region of the lakes probably cannot be satisfactorily determined. It may be competent, however, to suppose that these apparent "lake ridges" were the boundaries of the ancient sea formed during intervals of rest in the upward tendency of the land. The comparatively quiet state of the elements, and the greater length of time for which the waters covered the extent described, will satisfactorily account for the uniformity of surface which characterizes the country bordering on the present lakes and those vast plains of the west, which were subjected to the same influencing circumstances.

There are, however, some reasons for concluding that a part at least of this area *was occupied by fresh water,* and to this supposition we shall advert hereafter.

There also exist strong reasons for supposing that the relative levels of the land did not everywhere remain the same, or that disproportionate elevations took place. Thus appearances warrant the supposition that at several points barriers existed to that free communication which I have assumed of the water of this inland sea with the Atlantic. If we suppose the great Appalachian range of mountains, at any of the points where it meets the St. Lawrence, to have once formed a barrier to that river, a communication through from the ocean in that direction would have been cut off. The "uplifts" at Little Falls, which rise 147 feet higher than lake Erie, and the "highlands" of the Hudson might also have interposed barriers to an outlet across the state of New York. A single communication only would then exist with the ocean, viz: through the valley of the Mississippi. That the lakes once discharged their waters in this direction, such additional evidence is furnished by the appearance of the country, that in this our argument, but serves to add confirmation to the general opinion.

There is further reason to suppose that a barrier has existed across the strait of Mackinac, cutting off lake Michigan, and perhaps lake Superior, from the lower lakes. Now if we supposed that the erection of this barrier, or the continuance of

that elevatory movement, closed up the communication by way of the Mississippi valley a body of water would remain, filling nearly the whole "basin of the St. Lawrence," and receiving constant accessions from the streams which discharge into it. At this period, we may conclude the rocky barriers of the Mohawk and Hudson, unable to resist the enormous pressure of the accumulating volume, gave way, discharging the surplus waters with tremendous violence, and thus opening a passage for the present great channels of water communication with the ocean, through the state of New York.

Subsequent to this event, the continued uplifting of the land, or the bursting of the barrier of the Alleganies, opened a passage for the waters through their present outlet of the St. Lawrence, when lake Erie and the upper lakes subsided to about their present levels. Then, for the first time, their accumulated waters, confined by the valley of the Niagara, rushed over its "wave-worn precipice", producing that stupendous cataract, which now seems likely, for ages, to emit its unceasing thunder.

The "lake-ridge", of New York, may be considered as the shore of Ontario, after this *parting of the lakes* had taken place, and must necessarily be of subsequent formation to those of lake Erie. A still further progress of the elevation afterwards, alone, would reduce that lake to its present level, without affecting the levels of the upper lakes.

It is not our design, nor would it come within the scope of this report, to discuss the prime causes of these great changes. We rest here on the assurance that it involves no principle which a geologist, at this day, will deny. A fact is mentioned by Prof. Emmons, in the first geological report of New York, which has so immediate a bearing on the principle here made use of, that I cannot refrain from alluding to it. It is this—"That the waters of the St. Lawrence are declining, or do not appear at so high a level now as formerly, or, what is about the same thing, *the country is rising.*" "The possibility of such a change," he justly remarks, "can no longer be doubted, since

it is clearly proved that portions of the continent of Europe are now undergoing the same change. Norway is gradually rising, and Greenland is gradually sinking." Similar phenomena are also taking place on the western coast of South America. Other facts relevant to this subject might be introduced, connected with the earthquakes in the Mississippi valley, had I not been already enticed to greater length than may seem called for in this place.

It may be added, that the unusually marked character of the ridge on the west end of lake Erie, is a consequence of the even surface and extent of the limerock, and its overlying clays, which here form its base. It may be doubted whether any similar ridge, at least so distinct, may be traced over the more broken country which circumscribed the eastern limits of the waters in New York.

LAKE ALLUVION

The facts and suppositions above stated, lead to several important conclusions in determining the alluvial deposites of the peninsula.

Under the name of *diluvium,* were classed all those alternating deposites of sand, gravels and clays, which envelope the upper rock formations of the peninsula. As we descend from the more elevated interior, and come within that area which I have supposed circumscribed by the waters of the ancient lakes, a different character of surface and of soil, prevails. The great deposit of blue and yellow clays, since they underlie and extend beyond the ridge, must be of a date anterior to the era under consideration. Nor do they seem to have been much disturbed during that comparatively quiet state of the waters. An evident disarrangement, however, took place among the more loose sands and gravels, which assumed the character of *alluvion;* being subjected to a less disturbed and longer continued action than the diluviums, and deposited with fewer inequalities of surface. This alluvion consists, in the main, of a covering of sand, or of sand ridges, with the underlying clays outcropping at intervals. Boulders are thinly dispersed, and a few local beds of clay are found, like those embraced in the diluvium. Most of this alluvion is clothed with a dense growth of timber.

Similar results from the same cause are found strikingly exemplified in the state of New York, over an area described by Mr. Vanuxem as occupying "a portion of Oneida, the northern part of Madison, Onondaga and Cayuga, and the western and southern portions of Oswego." The area included within these limits will be found to correspond with that which I have supposed occupied by the waters when raised to the assumed level. "Were the whole of this ancient level or area," he adds, "stripped of its alluvial materials, we should find that the surface presented a lake bottom, appearing as through Ontario and Oneida once had a higher level, their waters uniting and covering the whole surface."

Very important practical conclusions are drawn by Mr. Vanuxem, from these facts.

It is in this *alluvion* that we find buried trunks of trees, the remains of the mastodon, and fresh water shells, and I am not aware that any of these have been found, under similar circumstances, in the diluvial deposits.

Instances in our state, though rare, are all confirmatory of the position assumed. Bones of the mastodon were two years since found on the Paw Paw river, in Berrien county, beneath twelve feet of sand and gravel. A few of these are preserved in the state collection. In the same manner, trees may be seen imbedded in the gravel which overlies the clays on St. Clair river, at the foot of lake Huron, and at a depth of ten to twenty feet from the surface. The discovery of *fresh-water shells* under similar conditions, has been made in Saginaw county, and elsewhere in this state, and in the Niagara valley, at a height far above the present stream.

We do not by any means consider these facts conclusive that this inland sea was one of *fresh water,* nor do we see

much difficulty in the way of so important a conclusion. If such was the case, the *barriers* which cut off the influx of the ocean must have existed during the quiescent state of the waters. For, had the present passages to the ocean been then open, no such accumulation of *fresh water* could have taken place; but we must necessarily suppose the inland sea to have been at the same level with the briny Atlantic. Assuming our theory of the erection of these barriers, as proposed above, we may then conceive the uplifting of the continent to have been still in progress, until the whole became elevated far above the influence of the ocean, and could receive accessions only from fresh water streams.

In conclusion of this subject, the aspect of the surface throughout this region, seems to indicate *three great eras* since the formation of the newest rocks:

1st. After the elevatory process had commenced, and land appeared above the surface of the ocean. At this period many of the secondary and tertiary rocks were removed by the agitation of the waters, and the whole covered with that mass of disruptured fragments of rocks of all ages which constitute our *diluviums.*

2d. When the upheaving force became stationary, at long and successive intervals, or when the elevation of mountain ranges had erected barriers against the influx of the ocean. During this period lake *alluvions* would be forming over the area then occupied by the waters.

3d. The era of the present levels; which commenced after the increasing pressure had burst passages successively through the opposing barriers, occasioning sudden subsidences of the waters.

Thus we may suppose that the lakes assumed their present forms in successive order, beginning with the most elevated, until finding their final passage through the St. Lawrence, the chain, as now existing, became complete.

Thus, (whichever assumption be correct,) the "lake ridge" becomes a *record* of one of those great changes which the surface of our world has been ever undergoing, to fit it for the habitation of man.

The extent of the district gone over during the season's survey, has compelled me to confine this report, in the main, to general observations. No apology, therefore, it is conceived, will be necessary, for the omission of the innumerable details collected, very many of which might be deemed of practical importance, and which are fully laid before you in the returned field notes.

BELA HUBBARD,
Assistant Geologist.

INFORMAL REPORT OF PROGRESS

(From manuscript collection, University of Michigan)

Office of State Geologist
Detroit, Dec. 16, 1840.

To his excellency Wm. Woodbridge.

Sir,

In fulfilling the duties that devolve upon me as Geologist of the State of Michigan, I have the honor to transmit the accompanying, somewhat informal, report of the general progress that has been made, during the past year, in the department over which I have been placed.

At as early a day as the season would permit, accompanied by the two assistants attached to the department and an additional force of nine men, I proceeded to the survey of the northern or upper peninsula of our State. The unexplored and unknown condition of the country rendered it necessary virtually to add a third assistant to the corps, and this third assistant was placed in charge of the instrumental observations, for the determination of geographical points, topography, etc., etc.

These assistants accompanied me only until the whole party, either separately or together, had completed so much of the

work as was required to be done immediately upon, or only a few miles from, the coast of Lake Superior. So soon as this had been accomplished the condition of the surveys in progress upon the southern or lower peninsula rendered it imperiously necessary that they should return, in order to complete, during the working season, as nearly as the circumstances would permit, the surveys of this district.

After the departure of my assistants I carried forward the work in the interior of the upper peninsula, and continued assiduously engaged until the severe fatigue and hardships to which I had been exposed had so far impaired my health as to render me wholly unfit for duty. I accordingly suspended the surveys of this district after having spent nearly five months of the most excessive labor in it, and during which time I had been almost constantly exposed to all the vicissitudes of weather, and for nearly three months, in consequence of the impractibility of transporting them, mostly without either tent or blankets. The fall storms had already set in, and the sufferings were much increased by constant exposure to wet and cold.

Much expense, trouble and delay had been looked for in transporting provisions, men, etc. from point to point upon Lake Superior, and particularly so in reaching Isle Royale and the north shore of the lake; but in this I was agreeably disappointed for the agents of the American Fur Company, with a kindness which appeared to know no bounds, not only made all arrangements in their power to facilitate my operations, but also in many things anticipated my wants. Through the instrumentality of the company I have been enabled to accomplish much that otherwise could not have been done, and the manner in which the assistance was given, has not only placed me individually, but also the State, under the deepest obligations to them.

The surveys of that portion of the upper peninsula extending from pointe Du Tour of Lake Huron to Chocolate River of Lake Superior and south to Lake Michigan have been so far

completed, that the geology and general topography may be satisfactorily defined and delineated. The geology of this district is simple, involves but few obscure points, and in an economical point of view, when compared with the country lying west of it, is of little importance. Nevertheless its valuable sand and lime stones are deserving of very great consideration. The general face of this district of country is level, though there are several ranges of regular and unbroken hills stretching through it. Its greatest absolute length as reduced from astronomical observations, is a fraction over 170 miles. This estimate is made from point du Tour to the mouth of Chocolate River, and does not include Drummond's island.

West from Chocolate river and extending to our boundary line at Montreal river the character of the country is completely changed. Instead of the level or gently undulating country, constituting the easterly portion of the peninsula, we have a series of ranges of rugged and broken hills with beautiful intervening valleys.

With this change in the general aspect of the country, the geology undergoes a corresponding change, and both topography and geology become exceedingly complex and difficult to unravel. This district which has a length of very nearly 147 miles, and an average breadth which is roughly estimated at 40 miles, embraces all the rocks that are rendered so highly interesting by their mineral riches. It should, however, be stated that only a small proportion of the rocks in this district belong to those which are truly metalliferous, for although the metalliferous rocks are believed to traverse very nearly, or quite the whole length of this district, they only make up a small fraction of the total width.

South of the country last alluded to, is a wide area that remains unsurveyed and of which but very little is now known.

The chief of my own labors during the past season has been devoted to surveys in the metalliferous district before alluded to, but with the utmost of my powers I have only been able

to accomplish a portion of this arduous and difficult task. The imperfect knowledge which was possessed of the geographical features of the country, rendered it necessary first to settle with accuracy several important points to serve as a basis for the geological survey which was to follow. After this had been accomplished I proceeded to a survey of the several groups of rocks in order to define their area, thickness and relative position; a task more difficult than any I had ever been called upon to perform, and upon the accuracy and faithful performance of this portion of the work depended nearly all the deductions which were to be drawn.

When the surveys of the geology of so much of the district as time and circumstances would permit me to traverse had been completed, and after having satisfactorily defined portions of the area occupied by the several groups of rocks, together with their character, thickness, etc. I directed my attention to a minute survey of those rocks embraced in a portion of what may be denominated the mineral district; a group of rocks which had been defined in the previous surveys I had made.

The precise extent of the mineral district I am unable at this time to state, since the surveys have not extended through its whole length. The district is long and narrow, at times approaching near to the shore of the lake and again stretching into the interior a distance of twenty-five to thirty miles. The width varies from one to four or five miles, and its length will probably exceed one hundred and twenty miles, though there may be considerable portions of this so situated as to be of no practical value. These observations are only intended to convey to you a very general idea of the extent of the region, and can only be considered as an approximation to the precise length and breadth of the district.

The minute examination of the mineral region has developed resources very much greater than had been supposed to exist, and those which are of such a character as it is conceived will not only add very much to the future settlement

and prosperity of the upper peninsula, but also the state as a whole. The chief of the important minerals that occur in this district are the different ores of copper; which are found in veins traversing the rocks of the mineral region; and these veins are of a width which will not suffer by comparison with veins of a similar character in any known mining region. Upon the whole (while I would carefully avoid exciting any unfounded expectations among our citizens, and caution them to avoid engaging in wild schemes with a view to gain sudden wealth) the examinations and surveys which have been made would serve fully to justify the conclusion that this region of country will prove a continued source of wealth to our State.

But little, in fact almost nothing has, heretofore been known of what in reality constitutes the true mineral region of the upper peninsula. Loose pieces of native copper were occasionally picked up in the vicinity of Lake Superior and this lead to the general belief that the metal existed in quantities in that region, but nothing definite was known upon the subject, for the reason that nearly the whole of the metalliferous rocks are situated in the interior, and in those rugged districts which heretofore have scarcely been visited by whites, and so little resemblance do most of the ores which occur, in the veins alluded to, bear to the native metals, that the Indians would scarcely detect them.

Very extensive collections of minerals from the mineral district have been made, but time has not as yet permitted much progress in the analysis of them; and in fact the analysis of these minerals if faithfully performed would occupy several months of constant labor. I am now busily engaged upon this portion of the work.

In addition to the ores of copper, several other ores of metals occur, which may possibly prove to be of practical value, but of this I shall be unable to speak definitely until further progress has been made in the analysis.

Much yet remains to be done in order to develope fully the resources and capabilities of this interesting and important

district of our state, and the surveys should by all means be made to cover that district to the south of that which has been already examined. If properly examined there can be no doubt but capital for permanent investment would flow into the country, while many of the wild and hazardous explorations for minerals, by visionary men, would be prevented.

The mineral district of the upper peninsula, so far as has been examined, is made up of a series of rugged hills, or low mountains, with intervening valleys sometimes of considerable width. The soil of these valleys is mostly of a superior quality and is well adapted for use for the purposes of agriculture, and with a climate far less rigorous than is commonly supposed. In fact the opinion so prevalent that this portion of our state, in consequence of its cold climate, will not admit of advantageous cultivation is almost wholly founded in error.

The operations of the past season, not only in the northern but also in the southern peninsula have added much to our geographical and topographical knowledge and of a very considerable portion this has been carried to as great perfection as the character of the work will permit.

In accordance with instructions from the Hon. Legislature I have placed so many of the county maps as are sufficiently advanced to permit it under the hands of the engraver, and four of them will soon be ready for publication. Some little delay has occurred in preparing a small state map, as directed by the act above referred to, which has been caused by the non-completion of a portion of the survey, but this difficulty is now in part remedied and the map will soon be ready to be placed in the hands of the engraver. No steps have as yet been taken for the disposal of the county and state maps for the reason that I was desirous to determine accurately the entire cost, before offering the maps for sale. There can be no doubt but they may be made to bring a handsome return of profit to the State.

The region of country which has been traversed during the past season, has been such as to bring me frequently upon the

boundary line between our State and the Territory of Wisconsin, and after an examination of the subject, so far as circumstances would permit, my former impressions are fully realized, that the boundary as defined is absolutely impracticable.

By giving to the lakes and streams the same name as those contained in the act of Congress, and filling up some vacancies which exist, a boundary might be made very nearly in accordance with the original intent of the framers of that act. This subject is an important one to the interests of Michigan and most assuredly deserves early attention. [The facts connected with this subject I will lay before you, in a separate communication at as early a day as circumstances will permit.]

Of the condition of that portion of my duties relating to the Salt Springs of our State, you are already in general terms informed, and upon the completion of some of the details connected with the proposals for contracts at the Salt Springs I will transmit a separate communication to you upon this subject. Nothing has been drawn from the appropriation for these works for the year 1840. A small amount of expense has, however, been incurred in keeping the machinery and fixtures in repair, and for the purposes connected with the proposals issued for contracts which it will be necessary to provide for, and since I have no funds connected with this project at my disposal, some special action will be required upon the subject.

Since the fiscal year of the Geological department *proper* ends on the first of March 1841, it is impossible for me to lay before you at this time an account of the financial condition of the department.

The appropriation for the geological survey under the act by which the board is now organized ceases upon the 1st. of March next. The whole amount appropriated to the work by the act referred to has not been expended, but since the amt. appropriated was to be applied annually nothing can be drawn after that date.

The survey is so far advanced towards completion that a large proportion of the expense that has been heretofore necessarily incurred may now be dispensed with; but in order to secure to the State the benefit of what has already been done a sufficient appropriation will be required to enable the department to fill up some deficiencies that remain in the surveys of the lower peninsula, and at the same time to extend those of the upper peninsula.

The services of the Topographer will be absolutely required, for the work on hand in that department will not be closed and there is now on hand a very large amt. of matter which has not as yet been sufficiently digested to pass into the hands of that officer.

The duties of the topographer have been of the most arduous character and they have been performed with an ardor and fidelity which deserve the highest commendation. During the progress of the publication of the maps his services will be required, and it will be many months before he will be able to dispose of the mass of matter now on hand.

After the ensuing 1st. of March the services of the other assistants in the department may be dispensed with, as may also a very considerable portion of the contingent expenses.

While referring to the pecuniary portion of the subject, it is with pride that I call your attention to the fact that in none of the thirteen states where these surveys are in progress has as much been accomplished for the same amt. of expenditure as in our own. My attention was called particularly to this while in attendance upon the convention of geologists of the several states, at Philadelphia in April last; and afterwards upon my visit to the legislature of the State of New York, at which time that body had under consideration a bill for extending the time of the survey of that state.

The original time specified for the completion of the survey of New York was four years, but by an act of the last legislature of that state, that time having been found insufficient

for the completion of the work, was extended two years, thus making the total term six years.

We have now nearly completed four years of labor in a country which is vastly more difficult to explore than that of New York and with a force less than one-fourth that of the last state alluded to, yet in practical information we are nearly equally advanced.

The survey of New York is strictly a geological one, while that of Michigan includes also a topographical survey. In this respect the character of the works differ, but in consequence of it the practical value of that of our own State is much increased, at the same time that profits which will accrue from this portion of the work, if faithfully carried out, will replace a very considerable portion of the expense which has been incurred during the progress of the work.

The final and connected report which I am called upon to make at the close of my official labor must necessarily involve not only my individual reputation but also that of the State, and while I would be unwilling to involve my reputation in connexion with these surveys while portions of the work remain incomplete, the State most certainly can not desire the publication of imperfect surveys. In addition to this there are a portion of the maps of the several counties in such condition as absolutely to prevent publication until further surveys be made.

At as early a day as circumstances will permit I will lay before you a more detailed statement of the true condition of the Boundary line between Michigan and Wisconsin, so far as I have been able to determine the same, believing it to be of vital importance to the best interests of the State that the subject be adjusted at the earliest day practicable.

I have the honor to be,
Sinc. Your Obt. Servt.
DOUGLASS HOUGHTON,
State Geologist.

REPORT OF CONTRACTS

(From Documents accompanying the Governor's special message, relative to the state salt spring lands. Joint Documents, 1841, No. 5)

Office of State Geologist,
Detroit, December 26, 1840.

To his excellency William Woodbridge:

Sir—In compliance with the requisitions of an act entitled "An act for the improvement of the state salt springs," approved March 31, 1840, I have the honor herewith to transmit for your examination, contracts which have been entered into, for the improvement of the salt springs at Tittabawassee and Grand river.

I also send you a copy of the advertisements for proposals, in order that you may have the whole subject before you. The contracts were closed with those whose bids were lowest. The sureties upon the bonds are all personally known to me, and are perfectly satisfactory. Some little delay has occurred in forwarding these contracts to you, for the reason that it became necessary for me to await the return of the bond of Mr. Farrand from Saginaw, which has but just arrived.

The contracts are believed to contain all the information which you wished me to transmit to you, for which reason, further explanation will be rendered unnecessary.

I have the honor to be, sir,

Your obedient servant,

(Signed) DOUGLASS HOUGHTON,
State Geologist.

[Here follow contracts with Lucius Lyon and Ira T. Farrand]

1841

ANNUAL REPORT OF THE STATE GEOLOGIST

(Joint Documents, 1841, Vol. 1, No. 11)

Office of State Geologist,
Detroit, February 1, 1841.

To the Senate and House of Representatives:

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

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

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

UPPER OR NORTHERN PENINSULA

General description and Topographical features

The published maps of that portion of the state of Michigan usually known as the upper peninsula, are so defective, not only in details, but also in general outline, that the task of giving a description, of any portion, in such a manner as to render it intelligible to any person who has not actually traveled over it, is exceedingly difficult. The extent of these geographical inaccuracies is much greater than would at first be supposed, for scarcely a single feature of the interior is given as it actually exists; mere brooks are magnified to rivers, and again those streams justly deserving the name of rivers, are either wholly omitted or scarcely noted, while the courses of the streams, as laid down, are almost invariably as far from the truth as could be conceived. Nor do the inaccuracies stop here, for even the coast maps of the great lakes, by which our upper peninsula is in part surrounded, are usually so defective as scarcely to be recognized, except in their most general outlines.[40]

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

So little is known of the extent of country constituting the upper peninsula, that it may not be misplaced to make some reference to its dimensions, though at this time most of the estimates must be regarded as mere approximations. The most extreme length of the district is embraced between Point de Tour, of Lake Huron, on the east, and the mouth of Montreal

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

river, of Lake Superior, on the west. From Point de Tour, the direction of the mouth of Montreal river is very nearly north, 80° 30′ west, and the direct distance does not vary far from 316 miles. This estimate, it will be perceived, does not include Drummond's Island, which, if included, would add some twenty miles to the length as already given.

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

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

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

Although the rocks of the district extending from Point de Tour to Chocolate river, upon the northerly or Lake Superior slope, belong to an older series than those lying south, and are different in composition, the general features of the two districts, nevertheless, bear a close resemblance. Easterly from Point Iroquois, the country is for the most part flat, or but slightly elevated, and the near approach of the rock to the surface so far prevents the descent of the waters as to give rise to extensive districts of wet and swaly land. Westerly

from point Iroquois to Chocolate river the country is more elevated and has a much smaller proportion of wet land. A range of hills, having an elevation varying from 300 to 600 feet above Lake Superior, commences a little easterly from Point Iroquois, and stretches very nearly west, or but a few degrees north of west, until the western escarpment again appears upon the coast, giving rise to the elevated hills of which the Pictured rocks and Grand island form a part. The outline of this range of hills has the most perfect regularity, being unbroken and uniformly covered with a dense growth of timber.

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

The only exception to the general easterly and westerly direction of these ranges of hills, occurs in that range constituting the Porcupine mountains. These mountains rise somewhat abruptly almost upon the immediate coast of Lake Superior, at a point 37 miles north-easterly from the mouth of Montreal river, and from this point they stretch inland, in a direction

which, for the first thirty miles, is very nearly south-southwest, after which their course is more westerly, and in the direction of the sources of the Wisconsin river. The most elevated points of the Porcupine mountains, near to Lake Superior, attain an altitude of very nearly 950 feet, but several of the knobs, at a distance inland, rise from 1,000 to 1,300 feet above the level of the waters of that lake.

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

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

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

Of the district of country lying between the hilly country and Green bay, less is known than of any other portion of the

upper peninsula. The extent of my duties did not permit me to extend my examinations very far into it, nor was I enabled to obtain any information as to its general character.

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

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

The Tequoimenon river, which is the only stream east from Chocolate river that in reality breaks through the range of sandstone hills, before mentioned as extending westerly from Point Iroquois, has its embouchure about 18 miles south from

Whitefish point, and near the foot of the lake. The discharge is through loose sands, and there is an average of 4 to 4½ feet water over the bar. Having passed the bar, the water for a distance of 7 to 8 miles varies from 10 to 15 feet.

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

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

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

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

This stream will be made a point of reference in the strictly geological portions of this report, for it winds along near the line of junction of two widely distinct geological districts, the general features of one being characterized by its ragged and

broken hills, while the other is not less marked by its generally level or regularly undulating surface.

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

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

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

lake, is rapid and shoal, but below this, the stream is comparatively still, and with a good depth of water. The mouth of the Ontonagon river is obstructed by a bar of sand, over which there is usually, at low stages, about six feet of water.

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

Montreal river is a comparatively small stream, made up of numerous small tributaries that rise among the ranges of hills to the south-west and south-east of its mouth. The pas-

sage of the river through the range of hills near the lake, gives rise to several very considerable water-falls, as also to much rugged and wild scenery. Almost directly at the place of embouchure into Lake Superior, there is a perpendicular fall of about forty feet. This stream, it will be recollected, forms a portion of the boundary between Michigan and Wisconsin.

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

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

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

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

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

The route of the fur trade to the northwest, via Rainy lakes, Lake of the Woods and Lake Winnepic, was formerly wholly carried on by passing over these hills, from a point a few miles west from the mouth of Pigeon river. The trail or portage path passes over a low portion of the range, and finally falls upon Pigeon river, which is ascended to its source, from which, by a series of portages, the sources of the streams flowing

north-westerly are reached. The hilly portion of the country, though of exceeding interest in a geological point of view, is the most desolate that could be conceived.

GENERAL GEOLOGY OF THE UPPER PENINSULA

The geology of the upper or northern peninsula of Michigan, when compared with that of the southern or lower peninsula, bears a striking contrast, for while that of the district last referred to is uniformly regular, with rocks, which, though rarely exposed to view, are few and for the most part but little disturbed, over large areas of country, the upper peninsula embraces a much greater number of rocks, distributed over a somewhat smaller district of country, and a portion of which are so much disturbed as to render their delineation exceedingly complex and difficult.

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

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

With a view of rendering the local details of the separate formations more intelligible, I will first describe in general terms the rocks occurring in so much of the peninsula as has been examined, together with their general extent. This will

necessarily involve a repetition of a very small portion of the report last made, upon the subject of the limestones of the south and east portions of the peninsula, but since the examinations of the past year have enabled me to add another member to the limestone group, and to define with more certainty its outline, this may not be devoid of interest.

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

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

2. *Trap Rocks.*—Flanking the primary rocks already described on the north and north-west, are a series of ranges of hills stretching in a direction generally south-westerly and north-easterly, which attain an altitude of from three to nine hundred feet above the lake. They are more regular, or rather

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

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

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

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

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

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

In the course of the range of conglomerate upon the south shore, it forms a nearly continuous range of hills, with somewhat steep esca[r]pements, but with a generally rounded out-

line. These hills sometimes rise to a height of from three to five hundred feet above the level of the lake.

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

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

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

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

The mixed rock dips regularly to the north and northwest.

6. *Lower, or Red Sandstone and Shales.*—The red sandstone, with its accompanying red and gray shales, occupies a much larger extent of the country bordering upon Lake Superior than any other single rock or group of rocks. It rests upon the primary, and metamorphic rocks, immediately west from Chocolate river; upon the conglomerate and mixed rocks from near Eagle river, of Keweenaw point, west to the head of Lake Superior; upon the primary trap, metamorphic

and conglomerate rocks of the north shore of the lake, and upon the conglomerate rock of Isle Royale. It is this rock which forms the basis of the level plateaus or valleys occupying the spaces between the several ranges of hills south from Lake Superior, and west from Chocolate river. In these last situations this rock is frequently seen undisturbed to surround the bases of isolated knobs of granite, though when near to or in contact with knobs or trap there are invariable evidences of very great disturbance.

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

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

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

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

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

The elevated range of hills before described as commencing a little easterly from Point Iroquois and extending to the

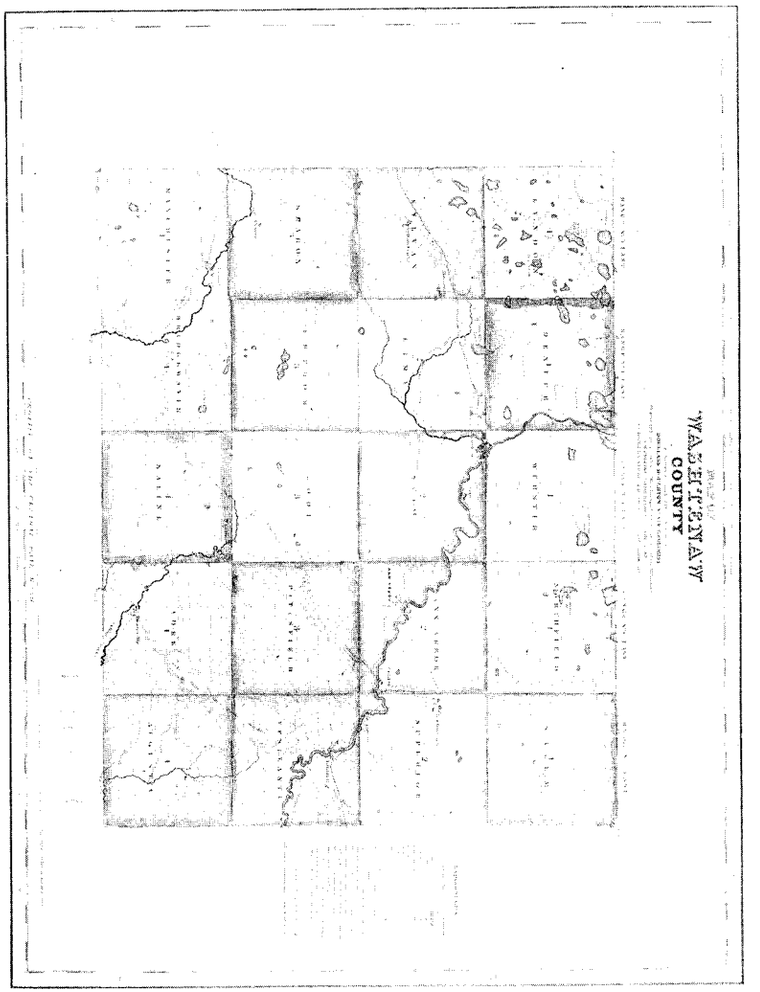
Pictured rocks, are composed of this rock. From the Pictured rocks, the range of hills curves more to the south, stretching very far to the south-west, but its precise limit is not yet determined.

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

8. *Sandy Lime Rock.*—Resting immediately upon this upper or gray sandstone is a sandy limerock, which, although nearly wanting at the very easterly extremity of the peninsula, as we proceed westerly, occupies a more important place. This rock, which, as its name implies, is intermediate between a sandstone and limerock, may be seen on Sailor's encampment island of the Riviere Ste. Marie, as also at several points in the vicinity of Monusco bay, from whence it stretches westerly, occupying nearly the central portion of the peninsula, for a distance of at least sixty miles; from which its precise range and limit has not yet been determined. The outcropping edge of this rock appears at a level very considerably below that both of the sandstone to the north, and of the limestones to the south. Its width, for the distance mentioned varies from ten to fifteen miles, and it dips uniformly to the south-south-east.

The sandy limerock has not yet been examined with sufficient care to admit of accurate description. It contains but few fossils, but those few are sufficiently characteristic, were there no other considerations, to separate it from the lower limerocks and shales.

Upon the sandy limerock to which reference is above made, rests the lower limerock and shales, and upon this last the upper limerock, both uniformly dipping to the south or south-east. These limerocks were described in general terms, in



my third annual report, and although many additional facts have been gathered respecting their character, range and extent, it is, perhaps, unnecessary to lay them before you at this time. I will barely add, with respect to them, that the suggestion there mentioned, that a more careful examination of these limestones would render a farther division of the groups necessary, has been fully confirmed.

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

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

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

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

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

PRIMARY ROCKS

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

The rocks of the southeasterly portion of the primary range of hills are more clearly defined as granite rocks, than those situated more northerly, for they are more distinctly and largely crystaline in structure, and quartz enters much more largely as a constituent into their composition. As we proceed north-westerly, from the south-east boundary of the primary, over the several broken ranges of hills, we find the character of the rocks in mass almost imperceptibly changing. The quartz as a mineral gradually forms a less important part, and it finally almost wholly disappears, leaving a binary compound of feldspar and hornblende, which then assumes a granular structure, constituting greenstone. The intermediate rock, between the syenite and greenstone ranges, may not inappropriately be called a syenitic greenstone.

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

The granite rocks, so far as the range has been examined, in a southwesterly direction, are largely traversed by dykes, that are almost without exception made up of materials in all respects identical with the greenstone, before alluded to, as forming the more northwesterly range of hills. The courses

of these dykes or veins are invariably marked by striking changes in the character of the rock traversed, and in the larger dykes, the evidences of the changes produced by the heat of the injected matter, extend to several hundred feet upon either side of the dyke itself. The connection between the rocky matter composing these dykes and the ranges of greenstone, lying northwest, is clearly identified, not only by the perfect similarity in mineral character, but also from the fact, that as we proceed in the direction of the ranges of greenstone, the dykes become much more frequent, until at length it becomes difficult to determine which of the rocks predominate in quantity.

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

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

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

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

TRAP ROCKS

Were we to consider the rocks of the district under consideration, strictly in their chronological order, those rocks which I propose to treat as trap rocks, would undoubtedly *follow* those slates and quartz rocks which are considered as metamorphic, and which may be regarded as identical in time

of uplift with those rocks before alluded to, as being intermediate between the granitic and trap rocks. The almost insensible gradations by which the granitic rocks pass into the greenstone of the trap formation, and the near analogy of the whole of the rocks of both formations, to each other, renders it more convenient, at the same time that it is more simple to follow the arrangement or order that I have adopted.

I have already stated that in passing from the granitic region on the south side of Lake Superior, in a direction north-westerly, we cross a series of ranges of hills, varying in height from three to nine hundred feet above the lake, and that in pursuing this course, we observe that the character of the rocks gradually and almost insensibly change, until at length they become well defined greenstone.[41]

The rocks of the outer or northwestern range of hills, which were clearly the last of the series of uplifts, bears more unequivocally the evidences of igneous origin, than either of the outer ranges alluded to. The rock upon the south flank of these hills, is invariably very compact greenstone, while upon the north-westerly line it is almost equally invariably an amygdaloid, or at least, has an amygdaloidal structure. The causes of this difference of structure of the rock, upon the opposite sides of this range of hills, when carefully examined upon the ground, are very apparent, for it is evident, as will hereafter be shown, that the uplift of the rocks of this range of hills was wholly upon the south-easterly side, and while the rocks of this portion were in a solidified state, or, in other words, that a point in Lake Superior may be regarded as a

[41]In the present report, I use the term *greenstone* in its generic sense applying it to all the compact rocks, of a granulated structure, belonging to the trap range. By far the larger proportion of these rocks are greenstone, in its most restricted sense, or in other words, are composed of feldspar and hornblende; but the term is also used to include rocks which in a strict sense would be considered as altered syenite, syenitic, granite, hornblende and angitic rock. The term *amygdaloid,* I apply, as it is usually applied to that portion of the rock having a difference of form simply, without any reference to the constituents of the rock. This generic use of terms is employed for the reason that the limits of the present report will not allow any thing more than a very general consideration of the subject. The term *trap* is used in such a sense as to include both the greenstone and amygdaloid, though it may sometimes prove that the amygdaloid has had its origin from the fusion of the lower portions of the sedimentary rocks.

fixed axis of the uplifted mass. That this was the case, is shown by the fact that the sedimentary rocks to the south or south-east are scarcely disturbed, so far as regards this range of hills, while the sedimentary rocks on the north or north-westerly side are invariably tilted to a high angle near the range of hills, which angle gradually decreases as we pass farther and farther from the hills themselves. These sedimentary rocks, which upon the north side always dip *from* the range of trap hills, are in their close proximity to the trap inclined at angles varying from 45° to 85°. Dykes of from fifty to four or five hundred feet are of frequent occurrence, traversing these sedimentary rocks, but the widest of these have invariably been protruded between the strata of the sedimentary rocks, and consequently have the same general inclination. The result of these frequent dykes, which occur at comparatively short distances from the main body of trap, is, that the sedimentary rocks frequently so far lose their original character as scarcely to be recognized.

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

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

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

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

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

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

A single knob of trap appears under circumstances which add very much to its interest, at what is usually known as Presque Isle, an elevated rocky point immediately north-west from Riviere Des Morts, and almost directly within the granitic region. This point of land has its origin from the simple

elevation of a mass of trap rock which rises on the north in abrupt cliffs varying from twenty to sixty feet in height. The trap is mostly greenstone, though portions of it are so largely impregnated with a dark colored, almost black serpentine, as to deserve the name of serpentine rock.

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

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

The whole of the north-western portion of Isle Royale is made up of trap, and in truth that rock constitutes, by far, the largest proportion of the rocky mass of the island. The two northerly ranges of hills already alluded to as traversing the

island, in its greatest length, are wholly trap. The most northerly range of hills is composed almost exclusively of greenstone, while the rock of the south or south-easterly range, becomes more decidedly amygdaloidal in its structure; thus reversing the order which these portions of the rock bear to each other upon the south shore of the lake..

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

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

METAMORPHIC ROCKS

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

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

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

It has already been stated that Chocolate river is the boundary on the south-east, between these and the sedimentary rocks, and that they extend in a north-westerly direction from this stream to the granite, against which they rest. The group is made up of an alternating series of talcose and mica slates, sometimes graduating into clay slates, with quartz and serpentine rocks, the quartz rocks constituting by far the larger proportion of the whole mass. Since it would be nearly impossible to describe the alternations of these several rocks, in such a manner as to be understood, without the aid of a diagram, or section, no attempt will be made to do so.

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

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

The rock which, for the sake of convenience, I have denominated serpentine rock, bears a close resemblance to greenstone, being essentially composed of granular feldspar and hornblende, with which serpentine is intimately blended. This rock only occurs in the talcose slate as we approach the granitic

region, and possibly a more close examination may show it to be a simple series of dykes, lying parallel to the line of cleavage of the slate rocks.

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

CONGLOMERATE ROCK

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

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

The pebbles of which the mass of the rock is composed, consist of rounded masses of greenstone and amygdaloidal trap, of which the former make up by far the larger proportion, and scarcely a pebble of any other rock than trap enters into its composition. These pebbles vary in size from that of a pea to several pounds weight, but the average size may be stated at 1½ to 2 inches in diameter. The pebbles are usually united by a mixed calcareous and argillaceous cement, more or less colored by iron, and so firm is this union, that the most compact and tough of the greenstone pebbles, will fre-

quently break through as freely as the cement, and crevices and narrow veins are frequently seen passing indiscriminately across the pebbles and cement. This fact is the more worthy of notice, since the pebbles are almost without exception, made up of the hardest and most indestructible portions of the trap rock.

The conglomerate rock can scarcely be said to occur in such form as to be well defined, in any portion of the country, excepting upon the northern flank of the outer trap range, before referred to. On the outer or northern side of Keweenaw point, the conglomerate commences near the extremity of the point, and extends several miles westwardly, forming a series of abrupt and precipitous cliffs upon the immediate shore, as also a range of well defined hills, a little in the interior, which hills have an elevation varying from 200 to 300 feet. After appearing for a few miles upon the coast, this rock gradually stretches into the interior, following the line before described as the most northerly boundary of the outer trap range of hills, and invariably occupying a place to the north of this range, and it may be observed, nearly or quite continuously, as far as Montreal river, which stream it crosses at a short distance above its mouth, thus making its complete length within the limits of Michigan, computing its southerly curve, something over 140 miles; but the rock does not cease at Montreal River, for it may be seen at short intervals in the interior as far westwardly as the head of Lake Superior.

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

The conglomerate rock is imperfectly stratified, in masses of immense thickness, and it dips, upon the south shore of Lake Superior, regularly to the north, and north-west,[42] usually at high angles varying from 30° to 85°, while upon

[42]This variation in the dip is in conformity with the variation in the direction of the trap hills.

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

Upon the south shore of the lake, the thickness of this rock was not estimated at any point west from Montreal River, a little east from which it attains its greatest thickness, being, as estimated, 5,260 feet. In addition to the great variations in thickness, over comparatively small districts, the formation wedges out as we pass easterly along the range, and so rapid is this change, that near its easterly prolongation the thickness was estimated at something less than 1,000 feet.

The greatest estimated thickness of the rock upon the north coast is a fraction less than 2,300 feet.

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

MIXED CONGLOMERATE AND SANDROCK

This rock formation is made up of an alternating series of conglomerate and red sandstones, which rest comformably upon the conglomerate rock last described, dipping with that rock into the bed of Lake Superior. The mixed rock was not

noticed upon the north side of the lake, or upon Isle Royale, but upon the south shore the rock was traced continuously for a distance of about one hundred and thirty miles, extending from a few miles westerly from the extremity of Keeweenaw point to Montreal river. It follows the line of the conglomerate before described, stretching from Keweenaw point in a south-westerly direction, and again curving to the north-west, forming, as it were, a crescent between the points before mentioned, the result of which is, that the rock only appears for a very limited distance upon the coast of the lake, at Keweenaw point.

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

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

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

of this material will explain sufficiently why the true conglomerate, and the mixed rocks are referable to the same origin, for the materials of the several members of the group have their origin from the trap rock, and as a whole, may, perhaps, be regarded as a trap-tuff.

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

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

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

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

RED SANDSTONE AND SHALES

That rock to which I have applied the name of red sandstone is emphatically the chief rock that appears upon the immediate coast of the south shore of Lake Superior, and the same remarks will apply, in a more limited degree, to the complete coast of the lake. A traveler proceeding westerly along the coast, from Grand Island to the head of the lake, would imagine he had seen little else than red sandstone, and in fact, were he to confine his examinations to the immediate coast, he would see no other rock for nineteen-twentieths of the distance. From Grand Island westerly to the mouth of Chocolate river, no other rock is seen in place, and from Chocolate river to Keweenaw point, embracing the complete width of the primary, metamorphic and trap ranges, the hills forming these groups are almost invariably surrounded or flanked at their bases by this sandrock, so that even along this portion, the hills are, for a large proportion of the distance, cut off from the lake by a narrow belt of the rock under consideration, and westerly from Keweenaw point to the head of Lake Superior no other rocks appear upon the coast, if we except several trap dykes in the vicinity of the Porcupine mountains, and a series of more recent deposits of clay and sand that appear west from Keweenaw point. This sand rock also occurs upon the southerly side of Isle Royale.

The material of which the red sandrock is composed differs widely from that of the sedimentary rocks before described, for while the rocks last referred to are made up of materials clearly of trappean origin, and in which the material is very rarely quartz, the rock under consideration is composed of materials, the predominating portions of which are clearly derive from the granitic and metamorphic rocks, and in which quartz occurs abundantly, though with this, there is usually associated more or less sand, that has all the characters of the comminuted trap, constituting that portion of the mixed rock before referred to. Magnetic iron sand sometimes

becomes a constituent of the red sand rock, and occasionally continuous strata of several inches thickness, are almost wholly composed of this material. The material composing this rock is usually cemented by calcareous matter highly colored by the peroxyd of iron, though not unfrequently these are associated with argillaceous matter.

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

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

The material of which this argillaceous rock is composed, possesses an extreme degree of fineness, and is so soft as readily to be cut with the knife, which qualities render it a fit

material for the manufacture of pipes, to which purpose the Indians of the country have long applied it. It has also been applied to use in sharpening tools, but its softness is a serious objection to its use for that purpose.

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

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

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

I have already stated that the sandrock, at its westerly prolongation, attains its greatest thickness, which is estimated at 6,500 feet, but as the rock continues easterly, it gradually and quite regularly diminishes in thickness, and beyond Sault de Ste. Marie, the thickness is very inconsiderable. The average rate of diminution which takes place in the thickness of the rock as we proceed easterly, was shown by a great number of observations, upon the south-westerly portions of the coast of Lake Superior, to be a fraction over fifteen feet to the mile, but this rate of decrease could not be satisfactorily estimated upon the lower or easterly half of the coast. The red sandrock thins out as we proceed southerly or inland from the coast, at a still more rapid rate, as was most satisfactorily shown, where it is connected with the several primary, metamorphic and trap ranges of hills, for all or nearly all the valleys, after passing the outer or northerly range of trap hills, are based upon this sandrock, and since we have every reason to believe that this sandrock was deposited in part, during the gradual elevation of the several chains of hills, it would follow, that over those districts which were last elevated, the rock would attain its greatest thickness. I have already alluded to the order in which the several ranges of hills appear to have been uplifted, and since more particular reference will be made to this hereafter, I leave the subject for the present.

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

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

UPPER OR GRAY SAND ROCK

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

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

The upper sandrock, like the lower, abounds in clearly defined ripple marks, and its line of cleavage is very irregular, frequently being opposed to the line of stratification over very

considerable districts of country. Two indistinct species of fucoides were all the fossils noticed in connection with it.

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

TERTIARY CLAYS AND SANDS

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

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

ECONOMICAL GEOLOGY

Rocks

The series of limerocks resting upon the sandrock last described, were noticed in the report which was laid before you at a previous session, and the limits of the present report will not permit me to refer to them, more fully, at this time. My observations will, therefore, only include those rocks which lie below the limestones. It will be borne in mind that the whole

of the group of limestones are embraced in the southerly portion of the upper peninsula, and that their outcropping edges do not reach within many miles of the coast of Lake Superior. This is an important fact, for it shows the whole of the northern part of the upper peninsula to be deficient in materials for the manufacture of lime, which are, in truth, wholly wanting.

Materials adapted to the purposes of building, abound, throughout the district of country under consideration, and though they vary exceedingly in value for that purpose, yet no portion of the country can be said to be without a supply.

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

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

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

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

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

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

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

MINERALS AND MINERAL VEINS

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

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

Minerals of the Primary Rocks

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

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

Minerals of the Metamorphic group of Rocks

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

Of the minerals enumerated as occurring in the metamorphic rocks, the milky variety of quartz is abundant, sometimes composing almost entire ranges of hills. The novaculite is also abundant, but of a coarse variety. This last is associated with the talcose slates. The remaining minerals appear either

disseminated or forming druses in the quartz rock, though sometimes they occur in thin beds or veins, in the talcose slate, which beds conform to the line of cleavage of that rock. Although the hæmatite is abundantly disseminated through all the rocks of the metamorphic group, it does not appear in sufficient quantity at any one point that has been examined, to be of practical importance.

Minerals of the Trap Rocks

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

Since a consideration of the minerals contained in the trap, will also involve a portion of those embraced in the conglomerate, the mixed rock, and red sandrock and shales, I will, before referring minutely to those of the trap rocks, lay before you a list of those which occur most frequently in the sedimentary rocks last mentioned. The fact that veins of mineral

matter, traversing the trap, are frequently continued across the several sedimentary rocks, and that dykes are of frequent occurrence in these latter rocks, would lead to the influence that there would be a considerable degree of resemblance in the character of the minerals embraced in these dykes and veins, in both the trap and sedimentary rocks and to a certain extent, this inference would be true; but it should be borne in mind, as has already been stated, that the veins, in traversing the several upper rocks, undergo very great changes in mineral character.

Minerals of the Conglomerate, Mixed Rock and Red Sand Rock

Calcareous spar,
Quartz, common,
" milky,
" drusy,
Chalcedony,[43]
Carnelian,[43]
Jaspar,[43]
Agate,[43]

Copper, native,[44]
" pyritous,[44]
" blue carb. of,[44]
" green carb. of,[44]
" earthy green carb. of,[44]
" black,[44]
Zinc, siliceous oxyd of,
" carbonate of,

Iron, pyritous,
" black oxyd of, (cemented iron sand,)
" red oxyd of,
" hydrate of,
" silicate of.

Mineral veins of the Trap, Conglomerate, etc.

In order to render the subject of the mineral veins traversing the above rock, so far intelligible as may be in my power, I have already been particular to define, as far as could be done without maps and sections, the relation which the trap rocks, together with the superincumbent conglomerate, mixed

[43]Occasionally occurring among the pebbles constituting the mass of the conglomerate.
[44]Chiefly in those portions of the veins traversing the conglomerate.

sand and conglomerate and red sandrock bear to each other, and it will be necessary, in considering the mineral contents of these rocks and the veins traversing them, to keep this relation constantly and clearly in view.

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

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

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

That the veins under consideration belong to a single epoch, is inferred from the fact, that none have been noticed with other veins crossing them, as also for the reason that none

have ever been noticed with dislocations, heaves or disturbance of any kind, save what may be referred to causes connected with their immediate origin.

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

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

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

The earliest as well as all travelers who have visited the district of country under consideration, have not failed to make frequent allusion to the loose masses of native copper that have been occasionally found scattered over it, nor has any one failed to allude to the large bowlder or loose mass of that metal upon the Ontonagon river. Almost invariably, the opinion has been expressed, from the frequent occurrences of these masses, that the metal must be abundant in the country. But, after all, the true sources from which these masses had their origin, or the relation which they held to the rocks of the district, would appear to have never been understood; and all, or nearly all, that was known of their true relations, was left to conjecture. The result of this has been, that while some have excessively magnified everything connected with the subject of which, in truth, nothing was known, another class, equally far from what is really true, have regarded these masses of native copper as bowlders transported from high northern latitudes.[45]

As far back as 1831 and 1832, I had occasion to pass no less than three times, along the south coast of Lake Superior, as also to ascend several of the important tributaries of that

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

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

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

With a full knowledge of these difficulties, I determined, during the past season, to endeavor to surmount them by so far adding to our geographical knowledge of the coast of the lake and its immediate vicinity, as to enable me to place whatever geological observations of importance might be made, in such condition that the relation of the several parts might be understood. Having sufficiently accomplished this, I proceeded to a very minute examination of the several rocks overlaying or resting against the trap, together with a determination of the thickness of the several members and their rate of decrease or wedging to the east. With these data I was enabled, by noting the dip of the rock upon the coast, to determine, with sufficient accuracy for the purposes to which the rule was to be applied, the line of junction between the trap and conglomerate rocks. This rule, when put in practice, enabled me to decide, with a very considerable degree of certainty, this line of junction, when the rocks were covered with a very considerable thickness of detrital matter, and when so covered, I was enabled, by traversing the country, on the line of bearing of the upper rocks, the more readily to gain access to such points as would admit of examination.

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

metal that they would be the last suspected to contain it in any form.

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

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

I have had occasion to refer to the outer or northerly range of hills, or those from which the metalliferous veins may be said to spring as being composed of trap rock, and lest what

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

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

These metalliferous veins, like those which occur under similar circumstances in other portions of the globe, do not con-

tinue uninterruptedly of any given width, for great distances, nor is their width increased regularly, for they frequently ramify or branch off in strings, that pursue a course generally somewhat parallel to the general direction of the main vein, and which eventually again unite with it. Sometimes these ramifications or branches destroy, as it were, for a considerable distance, the whole vein; but they at length unite again, and the main vein is, after their junction, as perfectly developed as before.

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

As these metalliferous veins traverse the northerly portion of the range or approach the sedimentary rocks, they undergo a gradual change in width as well as in mineral character, and it has been noticed that where the amygdaloid is most largely developed, the vein, as a general rule, has not only a greater width, but also has its mineral contents more perfectly developed, a circumstance which might fairly have been inferred from the fact that those points where the amygdaloid occurs most largely, may be regarded to have been so many

centres of intensity of action at the time of the original uplift of the range, from which circumstance they would remain in a softened state, or in such condition as to admit of the more perfect formation of these cross veins for a longer space of time after that condition has been passed at other points.

In the outer or amygdaloid portion of the rock, the vein is almost invariably accompanied by a veinstone of quartz, involving all the varieties before mentioned, as associated with the trap rocks, which quartz, though occasionally it occurs massive, of several feet in width, usually appears in the shape of a series of irregularly ramifying and branching minor veins, that may be said to constitute the main vein. These subordinate veins of quartz, which may be stated as the true veinstone, vary from a mere line to several inches in thickness, and in the aggregate they may be said to constitute from one-third to one-half the total thickness of the vein. In their branches and ramifications, they sometimes include portions of the rock which they traverse, at other times they embrace imperfectly formed steatite, with silicate, carbonate and red oxyd of iron,[46] and occasionally, though more rarely, it is associated with carbonate of lime, usually assuming the form of an opaque rhombic spar.

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

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

[46]The latter closely resembling the Gossan of the Cornish miners.

its metalliferous character lost, that it would not if examined singly, be suspected to be any portion of a metalliferous vein.

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

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

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

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

can reasonably be hoped to be turned to practical account, are those of copper.

In these portions of the veins, the metal referred to, occurs very frequently in the form of native copper, with which are associated the red oxyd, azure carbonate, green carbonate, and more rarely what may be denominated copper black, and still more rarely, pyritous copper. *None* of these have been noticed in a crystaline form.

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

The specific gravity of this veinstone is very considerably above that of ordinary quartz, and usually, the difference is so considerable, even in those masses where the copper can scarcely be detected by the naked eye, as to be apparent to even the most careless observer. But in addition to this finely disseminated condition of the native copper in the veinstone, it is also disseminated in a similar manner through the rocky

matter embraced by the veinstone and in the amygdaloid and conglomerate portions of the rocks, it sometimes extends for a distance of from two to three feet into the rocky matter on either side of the veins, sometimes completely, or in part, filling the cells of the amygdaloid rock.

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

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

copper is so rare in connection with the trappean portions of the veins as scarcely to deserve notice.

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

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

This vein, which reaches the immediate coast of the lake, upon the easterly cape of the bay known to the voyageurs as the Grande Marrais of Keweenaw point, terminates, so far as examinations can be made, in the coarse conglomerate rock. The coast of the lake, for many miles on either side, is made up of abrupt cliffs of a similar rock, the rock as usual, being

made up of coarse rolled pebbles of trap, chiefly cemented with calcareous matter, which is usually associated more or less with the red oxyd of iron. Immediately south of the coast a heavy dyke of trap traverses the conglomerate, which dyke corresponds in position with line of bearing and dip of the conglomerate rock.

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

It has already been stated, that these true veins, in traversing the conglomerate, frequently almost loose their character, and it becomes difficult to define their absolute width, or in other words, it would appear as if, at the time of the formation of the veins, the conglomerate had not been perfectly cemented, the result of which would be, that the mineral matter, which, under other circumstances, would constitute a perfect vein, would frequently appear in only an imperfect one, or the mineral which would, under other circumstances, make up the vein itself, may have been injected latterly through the interstices of the rolled masses constituting the conglomerate, in which case the mineral would, in fact, take

the place of the ordinary cement, thus simply investing the pebbles of the conglomerate. Now, although at the point under consideration, a wide and remarkably distinct vein is developed, the rock, for many feet on either side, has the interstices between the pebbles filled wholly, or in part, with various mixed and irregular forms of the ores, accompanied by calcareous matter, as before stated, and with occasional specks and small masses of native copper.

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

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

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

The district of country to which these veins have been referred, thus far, only comprises the ranges of hills south of

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

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

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

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

The limits of the present report will not permit a separate description of these several distinct trap knobs. I will therefore confine my remarks to that already referred to, as occurring upon the south coast of Lake Superior, immediately

northwest from Riviere Des Morts, and which forms the promontory known as Presque Isle.

In nearly all those portions of this knob, where the trap, conglomerate and sandstone are exposed in such a manner as to permit examination, each of the rocks are seen to be traversed by innumerable irregular ramifying veins, which in the sandstones are made up of quartzose and calcareous matter; but many of which, near the junction of the igneous and sedimentary rocks, are metalliferous, and this metalliferous character is more fully developed as the veins are extended into the trap rocks.

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

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

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