in loose slabs along portions of the shore line, but no ledges could be seen.

Further east, on the island of Encampement d'Ours, the rock is of more arenaceous nature, and differs from the underlying Lake Superior sandstone only by a greater proportion of calcareous cement. The formation is well exposed on the eastern declivity of the hill-top, crowned with the fossiliferous limestones of the Trenton group. Right below the shales, forming the base of the Trenton strata, half way up the terminal limestone terrace, a small quarry is opened in the calcareous sandstones of yellowish white color, and of middling coarse grain, which, in certain seams, contain numerous Lingula shells and stems of Chaetetes. The Lingula is twice as long as wide; its greatest width is below the centre, and a faint radial striation from the umbo to the periphery is perceptible. Lingula mentelli of Billings is the nearest form to it.

A number of rock specimens from the above described lower Silurian strata have been chemically analyzed. The results are given in the subjoined list. The small quantities of iron and alumina contained in almost every limestone have not been separated; and also the analysis of the insoluble residue, after treatment of the rock with muriatic acid, was neglected. The nature of the residue could in many cases be determined by the eye, because the rocks were not pulverized before dissolving them, and the intermingled insoluble minerals could be much easier recognized.

LAKE SUPERIOR SANDSTONE.

Of the palæozoic rocks, comprising the Upper Peninsula of Michigan, it remains for me yet to describe the sandstone formation, of which the larger portion of the south shore of Lake Superior is formed.

The age of this sandstone has been a disputed question. Jackson and Marcou considered it as being of *Triassic age*. Others made it contemporaneous with the Potsdam sandstone, and still another shade of opinion took it as contemporaneous with the Chazy or the Calciferous formations of the Eastern States. Recently, the almost forgotten first idea of its Triassic age, has found an advocate again in Mr. Bell, of the Canadian Survey. There is nothing to support this latter opinion, except a vague similarity of rock characters between the Lake Superior sandstones and the sandstones of the

Connecticut valley and other Eastern localities, or with the variegated marls and sandstones of the European Keuper. The lower Silurian age of the Lake Superior sandstone is unequivocally proved by its stratigraphical position. In its whole extent it is visibly overlaid by calcareous ledges, containing fossils peculiar to the Calciferous formation, or, in other cases, by the Trenton limestones.

Name and Locality of the Specimen.	Carbonate of Lime. Per cent.	Carbonate of Magnesia. Per cent.	Iron and Alumina, Hydrat. Per cent.	Residue, insoluble in Muriat. Acid. Per cent.
Argillaceous limestone from the Hudson river group of Bay de Noquette	36	18	4	42 Argillaceous, with intermingled quartz sand and iron pyrites.
Dolomites forming the upper strata of the Trenton group, at the mouth of Escanaba river	52	38.5	3	5.5 Silicio-argillaceous.
Wedge-shaped limestone of Escanaba river, next below the former Dolomite	88	4	1	6.4 Silicious.
Fossiliferous shaly and arenaceous limestones, next below the wedge-shaped limestone of Escanaba river	55.8	21	2.4	20.8 Quartz sand with some clay parts.
Limestone containing Orthoceras proteiforme of Escanaba river	90	3	1	4.6 Silicious.
Lowest beds of the Trenton group on Escanaba river, containing Cyrtodonta	92	2	1	5 Silicio-argillaceous.
Dolomite of the Trenton group on Whitefish river, two miles above the saw-mill	51	38	2.5	7 Quartzose.
Upper limestone of Encampement d'Ours, with Orthoceras proteiforme	89	2	1	8 Quartzose.
Blue limestone, with smooth conchoidal fracture, forming the middle strata of the Trenton group on St. Joseph's island	82	3	1.5	13 Argillaceous.
Lowest sandy beds on St. Joseph, containing Orthocerata and Cyrtodonta shells	47.3	2.5	1.6	48.6 principally coarse quartz sand.

The recognition of a separate rock-series, identifiable with the Calciferous formation, at once nullifies the other mentioned opinions of Geologists, and leaves no choice but to see in the Lake Superior sandstone the equivalent of the Potsdam sandstone.

Except the stratigraphical position, and the lithological similarities existing between the Potsdam and Lake Superior sandstones, in proof of the identity of the compared sandstone formations, some fossils are enumerated, said to be found in the Lake Superior sandstones; but these are only of a relatively affirmative force. There is no record of any instance in which recognizable fossils were found in situ in the Lake Superior sandstones.

Name and Locality of the Specimen.	Carbonate of Lime. Per cent.	Carbonate of Magnesia. Per cent.	Iron and Alumina, Hydrat. Per cent.	Residue, insoluble in Muriat. Acid. Per cent.
Dolomite forming the top stratum of Sulphur island	47	38	3	12 Quartz sand.
Calciferous formation, Grand Rapids of Menominee river, lowest strata above the sand-rock of Oolitic structure	54	42	1	2 Silicious.
Variegated limestone, stratum No. 3 of the Grand Rapids section.	42	33.6	1	23 Silicious sand, with dark, bituminous, cloudy sediment.
Upper strata at Grand Rapids of Menominee river	45	35	2	18 Quartzose.
Arenaceous limestone, with Lingula antiqua, from Escanaba river	50	33	2	14 Quartz sand.
Lowest brecciated limestones, near the forks of Escanaba river	49	32	2.5	15 Silicious.
Dolomite from the forks of Escanaba river	47	37	0.8	15 Quartz sand.
Falls of Au Train river, calciferous sand rock	47	36	2	15 Quartz sand.
Mud lake, three miles south of Au Train river falls, calciferous sand rock	42	34	0.7	23 Silicious, finer comminuted dust.
West Anebish Rapids, calciferous dolomite	52	40	2	6 Quartz sand.
Calciferous strata on top of the ravine near Munising furnace, Grand Island Bay.	49	40	5	6 Quartz sand.
Calciferous strata from coaling station No. 3, of Munising furnace, pure dolomite stratum.	53	39	4	3.7 Quartz sand.

The Lingula, mentioned as occurring in the sandstones of the Taquamenon river, was found in a loose fragment of a highly Calcareous sandstone, mixed with the drift pebbles near the shore of Taquamenon bay. Lingulas of similar form are found in the Calciferous sandstones of the Escanaba river and in the Calcareous sandstones of Encampement d'Ours island. The Calcareous nature of the specimen from Taquamenon river likewise points to these higher strata. Those forming the bed of Taquamenon river are sandstones with silicious cement. Mr. Murray found near Marquette the cast of a Pleurotomaria, which was identified by Mr. Billings with a Calciferous species, and which probably originates from the Calcareous beds overlying the sandstones some distance east of Marquette; the exact locality where the specimen was found is not stated. Much stress has been laid on the occurrence of *Dicelocephalus*, in loose arenaceous rock-fragments, found by Mr. Desor in the bed of the Menominee river, not far above Grand rapids. Prof. J. Hall makes the statement that the rock-piece containing the Trilobite is eminently Calcareous. At the indicated locality, or not far from it, I found in the drift water-worn limestone pebbles, which enclosed apparently the same Trilobite species as those figured in Foster and Whitney's report, besides many fractured shells of Lingula. The nature of the rock is that of a fine-grained brecciated limestone, pervaded with seams of a green pigment, and perfectly resembling the brecciated

limestones forming the lowest bed of the Calciferous formation in the Escanaba river section. I have not the least hesitation in connecting my rock specimen with the Calciferous series, and not with the Potsdam sandstone. Very likely in all the three recorded cases the fossils had nothing to do with the lower sandstones, which, up to the present time, have frustrated all my efforts to discover fossils in them.

The thickness of the Sandstone formation is difficult to ascertain. Its lower portions are so intimately connected with the sandstones and conglomerate beds of the copper-bearing Trappean series, that I could draw only an arbitrary division line between the two groups, which would swell the thickness of the sandstone group to many thousand feet, while east of the Copper range, the whole sandstone series reposing on the Huronian and Granitic rocks does not exceed the thickness of 300 feet. Leaving, for the present, the sandstones west of the Copper range out of consideration, the formation east of the range can very appropriately be divided in two sections, an upper and a lower one. The upper section is composed of light-colored, almost white, sandstones of generally soft friable nature. The lower section is intensely red colored by iron pigment, and contains various hard compact ledges, which are valuable building stones. West of Marquette, only the lower section of the group is developed; east of it the heights are formed by the upper division; the lower has exclusive possession of the shore, as far as Grand Island bay. East of Grand Island bay, the upper division sinks down to the level of the water, and only in limited spots the lower red-colored strata come to the surface.

In giving a detailed description of different localities, in which the sandstone is well exposed, I shall have occasion to communicate the results of my investigations with more rapidity.

ENCAMPEMENT D'OURS.

As we approach from the west, on the northwest side of this island, a steeply ascending hill, densely overgrown with hard wood timber, becomes conspicuous. The lower 15 feet above the water are formed by erected beds of a red Quartzite of Huronian age, above which horizontal layers of coarse-grained white sandstone project in mural escarpments. About 10 feet above the base of the sandstone, some harder, but partly conglomeritic, beds are noticed, in which a quarry has been opened, from which the material for the erection of a dwelling house, in St. Mary, was taken; the quality of the rock is not very good. The remainder of the hill, which is about 100 feet high, is built up of regularly stratified, soft, and partly conglomeritic sandstone ledges. The upper strata may belong to the calciferous sandrock, but at the time of my visit to the spot I was not aware of the fact, which only subsequent examination of the east side of the island clearly verified to me.

Eastwards, high cliffs of Quartzite and Slate rock, with vertically erected ledges, form the shore portions of the island, and seem to be the surface rock over a large portion of the more elevated central parts. Not far from the northeast end of the island, where, a now deserted farm was located, a road leads up the hill to a plateau, elevated 60 or 70 feet above the lake. The shore is formed by Huronian Quartzites and slates, the platform is superficially covered by drift sand, but is underlaid by a soft white sandstone of Potsdam age. On this platform a second steep hill elevation, also 60 feet in height, reposes, which at its base is formed by the above mentioned Calcareous sandstones, containing Lingula mantelli and Chaetetes stems. A similar outcrop of the sandstones, overlaid by the Trenton strata, is described in the Canadian reports ; on the north side of St. Joseph's island, two miles south of Encampement d'Ours. Along the northwest end of St. Joseph, and also eastwards, near the described outcrops of the Trenton formation, heavy boulder drift hides the sandstones from view, and on the shore only the bold cliffs of the Huronian Quartzites are denuded.

SUGAR ISLAND.

The Huronian Quartzites forming the Canada shore on the north side of the narrow lake channel, and a number of small islands, compose also the south part of Sugar island, but are only in a few places visible at the surface, which is formed by sandy drift material, and has a comparatively low elevation above the lake. Towards its northern end the ground gradually rises and attains in its highest portions an approximate height of from 100 to 120 feet. This highest part of the island is all composed of drift, inclosing an abundance of large metamorphic boulders and of more angular sandstone blocks of the Potsdam group which underlies the north part of the island. On its east side, six miles south of Church's Landing, a drift terrace surrounding the base of the island is almost entirely composed of large sandstone blocks, intermingled with a smaller proportion of large metamorphic boulders. The unworn condition of the sandstone blocks, and their crowded condition, indicate the proximity of the undisturbed ledges, which are not seen here, but on the north side of the Landing, a small distance west from the saw-mill, under a similar accumulation of sandstone and metamorphic blocks, the actual strata are found well denuded. The rock is a coarse-grained violet-colored, or, in part, variegated, hard sandstone, with silicious cement. Some of the ledges are disposed to split into thin laminæ, and are frequently of irregular discordant stratification; other beds break in thick massive blocks and promise to be an excellent durable material for coarser masonry work. By these sandstones the upper terminus of the lower division of the Potsdam group is represented.

SANDSTONES OF ST. MARY.

In the falls of St. Mary, and in the channel of the ship canal, the lower division of Lake Superior sandstone is exposed. In excavating the new canal, (at this time in construction,) the following strata are penetrated: First, several feet of coarse boulder drift, under which follow five feet of thin and even-bedded hard sandstone slabs of a light drab color, or sometimes variegated with red. Below them, alternating strata of argillaceous fine grained sandstones and beds of sandy shales are cut through to the depth of 20 feet.

These lower beds are of dark red color, or in places variegated with white, in stripes parallel with the stratification, or in irregularly dispersed blotches and dots. Many of the ledges are plainly ripple-marked. When fresh quarried, some of the sandstone layers appear to be good building stones, but are found to decay very rapidly on exposure to frost and weather. Some harder ledges of the upper thin-bedded series are more durable, and have been used in part to build up the inclined protection walls of the canal, and frequently find application for building up stone fences. The before mentioned more massive blocks of sandstone near Church's Landing, on Sugar island, are the next higher stratum to the rock beds of St. Mary, and loose boulders of it are found plentifully mixed with the drift of the place. A similar belt of argillaceous red sandstones is found on the opposite Canada side, surrounding the foot of the higher mountain range of crystalline and metamorphic rocks. Above the Falls the red sandstones soon disappear under the drift, which, for a good distance westwards, takes undisputed possession of the shore line, and shows itself in Point Iroquois in a thickness of over 300 feet. *Salt Point*, near the Indian reservation in Taquamenon bay, offers the first outcrops of sandstone after this interruption. The land there is a low, marshy spur, surrounded by low cliffs not over four feet high, and by shoals, exhibiting the flat sandrock ledges. We find here the soft, white sandstone of the upper division, with very irregular discordant stratification, and full of ripple marks, indicating the shallowness of the former ocean-bed in this place.

At the west end of this spur, on the farm of Mr. Tipple, the sand-rock comes out from the side of a drift terrace rising some distance back from the shore. The higher hills further inland are all drift covered, but I am informed that occasionally the sandrock makes limited outcrops from their sides. The drift in this district is a mixture of clay and gravel, and its fertility is indicated by the vigorous growth of hardwood forests on the heights south of the shore.

SANDSTONES OF THE TAQUAMENON RIVER.

The lower part of Taquamenon river creeps in meandering course through its drift-lined bed to the lake. Fourteen miles above its mouth, to which distance it is navigable for a Mackinaw boat, it is found running with swift current over sandrock ledges, and a short distance farther, we see it coming down with noisy haste over a rocky stairway, with very irregular steps, from one to seven feet in height. Another arm, which branches off from the main river above the Falls, comes in from the east side, and leads us to the foot of a second series of cascades, which, after-several smaller leaps, make at once a vertical descent of twenty feet. The entire descent the river makes in the Falls, I estimate to be fifty feet. The exposed rock-ledges are white sandstones, composed of glistening, little water-worn, small quartz crystals, cemented by silicious matter, and of sufficient hardness to be used as building stones, but nearly all the ledges are too thin for the purpose, and made very irregular by the frequency of discordant stratification. Of fossils I could not find a trace, ripple marks are very common.

Four miles above this locality the river forms other falls of 40 feet perpendicular height, and above the falls, for the distance of half a mile, it makes in rapids a descent of 20 feet. The rock-beds are light-colored sandstones of a soft friable nature, and of various grain, interstratified with conglomerates and arenaceous shales. Thin seams of intensely red-colored micaceous shales, or similar streaks of bright green tints, are occasionally wedged in between. The strata of the upper falls, doubtless, follow those of the lower falls in regular ascending succession, and the thickness of the whole series will amount to about 120 feet. A mile above these second upper falls, all rock-ledges have disappeared under the drift, which on the east side of the river ascends in hills from 70 to 100 feet in height. The west side is lower, and extends in swampy undulating high plains.

The river has here scarcely any current, and is very deep. I had struck the, river twelve miles further up, and came down on it on an extemporized raft of cedar trunks lashed with bark. The slightest head-wind would move our craft, provided with a blanket for a sail, in a retrograde direction, if we did not double our efforts to pole it downwards, and by the entire absence of a current at the entrance of a sidearm we came into an embarrassing dilemma how to find our way, and really ascended the sidearm in the belief that we were descending the main river.

West of Taquamenon river, for the long distance to the Bay of Grand Marais, neither in the shore line nor in any of the river beds outcrops of the sandstones could be discovered. This whole district is overlaid by sandy drift, and its forests are almost exclusively pine. In a creek entering the southwest side of Grand Marais, the lower red sandstones give occasion to small cascades; and six

miles further west, at the foot of the drift hills of Sable point, the shore is lined with sandstone escarpments from 15 to 20 feet in height. Intensely red-colored, or red and white, variegated arenaceous shales alternate with red sandstones and conglomerate beds of very irregular, discordant stratification, and with ripple-marked surfaces. No rock of any practical value is to be found there.

Passing around the cape at the mouth of Hurricane river, the sandstones have again disappeared under the drift, which forms the shore for eight or ten miles westwards, when we come to the renowned vertical rock-walls, the Pictured Rocks, which for many miles face the lake in an ever-changing variety of grotesque forms, into which the soft, easily-disintegrating rock was moulded by the battering waves and the winter frosts of centuries.

I admired the silvery water streams leaping over the rocks into the lake, and listened with awe and delight to the splashing sound of the breakers, reverberated from large sublacustrine caverns; but I looked in vain for the brightly-painted rock-walls from which the name Pictured rocks is derived. What I saw in this kind was of rather doubtful beauty.

The vertical walls of the Pictured rocks rarely exceed the height of 70 or 80 feet. From the top of these, in receding steps or in gradually sloping ascent, the hills rise to the height of 150 and 200 feet, but not all of the rock is Sandstone; the hill-tops bear a considerable coating of drift. The aggregate thickness of the Sandstone strata I estimate to be 120 feet. The Pictured rock series is exclusively composed of light-colored, almost white, soft sandstone beds, with intermingled conglomeritic seams. The conglomerate pebbles are principally a milk-white or a translucid Quartz; bright red Jaspers of banded or sometimes oolitic structure; black or black and white banded Hornstone and other varieties of Quartzose rocks; together with some Feldspar and Granite. The cement of the Sandstones is a kaolin-like absorbent substance. The vertical cliffs are formed by massive soft Sandstones of a pinkish white color, with interstratified seams of Conglomerate, or with single pebbles dispersed through their mass. The higher strata are more thin-bedded slabs with argillaceous partings, some of them quite indurated, but the prevailing part being very soft, exhibiting much discordant stratification, which is also observed in the lower strata. For building purposes none of the layers are suitable.

GRAND ISLAND BAY.

In the recess of Grand Island bay, at Munising furnace, the Sandrock escarpements have lost their imposing character, the hillsides become gently rounded, and only in ravines now and then vertical rock walls are met with. The furnace is built up in such a ravine at an elevation of about 5° feet above the lake, leaning against a vertical cliff of a soft white Sandrock, 75 feet high, which is overlaid by ledges of the arenaceous dolomite, mentioned in the description of the calciferous strata.

On the landspur forming the opposite side of the bay, owned by Mr. Paul, at the water's level, fine-grained dark red or variegated sandstones of argillaceous, easily-decaying character, and alternating with softer shaly layers, project to the height often feet. They are overlaid by 15 or 20 feet of massive, thickly-stratified, coarser-grained sandstones of pale bluish red color, or mottled with lighter and darker-colored specks.

A quarry has been opened in them, and the stone used in the construction of the two neighboring furnace buildings. A part of this rock is of fair quality; but the frequent false bedding and the easy fissility in these directions, together with numerous bits of shaly matter mixed with the rock-mass, greatly impair its usefulness. This same rock, with the underlying strata, composes the base of the rock escarpments of Grand island, which compare with the Pictured rocks in grandeur. The top of the island is formed by the entire series of the upper light-colored soft sandstones, with some super-imposed layers of the calciferous formation. The two lower islands west of Grand island, Au Train island, and the land-spur forming the east shore of Au Train bay are formed by the lower red-colored and variegated division of the Lake Superior sandstone. The lower course of Au Train river and the Au Train lake are surrounded by a low, marshy land, covered by loose, fine drift-sand.

Beyond the lake the river bed begins to rise rapidly, and occasionally exhibits denudations of the sandstones, which form the nucleus of all the highlands there. Higher up the river more extensive rock exposures present themselves, which, as already described, belong to the calciferous formation.

LAUGHING WHITEFISH RIVER.

One of the most instructive localities for the study of the Lake Superior sandstone formation is around the mouth and along the course of the Laughing Whitefish river. It offers a connected section through the whole thickness of the formation, as developed in this portion of the country. Commencing at the east end of Whitefish point, the following section can be observed in ascending order, as follows:

1. Alternations of thin-bedded, hard, often micaceous, sandstone slabs, with arenaceous shales. The sandstone slabs are in beds of from half an inch to one inch in thickness, but often splitting in paper-thin laminæ. Their surface is perfectly even, others are of undulating, rippple-marked surface. Some beds are white, or blotched with red and white, or red and white laminæ alternate. The inter-stratified shales are prevalently red or spotted with round white dots. Their visible thickness amounts to 25 feet, but is probably much greater, as the lower strata continue downward in the bottom of the lake.

2. A fine-grained, more or less argillaceous red sandstone, in layers from one to three feet in thickness, with seams of red shale twelve feet thick. This

sandstone is of an even, agreeably red color, only rarely spotted with white; it has a silicious cement, is sufficiently hard, and can be worked well with the chisel or the saw; but it is not in all localities alike, and becomes in places so argillaceous as to be worthless. A company opened a quarry on this point, at very great expense, but suspended operations after severe loss. The rock did not hold out in uniformly good quality, and too much worthless material had to be handled. I found a considerable lot of large blocks piled up on the dock, which were exposed there to the severity of the winter frosts, and were partly enveloped in ice even at the end of May; they were not seriously damaged by this exposure.

3. A hard, coarser grained, red or speckled sandstone, in heavy ledges, up to four and five feet in thickness, and amounting in the aggregate to fifteen or twenty feet. This rock forms high cliffs around the shore line, and is the surface rock of the landspur and of all the lower elevated hills on both sides of the river, as high up as Whitefish lake, which is partly surrounded by cliffs of the same rock. In places the regularity of the ledges is much disturbed by discordant stratification, and also streaks of conglomerates run through it. I consider it a very valuable rock. It is close to the surface, which, for miles in extent, is actually paved with huge blocks of it, which after an exposure of centuries have remained perfectly sound. Their great hardness and coarse grain does not qualify them for the same purposes as the softer sandstones of the Marquette quarries; but for strong, heavy masonry, much exposed to hard usage, as for bridges and canal structures, I think it would serve an excellent purpose, and is worth the closer attention of the professional builder.

Above the Whitefish lake, in whose cliffs, fifty feet high, this coarse-grained sandstone, and the before mentioned lower beds, No. 1 and No. 2, are exposed, the hills rise 120 feet above the river bed, and, in their declivity, the subsequent higher strata are exposed.

4. Light-colored, middling soft sandstones in thick ledges, with seams of Quartz pebbles, followed by a few feet of a dark-red, coarse conglomerate. Thickness not accurately ascertained.

5. A series of thin-bedded, soft, whitish sandstones, each layer separated from the other by a narrow seam of bluish shale. Thickness from 75 to 100 feet. It forms the steeply inclined declivities of the hillsides, and is crowned with massive soft white sandrocks projecting in vertical walls 50 feet high, which form the *sixth uppermost* member of the section. Right above, we find the strata of the calciferous sandrock, with casts of Pleurotomaria. The Whitefish river precipitates itself in a beautiful cascade over this upper vertical portion, strikes then the thin-bedded sandstone series below, and shoots, fan-like, expanding itself laterally over their highly inclined surface to the bottom of the ravine-like valley, where we find an outcrop of the conglomerate, No. 4 of the section.

To the west of Whitefish river, in the hilly country at the head waters of Chocolate river, this upper division of the sandstone group is hidden under the drift. The lower red-colored division is exposed in various places between Whitefish point and Marquette, on the shore, and in the valley of Chocolate river.

SANDSTONES OF MARQUETTE.

A locality on the shore, two miles south of Marquette, where the sandstones in their contact with the Huronian Quartzites can be seen, has been previously described in Foster and Whitney's report on the Lake Superior district. We find here vertically erected white Quartzite beds of the Huronian group projecting into the lake, which have preserved their granular sandstone structure, and are distinctly ripple-marked. They are surrounded by brown sandstone and conglomerate ledges, horizontally abutting against them. The sandstones, which are of very irregular discordant stratification, closely adapt themselves to all inequalities of the cliffs, which exhibit under the sandstone covering a rounded water-worn surface, indicating their long exposure before they were enveloped by the sandstones.

The Potsdam deposits seem to have formed a continuous belt all around the Huronian mountain district, which must have been an island in the ancient ocean. But a part of these deposits has been washed away again, and only in protected situations have patches of the rocks resisted destruction in places where the denuding forces had freely acted. One of these patches, surrounded by Diorite and Slate hills, we find within the city limits of Marquette, in a small side valley, at the lake front of which the Marquette gas works and an iron furnace have been erected.

The stratification of the ledges in this favored recess is more regular than usual, and in the quarries opened there an admirably fine building material is obtained. About 30 feet of the rock series are exposed to view, the ledges slowly dipping away from the hills towards the lake. In Mr. Wolf's quarry, the lower beds are a uniformly dark-brown colored sandstone, of middling coarse grain, easily worked, in banks of six feet thickness, which are capable of being split into thinner blocks. Very few vertical fissures interrupt the continuity of the ledges, and there is no difficulty of getting blocks of any desirable dimensions. The upper strata of the quarry are somewhat more broken up, have a coarser grain, and are sometimes conglomeritic; their color is less-uniform, but they are still a very useful material, which supplies the wants of home consumption, while the larger fine blocks go abroad to distant larger cities in the west.

Only a few steps from this quarry, on the opposite side of the little valley, another quarry is opened, in essentially the same rock-beds, but of not near as valuable a character. Their stratification is much less regular. We see fine substantial ledges quickly thinning

out and replaced by thin-bedded, worthless slabs, and conglomeritic layers are more abundant on that side of the valley.

The sound blocks, I think, are equal in both quarries, but the most advantageous situation is decidedly Mr. Wolf's quarry. Comparing these strata with the beds of other localities, I consider them in age contemporaneous with the strata No. 1 and 2 of the Laughing Whitefish river section. They are below the hard, massive, coarse-grained ledges, which form the surface rock of Whitefish point. The former extension of the sandstones over all the lower levels of the shore line is made evident by the great quantity of sandstone fragments mixed with the drift deposits covering these spots. In places, undisturbed sandstone strata may be hidden under this drift, but the generally great thickness of this covering would be a serious impediment for the quarrymen, even if such places were known.

PRESQUE ISLE.

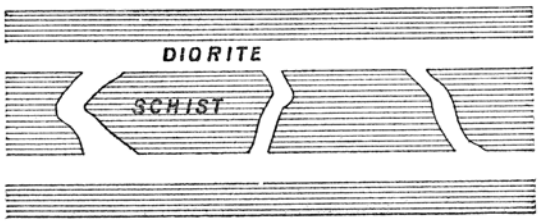
North of the mouth of Dead river is another instructive point to study the sandstone formation in its relation to the older subjacent rocks. This landspur is formed by a protrusion of peculiar rock-masses, differing considerably from the rock-beds of the Huronian group in the vicinity. Lowest is a black, unstratified, semi-crystalline magnesian rock, resembling a half-decomposed basalt or a highly ferruginous serpentine. It forms considerable cliffs at the north end of the spur;—more to the south we find It overlaid by a more light-colored, once-stratified rock, which is involved in the upheaval, with its ledges bent and broken up in great confusion. A network of sparry veins pervades the rock-mass in every direction with jasper, quartz crystals, chlorite, asbestus, iron and copper pyrites, besides a number of other minerals copiously intermingled. The principal rock-mass, which is found in all forms, from compact crystalline to an absorbent, earthy condition, is chemically a Dolomite. A specimen of the more compact kind, and of flesh-red color, gave on analysis:

Carbonate of Lime.....	55 per cent.
" Magnesia.....	35 "
Iron oxyd Hydrate, with little Albumina.....	5 "

The remainder was intermingled crystals of foreign mineral species. On the south portion of Presque Isle this dolomite is inconformably overlaid by a conglomerate and succeeding sandstone layers, which are identical with the sandstones of the Marquette quarries. The sandstone strata some distance off from the protrusive rocks are nearly horizontal. In immediate contact with them, they have a considerable dip, corresponding to the convexity of the underlying surface. It is possible that the strata were slightly uplifted after their deposition, but I am more inclined to explain the existing dip as an adaptation of the sediments to the surface on which they were deposited. The conglomerate beds at the base are five feet thick, and contain numerous fragments of the underlying dolomite rock and of their inclosed Jaspery minerals. In the sandstones above, which I have stated to be the same as the Marquette quarry rock, we find also wedge-like seams of conglomerates interposed. Some of the beds are in thick banks of apparently useful quality, others are more thin-bedded and alternate with shaly layers. The exposed faces of the better sandstone ledges are somewhat fissured, but we may believe that the more protected interior portions are of better quality, and may be successfully quarried. The partly argillaceous nature of all the Lake Superior sandstones makes them subject to be injured by heavy frosts, but in a more or less degree this is the case with all porous sandstones, and of our Michigan building stones I know of none which excel them in good qualities.

Although it is outside of the scope of my investigations, in going over this ground, some interesting facts regarding the Huronian rocks presented themselves to my observation, which I may be allowed briefly to mention.

The Diorites interstratified with the Huronian schistose rocks in the environs of Marquette, and particularly at the Light-house point, are of an evidently intrusive character. At the mentioned point, we see seams of a coarsely crystalline Diorite intercalated between the ledges of the schistose rock, which are connected among themselves by transverse bands, cutting across the strata of the schist, and forming In this way a network, in which smaller or larger portions of the schist are entangled, with retention of their bedding direction. The ends of the entangled pieces, and the edges of the exterior schist strata accurately correspond to each other. To explain this by intrusion of the liquid Diorite between the ledges of the schist and Into the existing fractures, seems to me most natural. On Pic-nic island, the Diorites are of eminently coarse grain, and inclose in the style of a breccia, numerous pieces of Huronian schists, and larger red granite masses. The granites at the mouth of Dead river are also pervaded by bands of Diorite, which is identical in appearance with the Huronian Diorities of the neighborhood.



SANDSTONES AT GRANITE POINT.

Eight miles north of Presque Isle, the granite sends a prominent spur into the lake, which is overlaid by about fifty feet of a soft friable conglomeritic sandstone of dark red color. The surface of the granite in contact with the sandstone is partly decomposed, and such portions can be crushed by the pressure of the hand into a granular sand mass. The lower portions of the sandstone contain also a large proportion of such decomposed granite particles. The sandstone m of thinly laminated structure, interstratified and intermingled with much argillaceous matter, and is of no practical value whatever. I observed there some of the light discolored round dots, so often noticed in these lower strata, which exhibited the centre perfectly bleached, and from there gradually darker and darker rings followed each other towards the outside. At the same locality I saw small vertical fissures extending for several hundred feet over the exposed flat rock-ledges. The rock mass joining the fissure was for half an inch or an inch perfectly discolored.

The removal of the coloring matter in this case plainly came from the easier access of solvents or deoxydizing gases through the fissure; and the white dots of the sandstones and shales in every other mentioned locality find their explanation in such a process of subsequent discoloration. In the bed of the creek, which enters the lake at Granite Point, at the saw-mill situated one-half a mile back from the shore, and having about thirty feet higher elevation, red sandstones of middling coarse grain form outcrops seven or eight feet high. This sandstone seems to be the same with stratum No. 3 of the Laughing Whitefish river section. It is in moderately thick ledges of sufficient hardness for a building stone, but much shattered at the surface, and in the interior of an excavation made for the water-wheel the rock is not free from cracks and fissures. A number of outcrops of the sandstones line the shore all along the distance west to the Bay of L'Anse, in which generally the lower shaly portions are exposed in the thickness of from forty to fifty feet. The inconformable super-position of the sandstones over the erected edges of the Huronian slates has already been mentioned. On the west side of the bay, similar rock escarpments, composed of shales and thin-bedded variegated sandstone layers, ascend in vertical mural walls from the lake, and above them coarse-grained thick-bedded sandstones and conglomerates come out in the terrace some distance back from the shore. Some of them are in sufficiently thick and solid ledges to be used as building stones.

At the lighthouse on the entrance to Portage lake, thin-bedded, variegated sandstone ledges, with ripple-marks and frequent discordant stratification, project a few feet above the water, and ascend northwards at a rapid rate, so that we find them a quarter of a mile further in this direction, 20 feet above the level of the lake. Underneath them, a red argillaceous fine-grained sandstone layer seven feet thick rises at the same rate, and soon after its emergence from the water, is found many feet above it. As it goes on towards the north, it thins out again, and the lower strata, which are perfectly similar to the beds above the red stratum, unite then in one uniform succession of thin-bedded variegated sandstones, without the intervention of the thick stratum, which, where it is best developed, has the qualities of a good valuable building stone, equal in all particulars with the quarry stone in stratum No. 2 of the Laughing Whitefish river section. I have not followed the further extent of the shore-line of Keewenaw Point, considering it the territory in charge of another member of the Survey; but, in order to inform myself of the existing relations between the Sandstone group and the Copper-bearing rocks, I went through Portage lake across to the other side of the Peninsula.

The sandstones lining the eastern shore of Keewenaw Point extend approximating to the centre of the Peninsula, retaining their horizontal position, and also their lithological characters to such a degree that the different strata can be parallelized without difficulty with those of the more eastern localities. Near the centre, the horizontal sandstone ledges are found at once abutting against the uplifted edges of a different rock series—the *Copper-bearing rocks*—which form the most elevated central crest of the Peninsula. The strike of this upheaved rock series is in conformity with the shape of the Peninsula, from southwest to northeast. The abrupt edges of the strata look to the southeast, and their dip is in the opposite direction, under angles variable from 40 to 70 degrees. Without intending to enter into a closer examination of the structure and composition of the Copper-bearing series, I describe it in general terms as composed of mighty conglomerate beds, connected with sandstone ledges, exhibiting perfectly plain ripple-marks, which demonstrate their aqueous sedimentary origin, alternating in often-repeated sequence, with powerful seams of crystalline or semi-crystalline rocks, which are comprehended under the collective name of Trap, but are of a very variable character and composition. The thickness of this formation is very considerable, and I think is rather under-estimated at 10,000 feet. The inconformable abutment of the Lake Superior sandstones against the Trappean series, is in several places near Houghton plainly to be observed. One place is on the property of the Isle Royale Company, in Town 54, Range west 33, Section 6, where the top of a ravine is formed by mighty conglomerate beds, inclosing pebbles of a porphyritic nature, besides fragments of a shaly, well-stratified sandrock, and of amygdaloid trap; they dip under a high angle to the northwest, and form the terminal point of a line, on which the company, for the length of a mile, systematically had opened exploring ditches at close distances, to get accurate information of the succession of strata within this interval. Immediately against the faces of the westward inclined projecting conglomerate beds, the horizontal ledges of Lake Superior sandstone, of much lighter color than the sandstones connected with the conglomerates, are seen abutting in the bed of the small creek, which runs through the ravine. The same inconformable abutment can be seen in a creek entering Torch lake, near the

stamp works of the Calumet and Hecla mines, and on the railroad line coming down from the mines to the stamp works.

At the last mentioned locality, the sandstone is of pink color, speckled with round white spots, perfectly resembling the speckled beds on St. Mary's river. A large patch of horizontal sandstones overlies unconformably the trap rocks on top of the hills near Houghton, on the Sheldon and Columbia property. I am not absolutely certain whether it came there as a huge drift mass, or whether it is the remnant of deposits which were there in their original position; but I am inclined to the last opinion. On the west side of the Trap range, half a mile south of Portage canal entry, large outcrops of only slightly inclined sandstone strata border the lake shore, and continue south west wards as far as the eye can reach. Along the space of about a mile, 200 feet of strata come to the surface. The uppermost are thin-bedded argillaceo-arenaceous layers; below these follow light colored sand rocks in thick ledges, which are quarried for the purpose of filling the cribs built out into the lake for protection of the entry; under them again more shaly and thin-bedded layers follow; and the lowest exposed beds are dark, fine grained, hard sandstones of laminated structure, in beds of five and six feet thickness, which are susceptible of being split into thin, even slabs of any desired thickness. This rock is also used for the above-mentioned purpose, but could be quarried in large, fine blocks, which would serve a better purpose. The strata are very frequently ripple-marked, and exhibit discordant stratification.

The white and red banded, or spotted appearance, so common in the series of the east side, are also observed here, and the geological horizon of these layers cannot be far below the eastern deposits. For the distance of ten or twelve miles eastward from there all the surface rock is sandstone, but the forest covering of the country does not allow us to follow across the series. A few miles west of Houghton, about a mile west of the South Pewabic stamp mills, dark, blackish brown sandstones of fine grain, intermingled with micaceous scales, and quite hard, compose the hills. Their dip is about 35 degrees to the northwest, and a succession of such layers continues as we go eastwards to the South Pewabic stamp mills, where apparently lower strata having the same strike and dip are largely exposed.

They are in beds of various thickness, and alternate with sandy shales full of ripple marks. Next below follow conglomerate beds, some of which are composed of granules not larger than mustard seed up to the size of a pea; they have a very abundant Zeolithic cement (Laumonite).

Other conglomerate beds are very coarse, with pebbles, some of which are bigger than a man's fist. The pebbles are of porphyritic character, and a good proportion of Trappean rocks and pieces of sandstone and shale are intermingled.

Laumonite and calcspar crystals likewise make part of the conglomerates, which immediately rest on crystalline trap rock. All these beds, which must amount to several thousand feet, are in conformable superposition; and the suggestion, which however is not perfectly demonstrated, Is, that such strata, with gradually decreasing dip, succeed in a westerly direction, and connect in uninterrupted comformable series with the sandstones forming the western shore line.

The rock character of all the sandstones of the west side of the Trap range is throughout of much darker ferruginous tint, and mixed with a greater proportion of cementing substance than the rocks of the east side. The red Zeolithic mineral exclusively forming the cement of the finer-grained conglomerates at the South Pewabic stamp mills is also, in the much higher beds near Portage canal entry, distinctly recognizable as an admixture to the sandstones. These upper beds of the west side seem to be lower than any stratum of the east side, but from their almost horizontal position it seems highly probable that they follow the strata in conformable succession; and, as the beds near the South Pewabic stamp mills, which undoubtedly make part of the copper-bearing series, seem to be their conformable continuation in the descending order, an uninterrupted serial connection between the Trappean copper-bearing deposits and the Lake Superior sandstones is obvious. The discordance of the strata on the east side of the axis of elevation, and their conformability on the sloping west side, finds Its explanation in the hypothesis of a gradual submarine upheaval of the Trap range. In its subsequent rupture, and the final emergence of the western margin from the water, while the eastern portion of the fissured earth's crust remains submerged. The deposits, which on the west side continued to accumulate with undisturbed regularity on the gradually diminishing slope, had to meet with the abrupt edges facing the east side In discordant horizontal position; and if we further suggest a following subsidence of this eastern portion, we can explain why, so close to the Trap range, on the east side of it, none of the lower beds of the series are found superimposed on the Huronian slates. These were submerged at the time that the later horizontal strata were forming.

The large area of Michigan territory to the south and southwest of the Huronian mountains, which is partially overlaid by sandstones of Potsdam age, forms part of the iron and copper district Investigated by other parties. It appears, however, that in the northwestern portion of this area only the older red-colored members of the series are developed, while in the southeastern part along the ramifications of the Menominee river, principally the upper light-colored sandstones of the Pictured rock series are found. At the Breen Iron mines, in the Menominee district, the vertically-erected edges of the ore beds, and the accompanying slate strata, are overlaid by horizontal sandstone ledges, which In their immediate contiguity with the hæmatites are colored red by the admixture of ore particles; but a few inches higher, the sandstone has the usual whitish color of the

upper Lake Superior sandstone division, and is composed of sharp-angled quartz crystals—a peculiarity also of the upper beds. In a great many places of the surrounding district, similar horizontal sandstone strata are found superimposed on the Huronian series, which is there the principal surface rock, and presents for the lithologist an astonishing variety of rock species, particularly of the Hornblende series.

The accurate limits of the extent of the sandstones over this region are not easy to be delineated; we find them dispersed far westwards in outliers. South of White rapids, on Menominee river, the formation strikes westward across the State of Wisconsin to the Mississippi, where in some localities many fossil animal remains are found imbedded, of which the strata in Michigan seem to be destitute. The few instances in which fossils are recorded from our beds are probably referable to the calciferous strata, as has been intimated previously. It seems, however, that the fossiliferous sandstones of the Mississippi valley correspond to the upper light-colored division of the Lake Superior sandstones, and that the lower red-colored division is older than any fossil-bearing strata in the West. Nearly all the limestone deposits of the Upper Peninsula are restricted to the palæozoic rocks in the east part, and their usefulness for technical purposes has incidentally been mentioned in the description of the respective strata. But the Huronian group is not absolutely without limestones, as we find considerable beds of it interstratified between the Slates and Quartzites of this formation, which have the qualities of a variegated marble. Many Inquiries have been made to me for Information about these marbles, the description of which will make part of the Report on the Iron District. But as they came under my observation during a reconnoissance trip through these districts, and are, as building materials, allied with the limestones which I had to describe, I will say in a few words what I know about them.

These limestones appear to be one of the upper members in the series. South of Marquette, below the mouth of Carp river, a very interesting section is offered in the hillsides facing the lake shore. As we go from north to south first we find Quartzite beds dipping under a high angle southwards; these are followed by a series of schists and slates dipping in the same direction; and still further heavy limestone beds, interstratified with shales, succeed regularly. We find in a higher position large limestone beds presenting themselves in a horizontal position, but bent in many short flexures by a lateral compression. After having passed these we find at once the same series of strata, in inverted order, dipping northwards, which had a southern dip only a few steps north of this place. We have the centre of a synclinal axis of elevation before us in which the central limestone beds, by the pressure acting on them from both sides, were pushed together into serpentine flexures.

An ideal section given below will illustrate the described conditions.

Similar limestone deposits, are seen near Morgan furnace, but I have not had occasion to make a close examination of the locality. In the Menominee district the limestones seem to be connected with the slates and quartzite beds of the upper division of the Huronian series.

These limestones are found in sufficiently thick layers to allow the quarrying of large blocks; their color is flesh-red or variously variegated with white and other shades of red; also cream-colored, almost white masses are found. They are of a compact subcrystalline grain, and very hard, susceptible of a splendid polish. Their chemical composition is dolomitic, with a very little of other impurities in selected portions of the ground-mass. But in nearly all the localities this purer ground-mass is pervaded by a dense network of coarse quartzose seams, which spoil the rock for ornamental purposes. On the Sturgeon river the limestone strata are less contaminated by these silicious seams, but are penetrated in all directions by fine fissure-planes, which, at the stroke of a hammer, open themselves, and cause the rock to break into angular fragments, much beyond the calculated effect of the stroke, so that it is difficult even to procure hand specimens of regular shape. Such rock sawed into slabs, as marbles generally are, would, as I suppose, be shattered into pieces before it came out of the hands of the marble cutter. It may be that some layers of better quality may be found in the Menominee district, but those which I saw I should not recommend for use.

An analysis of a specimen from Sturgeon river, of flesh-color and free from silicious seams, gave:

Carbonate of lime	61	per ct.
Carbonate of magnesia	34	"
Hydrated oxyd of iron and manganese	1	"
Silicious matter	0.25	"

After having described the geological structure of the eastern part of the Upper Peninsula of Michigan, it maybe proper, to look back over the district and examine its advantages for the practical uses of the State.

We see at once the greater value of the western districts, which rival any other part of the world in mineral wealth. But I think, also, that the eastern part of this Peninsula has enough of less striking sources of prosperity, to make it a precious part of our country, and a desirable home for many. Already of high importance are the extended pine lands, which furnish us with excellent lumber, and will do so for a great many years

to come, particularly if more 4 care should be taken to prevent the fires, which every year destroy thousands of acres of the finest forests.

Not less valuable are the widely extended hardwood lands, stocked with excellent timber for fuel and other purposes, to which, up to the present time, comparatively little attention has been paid, but which soon will be in demand with the rapid increase of our iron industry. The ample water-power of the rivers, the limestone for the flux, sandstone for the buildings right at hand, and the lakes an open street to all parts of the country, are advantages not found everywhere.

With the clearing of the hardwood lands, a large area of fertile land will be opened for tillage. It will, perhaps, be said, that the severity of the climate is an objection to the cultivation of these fertile lands. It is true, the winters are much longer there than in the south part of our State, and corn and wheat prove to be very uncertain crops ; but potatoes, oats, and grass in particular, grow as finely there as farther south, and the few farmers who have settled here and there seem to be doing very well. The mining districts are always an open, profitable market for their products; the lumber and fuel trade is a considerable additional income to them, or gives them employment if they seek it; and those near the lake have a rich harvest in the fisheries. With the increase of the inhabitants in these districts the facilities for all will be improved, and perhaps the time is not far distant when this neglected forest country shall justify the application of our State motto: "*Si quæris Peninsulam amœnam, Circumspice*"