Table of magnetic variations.

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

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

Respectfully, yours,

F. HUBBARD.

Report of C. C. Douglass, Assistant Geologist.

Detroit, January 4, 1841.

To DOUGLASS HOUGHTON, *State Geologist:*

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

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

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

Remarks on the general character of the

NORTHERN PORTION OF THE LOWER PENINSULA.

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

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

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

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

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

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

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

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

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

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

The hilly region to which allusions have been made, is mostly heavily timbered with beech, maple, bass, oak, ash, elm, birch, &c., interspersed with tracts of hemlock and pine, and with an occasional cedar swamp. In the vicinity of Grand Traverse bay, this character of country extends into the interior for many miles bordering on a series of small and beautiful lakes, which vary in length from two to eighteen miles, and

are in general free from marsh and swamp. This country, as also that in the interior from Little Traverse bay, is well adapted to the purposes of agriculture.

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

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

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

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

This is an erroneous opinion, and one which will most certainly be corrected as the facts with regard to this part of our state, come more fully to be known. The inhabitants of Flat, Rouge, Maskego and White rivers, and the Ottawa Indians, living on the Grand and Little Traverse bays, and on the Manistee river, have extensive cultivated fields, which uniformly produce abundant crops.

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

Settlements are rapidly advancing in this part of our state, and much of the land under cultivation, produces excellent

crops of wheat, oats, corn, potatoes, &c., and so far as experience has been brought to the test, is not far inferior to, or more subject to early frosts in the fall than the more southern counties in the state.

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

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

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

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

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

GENERAL GEOLOGY.

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

Rocks of Lake Michigan.

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

Rocks as seen forming the coast of Lake Huron.

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

It will be seen, by referring to the above sections of the rocks of lakes Huron and Michigan, that the same rocks, with one or two exceptions, occur on both sides of the state, having the same geological position; also, that they have very nearly

parallel and uniform positions. And from these outcrops the rocks would appear to have a bearing nearly north 70° west, and south 70° east, which line of bearing corresponds with the outcrop of the black bituminous slate on the east side of Lake Huron in Upper Canada.

Alluvium.

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

Shell Marl,

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

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

Tertiary and Bowlders.

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

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

Primary bowlders are very rarely met with on the upland;

but those of a small size are very numerous on the shores of the small lakes, where there were also numerous bowlders of limestones seen associated with them.

ROCKS OF LAKE HURON.

Point au Gres Limestone.

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

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

Black Shale.

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

Thunder Bay Limestone.

This limestone occurs at the south cape of Thunder bay, forming an abrupt cliff, which rises directly from the water to the height of twenty feet. It is composed of alternating layers of compact and shaly limestone, and fissile clay slate; the latter of which forms a considerable portion of the cliff, containing nodules of iron pyrites and chert. Most of the rock is of but little value for economical purposes. It contains numerous fossils, among the most characteristic of which, are the Atrypa aspera, and prisca, Delthyrus speciosa, Calymene bufo, Gorgonia, Millepore, Catenipora stellata, Cyathophyllum dianthus, Calamapora spongites, Pentremites pyriformis.

Black Limestone.

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

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

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

Blue Limestone.

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

Mackinac Limestone.

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

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

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

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

ROCKS OF LAKE MICHIGAN.

Rock has not been found to outcrop in that part of the state north of Grand river, lying between townships seven and fifteen north, and west of the meridian. But were the superincumbent sands and clays removed so as to expose the rocks to view, they would be found to correspond with those passed over in going south-east from the rapids of Grand river to Monroe county, being a succession of sandstones and shales.

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

Blue and Light Gray Shales.

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

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

Black Shale.

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

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

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

Associated with the shale at this point, are large angular masses of fœted limestone and shale connected together in the same mass; and these masses are frequently traversed by thin veins of pearl spar; the latter also filling the small cavities

formed in the rock. The masses of fœted limestone above described, occupy places simply in the lower portions of the shale stratum.

Corniferous Limestone.

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

Little Traverse Bay Limestones.

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

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

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

Most of the limestones of this bay are of an inferior quality for economical use. They are very much shattered, presenting in that respect a strong resemblance to the sandstones of the southern part of the state. Some portions of the rock on this bay are so shattered, as to have the appearance of a mass of loose blocks. Fossils were found in a very perfect state; among the most characteristic of which are the Atrypa prisca,

Productus, Strophomena, Calamapora polymorpha, Cyathophyllum vesiculosum, Isotelus gigas, sarcinata, Ceriopora verrucosa, Catenipora labyrinthica.

Blue Limestone.

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

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

Black Limestone (Subordinate.)

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

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

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

Deer Licks.

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

Ancient Lake Ridge.

In prosecuting my examinations in the north part of the southern peninsula, portions of ancient lake ridges were met

with, which were found to correspond with that whose character was determined by Mr. Hubbard, and described in his report of last year, as occurring in the southern part of the state. No large continuous ridge was met with, through the country examined by me, but rather a series of small ridges, which were found to be composed of water worn pebbles, gravel and sand, not unlike those composing the present lake beach, and having an elevation, as nearly as I was enabled to judge, of one hundred and forty feet above the present water level.

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

COLUMBUS C. DOUGLASS,
Assistant Geologist.

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Report of B. Hubbard, Assistant Geologist.

Detroit, January 24, 1841.

To Douglass Houghton, *State Geologist:*

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

Maps of the Counties.—The labor of correcting, while in the field, maps of those counties which were assigned to my geological and topographical supervision, has been completed, and the plats are now in the hands of the state topographer, to be prepared for publication. A great mass of information, both of a practical and purely scientific character, and which could not be transferred to the maps, nor be suitably embodied in the annual reports, has been compiled from my field notes, arranged for future reference, and for such use as may be found advisable in the final report on the survey. Particular

attention has been devoted towards the full collection of all such details as would give a completeness to the several objects aimed at, in this department of the survey, and I may be permitted to say that no source of information, known to me, has been neglected, which could subserve interests of so important and comprehensive a character.

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

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

General Geology of the

ORGANIZED COUNTIES OF MICHIGAN.

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

A. Erratic block group, or Diluviums.—a. Alluviums, ancient, recent.

B. Tertiary clays.

C. Coal measures. { Upper coal and shales. / Lower coal and shales. / Included sandstones. / Limestone stratum.

D. Sub-carboniferous sandstones.

E. Clay and kidney-ironstone formation.

F. Sandstones, of Point aux Barques.

G. Argillaceous slates and flags, of Lake Huron.

H. Soft, light colored sandstones.

I. Black, aluminous slate.

K. Limerocks of Lake Erie.

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

Erratic Block Group, or Diluvial Deposits.

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

As this whole deposit is one of transport by water, and is made up of the detritus and disruptured fragments of heterogeneous formations, its character depends upon that of the rocks from which it is derived. For instance, *sand* constitutes by far the greater proportion, and this circumstance may be, in part, accounted for, from the fact of the immense extent of sandstone rocks existing farther to the north; and in part, by the fact, further disclosed by the geological researches in the peninsula, that an immense thickness of rocks, mostly standstone, which composed the upper series of the coal measures, has been broken up and removed from our geological series. *Fine gravel* constitutes the diluvium in the next proportion, and is the result of a similar abrasion of rocks of harder materials. Owing to the friable nature of the sandstones, as might be expected, few large bowlders of that material occur. Limestone pebbles and bowlders are abundant; a condition which also might be looked for, when we take into view the immense extent and thickness of the limerocks of our state, they being by far the most prominent formation above the primary.

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

Whatever may have been the causes which swept these materials over the face of the rocks, whether oceanic currents or bodies of floating ice, the character of these *diluviums*, as well as numerous accompanying facts, plainly imply that they came

in a direction northerly from their present beds, and often from great distances. Consequently we find intermingled, as well as scattered upon the surface, numerous rounded fragments of those primary rocks which are known to exist in the peninsula of northern Michigan and in Canada, from the size of the largest "hard-heads," down to fine gravel. In proceeding from our state southerly, these deposits are found gradually to thin out, evincing a diminution of the sustaining power with the increased distance from the original bed of the transported materials. So that, while the peninsula of Michigan has been most liberally supplied with an uncommonly deep and arable soil, made up of a variety of materials, the states of Ohio and Indiana, on the south, are in great part destitute; its place being supplied by the clays of the next lower formation.

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

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

Most of the country thus covered by the diluvial deposits, exhibits the action of strong currents and eddies in a very striking manner. Districts of many miles extent frequently present a continued and close succession of rolling knobs or cones of gravel, with deep intervening basins. The more ordinary character of surface is a gentle roll or slight undulation occasionally subsiding to a perfect plain.

Except where a deposit of clay underlies, the growth of timber is almost invariably scanty, constituting what are denominated "oak openings." The character of their timber changes with the varying conditions of the soil, from white and black oak to burr oak or hickory, and the plains are frequently altogether destitute of timber. A dense growth of the usual hard wood timber sometimes occurs over isolated tracts, in swales, or along banks of streams. Of the character of coun-

try described are found the three most southerly ranges of counties, with the exception of those which immediately border the peninsula, on the great lakes, together with parts of the adjoining counties, and the counties of Ingham and Eaton. All the latter have a sub-stratum of clay, belonging to the great deposit to be presently described, and in consequence differ very materially in surface, soil and timber.

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

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

Another striking feature in the peninsula landscape, is the number and extent of wet prairies or marsh. Of these the proportion is much larger than of the lakes, and they often cover many miles of surface. These have their origin also from springs, issuing from the diluvium, aided often by the artificial dams of the beaver, and from being originally mere pools or shallow lakes, in time they become receptacles for beds of marl and peat. From the very tolerable hay which these prairies afford, and the very early supply of tender "feeding" for cattle, in the spring, these apparently waste places have been an invaluable aid to the settlement of the country. The primitive settler came hither, not to a desert waste or a "howling wilderness," but to lands cleared without aid from the woodman's axe, and verdant with unsown crops. He did not wait to provide pasture, but brought his herds and flocks with him, and the marshes furnished them ample sustenance throughout the year. And we hazard nothing in saying that these marshes, waste as many of them are now suffered to be, are destined to become still more valuable in sustaining the failing vigor of the country whose youthful prosperity they promoted. Their successful drainage is no longer a matter of experiment. Scarcely a marsh of much extent exists, which

is not capable of thorough drainage, with comparatively small expense, and, when thus subdued, of furnishing a soil rich almost beyond comparison. The literally exhaustless beds of marl and peat, with which these marshes abound, constitute another item of value no less important. But the consideration of these may more properly be referred to the head of *recent alluvions.*

But though affording a medium for the absorption of rain waters and their percolation through strata of gravel or quicksand, the diluviums are rendered sufficiently retentive, by the alumine contained in them, and by seams of cemented gravel and sand. Were it not for this, the moisture absorbed by our light, sandy soils, would soon be drained off and lost to the crops. A sub-stratum of cemented gravel, retentive of water, is common to many if not all the prairies, and to this circumstance may, no doubt, in great measure, be ascribed their accumulation of rich loam and consequent fertility.

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

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

Ancient Alluvion.

As the consideration of that immense mass of materials to which has been applied the name of *diluviums* or *erratic block group*, was necessary, in order to a correct appreciation of those lesser deposits, now to be considered, (which are associated with, and in fact compose a part of the former,) that important group claimed our first attention. We come now to the consideration of a class of deposits which may be called *alluvial.*

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

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

The portion thus distinguished by alluvial deposits, embraces a broad belt of border country, varying in width from about 25 to 50 miles. It is, with small local exceptions, heavily timbered and very level. But, on passing the bounding ridge, there is, in general, an almost immediate change to a soil of coarser character, and a more undulating surface. This ancient alluvion is a deposit, from a quiescent condition of the waters, and similar to that which is now taking place in the beds of the present lakes. It forms, in general, but a thin mantle to the underlying formations, consisting often of mere ridges

of sand, and, owing to the deprivation of its lime, has, in general, less fertility than the diluviums.

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

Recent Alluvions.

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

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

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

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

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

Organic Remains.

Bones of the Mastodon were last year discovered, in the ancient alluvion, in the western part of Macomb county. They were mostly so much decayed as not to bear exposure to the atmosphere, and a molar tooth only has been preserved. Similar relics were, several years ago, disinterred on the Paw Paw river in Berrien county.

There is now in possession of a gentleman in this city, a vertebal bone of enormous size, said to have been found, many

years ago, upon the St. Joseph river, and which is pronounced by the state zoologist, Dr. Sager, to be the caudal vertebra of a whale. It measures in vertical diameter, including spinous process, 18 inches; transverse diameter, including lateral processes. 2 feet; diameter of body, 11 inches; length of body, 10½ inches; length of spinous process, 9 inches. Its weight is 21 lbs, which is probably less than one half its original weight, as the bone is partially decayed.

Tertiary Clays.

These extensive deposits belong to an era subsequent to the removal of the upper coal bearing rocks. They cover all the border counties on the east and west slopes of the peninsula, and, in some instances, stretch far inland. These clays extend over more than two-thirds of that part of the state which lies south of Saginaw, Maple, and Grand rivers, embracing nearly the whole of the counties of Ottawa, Allegan, Van Buren, Berrien, Monroe, Wayne, Macomb, St. Clair, Sinilac, Huron, Tuscola, Saginaw, Lapeer, Clinton, and Eaton, and a large portion of Ingham, Genesee, Shiawassee, Ionia, Kent, St. Joseph, Branch, Hillsdale, and Lenawee. The remaining portions of the counties last named, and very nearly the whole of Oakland, Livingston, Washtenaw, Jackson, Calhoun, Kalamazoo, and Cass, are destitute of this sub-clay formation, and their diluviums rest immediately upon the rocks.

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

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

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

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

COAL MEASURES.

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

Limestone Stratum.

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

A gray limestone, in irregular, detached beds, is found along the extreme border of the coal bearing sandstones. They are evidently relics, in place, of a thin but extensive stratum, and as no coal has been found below this rock, I have assumed it as the terminating rock of the "coal measures" proper of our state. Following this rock, as it makes its occasional appearance, the southerly limits of the coal basin may be traced by a line drawn from the Shiawassee river, at Corunna, through the easterly parts of Ingham and Jackson, between ranges one and two east, to near Napoleon, in the latter county. It then turns westerly though town three south, ranges one and two west; from whence, taking a direction north-westerly, it pursues an irregular line, passing through Bellevue, in the southwest corner of Eaton county, to Grand Rapids, in Kent county. Here the limerock is more extended, and a thickness has been determined to it of fourteen feet. The rock is characterized by the fossils Nucula and Cyathophyllum vermiculare. This stratum affords the only limestone for the kiln, or other purposes, except occasional bowlders, to be found in the interior of the state, and its value is the more to be appreciated as the formation is itself of very limited extent.

Lower Coal.

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

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

Coal of Ingham County.—Passing down the easterly side of the basin, the coal is again met with, in the north-east corner town of Ingham county, where it is embraced in a succession of shales and friable sandstone, cropping out in the banks and bed of the Red Cedar river. The coal has here been penetrated two and a half feet. But neither here nor in Jackson county, is the entire thickness of the bed determined. "The coal at this point," as is observed in the report of Mr. Douglass, of last year, "is very accessible, and must, ere long, prove of great importance. It is situated on a stream that may be made navigable for flat bottomed boats and perogues, with comparatively small expense, for a considerable portion of the year, and opening a direct communication with Lake Michigan."

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

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

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

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

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

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

Upper Coal.

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

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

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

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

Included Sandstones of the Coal Measures.

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

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

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

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

General section, applicable to the coal basin of Michigan.

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

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

* Counties of Clinton and Eaton.

Sandstones immediately below the Coal.

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

These sandstones, which, in the report alluded to, are described under the name of *fossiliferous, ferruginous sandstones*, excepting in some of the uppermost strata, are generally fine grained and of a yellow color. Some strata of the latter abound in marine fossil shells, among which the genus Nucula is very abundant, and there were observed species of Atrypa, Bellerophon, Euomphalis, and Pterinea.

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

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

Clay, containing Kidney ore of Iron.

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

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

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

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

Sandstones of Point aux Barques.

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

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

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

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

Clay Slates and Flags of Lake Huron.

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

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

These slates and alternating sandstones may be considered as the upper salt rock of our state. They have been passed through in boring for salt at Grand Rapids, and found to yield strong supplies of brine. At this point they are found also to

alternate with beds of gypsum and gypseous marls, as will appear by reference to the table of the strata passed through, given on a subsequent page. The thickness ascertained to these slates, at that point, is about 170 feet.

Soft, coarse grained Sandstone.

A series of sandrocks answering to this description, and generally of a dark color, succeeds to the clay slates and shales last above described, and has been penetrated at the borings at Grand Rapids, 230 feet. There are, as yet, no data for ascertaining the entire thickness of this series, since it does not make its appearance at any point on the coast of the peninsula, this rock evidently forming the bed of Lake Huron, near its foot, and lying too deep for observation. In relative position and perhaps in character, this rock, or a portion of the series, corresponds with the lower salt rock of Ohio and Virginia, and is the rock from which, in these states, the strongest supplies of brine are obtained. The result of the borings in our own state, thus far, would seem to confirm the opinion that this rock is the equivalent of the lower salt rocks of those states.

Black, bituminous, aluminous Slate.

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

Limestones of Lake Erie.

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

The character and economical adaptation of these limestones

have been sufficiently set forth in former reports, to which, accordingly, I refer you for detailed information.

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

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

The following general section will exhibit the order of succession and approximate thickness of the rocks, above described, *lying below the coal basin*, and is a continuation of the table, given on page 130, of the successive rock formations of the settled portions of our peninsula:

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

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

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

Dip of the Rocks.

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

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

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

Borings at the salt well, Grand Rapids.

The borings for salt at the village of Grand Rapids, Kent county, commenced in the limerock stratum, mentioned above, page 561, as constituting the terminating rock of the coal basin. At this point, several of the next, succeeding series of sandrocks appear to have thinned out, and their place is here occupied by alternating strata of clay slates and sandstones, with

gypseous marls and beds of gypsum. These continued to a depth of 190 feet, and below this the borings have been carried mostly through series of sandrocks, to the depth of 415 feet.

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

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

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

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

		Thickness in feet.	Total depth, feet.
1	Hard gray limerock, irregularly stratified, and in portions cavernous,	14	14
2	Yellow sandrock, producing fresh water,	6	20
3	Blue clay,	2	22
4	Coarse, reddish sandrock,	5	27
5	Blue clay,	3	30
6	Clay slate, with thin layers of gypsum interstratified,	11	41
7	Clay slate,	18	59
8	Gypsum,	4	63
9	Clay slate,	2	65
10	Gypsum,	6	71
11	Clay slate,	3	74
12	Bluish sandrock, very hard, with sharp grit,	8	82
13	Bluish clay rock, intermixed with particles of reddish rock, compact. This rock is strongly impregnated with saline particles,	18	100
14	Sand and clay rock, alternating.	7	107
15	Carbonate of lime and gypsum, combined; very compact,	10	117
16	Gypsum,	7	124
17	Clay state,	9	133
18	Gray sandrock, of very sharp grit, and hard,	5	138
19	Clay rock,	$2\frac{1}{2}$	$140\frac{1}{2}$
20	Gypsum, with vein of salt water,	$6\frac{1}{2}$	147
21	Clay rock,	6	153
22	Gypsum and clay slate, or gypseous marls, alternating,	19	172
23	Gypsum,	3	175
24	Clay rock,	3	178
25	Gypsum,	1	179
26	Hard sand rock, producing fresh water,	$1\frac{1}{2}$	$180\frac{1}{2}$
27	Clay rock, free from saline matter,	$10\frac{1}{2}$	191
28	Hard sandrock, very compact and of dark color,	7	198
29	Soft sandrock, nearly colorless,	18	216
30	do of dark blue color,	32	248
31	Loose, coarse grained sandrock, of reddish color, opening a very copious spring of fresh water,	17	265

Below the strata last noted in the above table, the borings have continued through a further depth of 150 feet, but the data received are not sufficiently minute to enable me to extend the table. From the information obtained, they would seem to have passed through mostly soft, light colored sandrocks, of a coarse grain and with a sharp grit, and in the lower portions containing cavities into which the drill sometimes falls several inches. Particles of salt were brought up, and the rock yields a very strong brine.

All the strata, from the depth of 81 to 179 feet, or until the sandrock was reached, were strongly impregnated with saline particles, and yielded brine one-fifth saturated. These clay slates and marls may be regarded as the "upper salt rock," and they are thus shown to furnish a brine superior in strength to

that of many of the salt wells of Ohio, and which, even could no stronger brine be obtained, is capable of sustaining a profitable manufacture.

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

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

In addition to the quality of the brine obtained, the advantages for the manufacture of salt at the point under consideration, are not exceeded at those places in our country where the manufacture is conducted to the largest extent. The supply of wood for fuel and other necessary purposes is abundant, and will tend greatly to reduce the price for which the manufacturers will be enabled to furnish this article. And, though the whole matter may be said to be still in the incipient state, there is every reason to feel satisfied with the prospect, which so fair a beginning holds out to the state, for obtaining a result so very desirable, as that of supplying her citizens with this important article from the product of her own manufacture.

Summary,

Comprising general observations on the economical results of the survey.

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

Michigan occupies a portion of the great valley of the Mississippi—the richest in the world—and which is wholly occupied by a broad extent of the rocks classed by geologists in the transition and secondary formations. Of these, the great lime-

stone formation, (of which that of the west end of Lake Erie is a portion, and which concluded our view of the several geological groups which make up the organized portion of the state,) occupies the lowest place, and is the lowest and oldest of the rocks found on the lower peninsula of Michigan. The upper peninsula of our state, as will be seen by the report of the state geologist, is constituted of lower and still older rocks, and presents, in consequence, a very different aspect, as well as a different mineral character, from the lower peninsula.

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

Iron.—An ore of this mineral, under the form of kidney iron-stone, exists, chiefly in the counties of Branch and Hillsdale. It is sufficiently extensive to be of much value, and will give an average yield of about 30 per cent of metal. This ore is embraced in the clay formation, described on page 506 of this report, and a more extended notice will be found in the geological report of 1840, pages 25 and 86.

Iron, under the form of bog ores, is found in various parts of the state. The most extensive deposits, and those alone which it may be safe to assert will yield a rich profit, are at the county seat of Kalamazoo, near Concord, in Jackson county, in the county of Oakland, and perhaps Wayne. No furnaces, for the reduction of these ores, have yet been erected. It is shown, by the late census, that there are fifteen furnaces in the state for the casting of pig iron, requiring 614 tons, and the whole amount of iron imported, under various forms, is much greater. The cost of this importation, which in so heavy an article as iron, is very considerable, might and ought to be saved to the state, by a domestic manufacture from our own material. For more detailed observations, and an account of the localities at which this ore occurs, see geological report of 1840, pages 28, 60 and 100.

Bituminous Coal will be found in abundance for all the wants of the state. The only locality where mining operations have been commenced is at Corunna, Shiawassee county, where

this mineral has been already used to considerable extent, and, though in the midst of a heavily timbered country, is for many purposes preferred to wood or other combustible. Other points also, eligibly situated for the mining of coal, have been made known in Ingham, Eaton and Jackson counties, and it may be fairly inferred, from the facts already determined of the range of coal bearing rocks, that outcrops of the coal beds will be found at numerous other points than those now known in these counties, where it is not now *known* to exist, as through parts of Kent, Ionia and Genesee counties. (*See further statements under pages* 562 *and* 563 *of present report.*)

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

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

GYPSUM. An extensive deposit of this very valuable mineral occurs in the vicinity of Grand Rapids. The bed is here very extensive; is about six feet in thickness, and in quality is equal to the best gypsum of Nova Scotia. The same mineral is found elsewhere in our state, but this is by far the most important locality at present known, and one that affords every facility for quarrying and distributing the mineral over the state. A mill was erected during the past summer, and the ground plaster, for manure, is already manufactured in considerable quantities.

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

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

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

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

In comparing the extent of our resources thus obtained, with the little that was known concerning them a few years ago,

we have reason to feel satisfied with the prospect of future wealth and importance, which it has opened to us. If during the stirring times of an early settlement, so rapid as has been that of our state, for the past five years, less interest was excited by the development of our mineral resources than their importance might demand, a satisfactory cause may be found in the imperfect state of the knowledge hitherto obtained, and in the pressure of the more immediate wants of a new, somewhat fluctuating and unsettled community. During the period mentioned, however, the population of southern Michigan has advanced, from a less number, probably, than 60,000 to 212,000; a rate of increase unexampled even in the annals of a series of settlements, to the progress of which the world affords no parallel. Meanwhile, the liberal course of our state policy has been steadily unfolding her resources, and, at this moment, notwithstanding the burden of a heavy debt, and the accumulated pressure of more widely felt financial difficulties, we are rapidly advancing in wealth, and are becoming awakened to the means of which we find ourselves possessed, for successfully competing with older states, in the departments of agriculture, commerce and manufactures. With lands among the richest in the world, well watered and advantageously situated for market, with water power abundant, and with an extent of coast and facilities for water transportation unequalled by any other inland state, and, added to this, a population possessing a large share of that character for enterprise which distinguishes their countrymen, nothing will tend more to give full efficacy and permanency to these advantages than to make more perfectly known the value of our mineral resources. Our state is now sufficiently advanced to be able to avail herself, properly and with certainty, of the advantages alluded to, and there is every reason to believe, that these will not longer fail to command attention, and that the results will equal the most sanguine anticipations.

BELA HUBBARD, *Assistant Geologist.*

Report of S. W. Higgins, Topographer of Geological Survey.

Detroit, January 24, 1841.

To Douglass Houghton, *State Geologist:*

Sir—In fulfillment of your instructions, I have, in the present report, brought together such observations relating to the magnetic variation in this state, as will, I trust, assist hereafter in affixing data to important facts. Further developments will require a prolonged period and additional observations. But the readiness with which the direction of magnetic lines

may be ascertained, by the help of the solar compass, will render the labor and hazard of error a thousand fold less than any former method, and it is hoped that this compass will supercede everywhere, the necessity of depending alone upon the needle.

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

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

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

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

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

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

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

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

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

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

The opinion, then is an erroneous one, that mineral must always be present in masses, to cause the aberrations of the needle. This is not necessary, nor is it the fact; for those minerals which are deeply buried can have no influence, inasmuch as their influence decreases inversely as the squares of the distance, and it may be said that the needle is wholly indeterminate in their neighborhood in respect to them, "since

*Professor Farrer.

the resultant of magnetic forces being then vertical," or nearly so, or nothing, "the horizontal element would be nothing."

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

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

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

ting the declination of the needle, over this extensive region, on parallels of equal distances of six miles.

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

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

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

The latter condition is the true one, as we shall shortly demonstrate. We begin, then, at a point where the line of no variation passes out of Lake Huron, and first touches the south side of Drummond island. This island is one of the northwesternmost of the chain of the Manitous which divide the waters of the straits of Ste Marie. It first touches the island near the meander post on the shore, between ranges 7 and 8 east, in township 41 north, and is the tangent point to a curve of 4½ miles radius which it then makes on the island, the western extremity of the curve touching again the south shore of the island in the middle of the next township, in range 6 east; whence a reversed curve of 3¼ miles radius, approaches closely to the corners and one-fifth of a mile south of fractional township 41 and 42, ranges 5 and 6 east; thence on a course south 85° west, 6 miles, intersecting township line 41 between ranges 4 and 5, near the meander post, south shore of the island; which is another tangent point, to a curve, whose radius is 3¼ miles. Along this curve, at the distance of one mile, is the western end of the island, and at the meander post for fractional township 41 and 42, range 4 east; thence crossing the channel to the opposite side nearly, the curve terminates between Round island and the main land of the upper peninsula, one-fourth of a mile from the shore; thence another reverse curve of 2¾ miles radius, just sweeps along the edge of the shore, northward of Pointe de Tour, the western termination of the curve being in a lake, on the south-west corner of township 42 north, range 3 east; thence again the curve is reversed, whose radius is 2½ miles, crossing the south boundary of the same township, 1¾ miles from its western boundary; whence the curve is again reversed, with a radius of 2¾ miles, passing off the coast into Lake Huron again, passing over one of the small islands near Massacre Island; thence ascending, it rëcrosses the south boundary of township 41 north, in range 2 east, between sections 33 and 34; thence curving north-westerly, with a radius of 6½ miles, it crosses the town line between ranges one and two east, 1¾ miles from south boundary; still slightly curving northwardly, on a course of 12 miles, it crosses north boundary line of township 43, range one east; thence two miles it intersects Monusco bay, and curving westerly, leaves the water, and crosses the south-east corner of town 45, range one east, three-fourths of a mile from corner post, into town 45, range 2 east; thence curving with a radius of 6¾ miles, enters, at the mouth of the Miscota Sawgee river, the Canoe channel of the straits of Ste Marie, and crosses it about one mile above the Neebesh rapids in that channel, touching the most westerly point of Great Sailor's encampment island, and keeping the western and northern shore, with a curve whose radius is eight miles; here its course is again reversed, and beyond this we have no sufficient data to pursue it farther.

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

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

This line, before touching Drummond Island, where we first commenced with it, may with almost equal certainty be traced down along its southern course in, and to the foot of Lake Hu-

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

ron; although, for the reason that it is confined to the lake, we may not always ascertain its distance from the shore.

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

From the fact that the line of no variation passing through a part of our state, we are in some measure better able to determine the *rationale* of another system of curves found elsewhere on the peninsula, particularly on its western side, at the Great and Little Point aux Sable, where a greater intensity is observable on approaching Lake Michigan from the east.

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

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

Another peculiarity is, that corresponding curves, exterior to the line of no variation, on either side, bear no comparison. At the head of Great Sailor's encampment island, at the distance of two miles west, the variation is 1° 10′ east; and opposite the middle of the same island, at one mile east of the line, it is 40′ west; at five miles, 1° west, and at six miles 1° 10′ west; one mile south of Monusco bay, the distance of one and quarter miles east of it, the variation is 1° west; five miles

west, 2° 35′ east only, and the curve mentioned as again entering the lake between towns two and three, as well as the curve which passes around the edge of the shore above Pointe de Tour, have no variation at their centres, but on approaching either way, east or west, variation increases to 30′, and then again decreases to 0, on touching the line of the curve.

The same peculiarities are observed on the western side of the lower peninsula, particularly at Great and Little Pointe aux Sable, where the intensity increases, and the curves, though larger, exhibit as little conformity. It is evident that the needle "hauls to the land," to use a nautical phrase, for at these points, the increase of variation amounts to 3° in thirty miles, exceeding 6° at the points, while the increase is but 1° for the whole breadth of Lake Michigan; the variation being but 7° in Wisconsin, on the opposite shore.

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

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

We have not only now been enabled to adduce facts confirmatory of the general principles of terrestrial magnetism, but to enter considerably into detail on the subject of magnetic variation. A variety of reasons seemed to require this, the principle of which was, the definite course obtained of the line of no variation, and the consequent illustration of other lines on either side of it being also irregular; demonstrating a system of curves, and a series of distinct and separate centres of

attraction. This has been effected over no very limited space, and is free from all that might be considered empirical.

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

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

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

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

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

Diurnal Variation.

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

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

1839.		Thermometer.			Weather.			Magnetic variation.		
Day.		5½ A. M.	1 P. M.	6½ P. M.	A. M.	P. M.	Winds.	5½ A. M.	1 P. M.	6½ P. M.
July	13	60°	79°	62°	Clear.	Light showers.	W. S. W.	1° 42′	1° 28′	1° 42′
	14	59°	72°	67°	do	Flying clouds.	N. W.	1° 42′	1° 26′	1° 33′
	15	{ at 5, 53¾ { at 6, 58	73°	64°	Cloudy.	Light showers.	N. W.	1° 32′	1° 28′	1° 28′
	16	55°	71°	66°	do	Some cloudy.	W.	1° 38′	1° 28′	1° 30′
	17	52°	80°	69°	Clear.	Clear.	W. N. W.	1° 30′	1° 28′	1° 30′
	18	55°	85½°	83°	do	do	W.	1° 41′	1° 28′	1° 35′
	19	56°	89°	82°	do	Flying clouds.	S. W.	1° 40′	1° 28′	1° 35′
	20	63°	80°	74°	do	Cloudy.	S. S. W.	1° 40′	1° 25′	1° 35′
	21	70°	82½°	77°	do	do	S.	1° 42′	1° 28′	1° 30′
	22	72°	86°	75°	Cloudy.	Some cloudy.	W.	1° 40	1° 28′	1° 35′
	23	65°	88°	77°	Clear.	Clear.	E.	1° 41′	1° 23′	1° 36′
	24	72°	86°	77°	Rain.	do	W. S. W.	1° 43′	1° 25′	1° 35′
	25	69°	83°	80°	Clear.	do	N. W.	1° 41′	1° 15′	1° 32′
	26	66°	88°	79°	do	Cloudy.	W.	1° 40′	1° 23′	1° 35′
	27	50°	80°	76°	do	Showers.	W.	1° 41′	1° 30′	1° 37′
	28	64°	86°	80°	do	Clear.	W.	1° 42′	1° 24′	1° 30′
	29	66°	87°	78°	Cloudy.	do	W.	1° 41′	1° 21′	1° 30′
	30	69°	90°	79°	Clear.	Showers.	W.	1° 41′	1° 25′	1° 33′
	31	62½°	76°	72°	do	Clear.	W.	1° 40′	1° 24′	1° 33′
August	1	48°	79°	76°	do	do	W.	1° 40′	1° 24′	1° 28′

Note.—July 19, at 12 h. 30 min. P. M., variation 1° 10′; at 12 h. 45 min., var. 1° 15′; at 1 h., var. 1° 28′. July 24, at 6 h. 10 min. P. M., shower commences, var 1° 35′; at 6 h. 40 min, shower past, var. 1° 25′. July 27, at 5 h. 45 min. P. M. shower rising, var. 1° 47′; shower past, var. 1° 37′.

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

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

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

This question is of no less importance now, than it will be

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

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

in future, when all traces of the original lines shall have been lost, which is the case already, wherever the county has become settled, and roads or fields have been opened along the boundaries of section lines.

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

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

In giving the above estimate, we cannot avoid the opportunity of confronting its results with the compilations of draftsmen and geographers, who, in relation to the peninsula, have heretofore, in the main, copied such estimates as have fallen in their way, whether right or wrong. But little care has been exercised, even by those who ought to have been better acquainted with the errors which have always characterized not only the maps, but the descriptions of the peninsula. It is to be hoped that the period of such errors is now past, and that while most existing publications become obsolete, they will be rëplaced by correct ones; for it is not too much to say, that *now*, not only correct, but precise and definite information can be obtained, and wherever a dependence shall be placed upon former maps and descriptions, so far will their numerous and universal mistakes be the means of leading into important errors.

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

The last year is the second since the unusual elevation of the waters of the lakes; since which time there has been yearly

a remarkable coincidence in the ration of their subsidence, the more unlooked for, when taken in connection with the causes which tend to equalize the amount of falling water, in the form of rain, snow, and dew, with the constant action of evaporation.

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

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

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

Its rate of decrease is much more rapid than that of its increase from 1819 to 1838. In 1830 it was only two feet above the level of 1818; in 1836, three feet eight inches; having risen one foot eight inches in six years. In 1837, it was four feet three inches, increase, seven inches; in June, 1838, five feet; increase, nine inches; and in August of the same year, five feet three inches. Having been nineteen years in attaining the maximum of five feet three inches, and only two years in reducing that height one-half, or to the average year of 1833. Thus the rapidity of its decrease in two years, equals the increase of five years.

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

The diminution in a given quantity of water, exceeds by evaporation, all the supplies which it receives from rain, that is, the average amount of falling water, is equal per year to

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

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

Besides all this, the effect of winds sometimes acts in favor, as well as against the other irregularities. The geographical position of the lakes is such, as that, allowing them to prevail from the same point, at the same time over them all, (which is, by no means, always the case,) they produce a variety of results. A west wind forces the water of Lake Erie into the Niagara river, at the same time, the waters from the foot of lakes Huron and Michigan are forced into the straits of Mackinac, and these again are met by the waters of Lake Superior, through the straits of Ste Marie. Hence the straits which connect lakes Huron and Erie, have all the indications of a tide, though irregular as to time, as well as to the amount of its elevation and depression, and it has often both rose and fell in about the same proportion, and sometimes in the same period, as the lunar tides in those rivers which empty into the

ocean. But whenever these tides take place, either in the lakes themselves or in the straits connecting them, they are fortuitous, and are the results of accidental disorder, common throughout the lake region.

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

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

Table of elevation and depression in the waters of the Lakes, compared with that of June 1, 1839.

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

DETAIL OF THE ELEVATION AND DEPRESSION FOR 1840.

					Ft.	In.	Ft.	In.	Ft.	In.
1840.	January	30,	Height of water,							9
	April	25,	Increase,	......	1	5	2	2		
	May	9,	"	Rain and wind from N. E., fluctuations 15 to 18 in.		1½	2	3½		
	"	19,	"	Same,		1½	2	1½		
	June	8,	"	Wind west, season dry and hot,		1	2	4½		
	July	4,	"	Light showers, weather same as last observation,		3	2	7½	2	7½
	"	22,	Decrease,	Much rain in June and July, on Lake Superior,		3½	2	4		
	September	1,	"	Season dry, little rain,		2	2	2		
	"	13,	"	......		½	2	1½		
	"	20,	"	Wind west, river fell suddenly,		4½	1	9		
	October	1,	Increase,	Heavy rain last 24 hours,		4	2	1		
	"	12,	Decrease,	......		3½	1	9½		
	"	29,	"	Moderate,		½	1	9		
	November	10,	Increase,	do		1½	1	10½		
	"	24,	Decrease,	Freezing, wind moderate from west,		4½	1	6		
	December	10,	Increase,	Ice made in river in considerable quantities,		½	1	6½		
	"	21,	Decrease,	River blocked up by ice, no wind,		2	1	4½		
1841.	January	1,	"	River nearly closed, wind moderate from west,		10		6½		6½

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

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

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

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

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

Another cause of the stoppage of the streams, is the falling

of timber across them, which becomes permanently fixed by the superincumbent pressure of the waters.

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

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

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

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

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

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

The causes which will ultimately have a tendency to drain the great portion of them, is slow in its operations, but nevertheless, is sure. The operation may be expedited by artificial means; either, by straightening the usual serpentine course of the streams, or by enlarging their outlets, or which is the most effectual method, by removing the embankment, or beaver dam.

These may, in almost all cases, be found by examination, though they are in a measure concealed, from the long period of their standing, and the materials of their construction, having become overgrown and covered with rank grass and mould, accumulated through long periods of years.

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

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

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

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

Suggestions in relation to the cause of the late gradual decrease of the waters of the great lakes, in connection with the disappearance of these smaller lakes and drying of the marshes, have been offered, attributing both to the changes in the seasons only, so that a recurrence of circumstances hereafter

that shall produce a rise similar to the one of 1838, in the great lakes, will also, it has been supposed, produce a similar submergence of the marshes, and fill again the small lakes. But I apprehend there is no connection between the causes which have acted on the one, and those which have effected the other. It is true that the three thousand interior lakes, especially those of any considerable magnitude, have had their ebbs and flows in the same ratio, and at the same time and from the same causes, as the great lakes; but it should be remembered that no new instances of marshes being formed, have been discovered, but on the other hand, when the waters of the lakes were rising for years, and were at their maximum, an equal progressive subsidence was taking place in the waters of the marshes.

The number of irreclaimable marshes is comparatively few, and their areas are circumscribed to the dimensions of the lake which originates them, and to the basins which inclose them. In the first case the lake is central and cannot be approached; the vegetation which had taken root in their margin, has been so often rëproduced, as to contract the actual dimensions of large lakes, and confine the remaining open space of water to a small extent. This is in consequence of a floating, buoyant covering, fixed by the fibres of roots, which, having been first supported by and around the shore, has, in deep water, no other support than what the surface of the lake itself affords. Hence, where these lakes become entirely covered over, as in Sanilac, Cheboygan and Presque Isle counties, and in some other instances, to a greater or less extent, the weight of a man causes a depression and a wave-like and trembling motion to some distance round. The surveyor, who is often compelled to cross them, well knows the feelings of insecurity they create. It may not be said of them, as was said by some travelers from London, on their journey to the north, who, on arriving at Dumfrieshire, in Scotland, concluded, from the appearance of the mountains there, that *the world was finished no farther*, and returned quietly home.

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

S. W. HIGGINS,
Topographer to Geological Survey.

Glossary, including the technical terms used in this report.

Alluvial. The adjective of Alluvium.

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

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

Amorphous. Bodies devoid of regular form.

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

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

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

Arenaceous. Sandy.

Argillaceous. Clayey.

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

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

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

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

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

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

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

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

Botryoidal. Resembling a bunch of grapes in form.

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

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

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

Calcareous Rocks. A term synonymous with limestone.

Calcareous Spar. Crystalized carbonate of lime.

Carbon. The combustible element of coal.

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

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

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

Chalybeate. Impregnated with iron.

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

Chlorite. A soft green scaly mineral, slightly unctious.

Chloritic Slate. Slate containing chlorite.

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

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

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

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

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

Cretaceous. Belonging to the chalk formation.

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

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

Delta. Alluvial land formed at the mouths of rivers.

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

Deoxydize. To separate oxygen from a body.

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

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

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

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

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

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

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

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

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

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

Exuviæ. In geology, fossil remains.

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

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

Ferruginous. Containing iron ore.

Fluviatile. Belonging to a river.

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

Fossils. The remains of animals and plants found buried in the earth, or inclosed in rocks. Some of these are but slight-

ly changed, others are petrified and the organic rëplaced by mineral matter; some have decayed and left the impression of the bodies, while others have been formed by mineral matter deposited in the cavities left by the decay of the organic body. These last are called *casts.* The term petrification is applied to those cases, in which organic matter has been rëplaced by mineral substances. The form and structure of the original body both remain. In casts, the exterior form alone is preserved. Fossils are also called organic remains.

Fosiliferous. Containing organic remains.

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

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

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

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

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

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

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

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

Greenstone. A trap rock composed of hornblende and feldspar.

Grit. A coarse-grained sandstone.

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

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

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

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

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

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

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

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

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

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

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

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

Littoral. Belonging to the shore.

Loam. A mixture of sand and clay.

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

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

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

Mammoth. An extinct species of elephant.

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

Marly Clay. Clay containing carbonate of lime.

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

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

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

Metamorphic Rocks. Stratified division of primary rocks, such as gneiss, mica slate, hornblende slate, quartz rock, &c.,

and which may probably be regarded as altered sedimentary rocks.

Metalliferous. Containing metals or metallic ores.

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

Micaceous. In part composed of scales of mica.

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

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

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

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

Muriate of Soda. Common salt.

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

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

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

Nodule. A rounded, irregular shaped lump or mass.

Ochre. See *bog iron.*

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

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

Organic Remains. See *Fossils.*

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

Out-crop. See *Crop out.*

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

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

Palaeontology. A science which treats of fossil remains.

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

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

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

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

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

Productus. An extinct genus of fossil bivalve sheels.

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

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

Pudding Stone. See *Conglomerate.*

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

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

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

Sandstone. A rock composed of aggregated grains of sand.

Schist. Slate.

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

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

Sedimentary rocks. All those which have been formed by

their materials having been thrown down from a state of suspension or solution in water.

Selenite. Crystalized gypsum.

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

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

Shale. An indurated clay, which is very fissile.

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

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

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

Silicious. Containing silex.

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

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

Slate. A rock dividing into thin layers.

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

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

Stratification. An arrangement of rocks in strata.

Strata. Layers of rock parallel to each other.

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

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

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

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

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

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

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

Tepid. Warm.

Thermal. Hot.

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

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

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

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

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

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

Tufaccous. A texture of rock like that of tuff.

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

Unconformable. See *conformable.*

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

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

Zoophites. Coral spunges and other aquatic animals allied to them.

[No. 12.]

Report of the commissioners appointed by the act to provide for a settlement with the Ypsilanti and Tecumseh railroad company.

To the Senate and House of Representatives:

The undersigned commissioners, appointed by the act approved April 1, 1840, entitled "An act to provide for a settlement with the Ypsilanti and Tecumseh railroad company," beg leave most respectfully to represent to your honorable body, that they have held frequent meetings, and had several interviews with the officers of said company; that such statements have been obtained from the auditor general as show the times when, together with the amounts heretofore paid by the state on ac-

count of the loan of $100,000 made to said company, under the act approved April 6, 1838.

The commissioners are persuaded that this company entered into contracts for the construction of the road, with full reliance upon the pledged faith of the state for the payment of the money loaned them, agreeably to the provisions and conditions of said last act mentioned.

The undersigned are of opinion, that the company complied with the conditions required by said act, in perfecting their securities for the rëpayment of said loan, and that the said company had every reason to expect payment thereof, on the part of the state.

Unexpected circumstances, however, and such as could not have been anticipated either by the state or the company, prevented full payment, and greatly delayed even that which was paid by the state.

It is therefore certain, that whatever may have been the misfortunes or faults of the company, the state has not fulfilled, on her part, the conditions stipulated by the act making said loan.

The company appear to have expended between forty and fifty thousand dollars for materials, and on the construction of said road, have incurred heavy liabilities to contractors and for right of way, on said road, which they are not able to meet. The company will be utterly unable to complete said road, unless largely aided.

It is the deliberate opinion, therefore, of the commissioners, that the state is justly and equitably liable for damages to the company, and still, that such damages, if paid, would not benefit said company, inasmuch as this would not enable them to finish the road without further aid. Thus, some forty to fifty thousand dollars expended upon said road, will be entirely lost, should the completion thereof be delayed for any length of time. And further, the injuries sustained by those through whose lands the road passes, would not be materially lessened.

From the limitation of the powers given to the commissioners by the act appointing them, they have met an insuperable difficulty in making a final adjustment with said company.

There are, moreover, equitable considerations to which this company is entitled, which can only be reached by most ample powers vested in commissioners, or by the legislature itself.

The undersigned commissioners would, therefore, most respectfully recommend, in view of all the circumstances, that the Ypsilanti and Tecumseh railroad be added to the other works of internal improvement now undertaken by the state; and that such appropriations be made as may secure the com-