

cial 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 possessed of 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 supersede 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 in-

evitably in time become lessened in quantity, while its value increases, is to adopt those modes which will most speedily recover the tracts under consideration, and thus prevent the waste of timber which cannot be replaced.

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

VARIATION OF THE MAGNETIC NEEDLE.—*General law relating to magnetism—causes of the perturbations 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 Sables—BERT'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 perturbations 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 affect 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.⁵⁴

The opinion, then is an erroneous one, that mineral must always be present in masses to cause the aberrations of the needle. This is not necessary, nor is it the fact, for those minerals which are deeply buried can have no influence, inasmuch as their influence decreases inversely as the squares of the distance, and it may be said that the needle is wholly indeterminate in their neighborhood in respect to them, "since the resultant of magnetic forces being then vertical," or nearly so, or nothing, "the horizontal element would be nothing."

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

It may be laid down as a rule applicable hereafter in explanation of most of the deviations of the needle which occur in the central and western portions of the state, (there being but few rocks in *situ* that appear on the surface, and those

⁵⁴Professor Farrer.

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

Let us pause here a moment to satisfy the inquirer, who may have doubted even the ordinary correctness of the obser-

vations, 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 have given precision to the examples we have adduced; either the magnetic parallels have become greatly diminished in intensity and accommodated themselves to the plane of astronomical longitude, or care and skill have been exercised to modify the effects produced by them.

The latter condition is the true one, as we shall shortly demonstrate. We begin, then, at a point where the line of no variation passes out of Lake Huron, and first touches the south side of Drummond Island. This island is one of the north-westernmost of the chain of the Manitous which divide the waters of the straits of Ste. Marie. It first touches the island near the meander post on the shore, between ranges 7 and 8 east, in township 41 north, and is the tangent point to a curve of $4\frac{1}{2}$ 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 $3\frac{1}{4}$ 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 $3\frac{1}{4}$ 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 $2\frac{7}{8}$ 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 $2\frac{1}{3}$ miles, crossing the south boundary of the same township, $1\frac{3}{4}$ miles from its western boundary; whence the curve is again reversed, with a radius of $2\frac{3}{4}$ miles, passing off the coast into Lake Huron again, passing over one of the small islands near Massacre island; thence ascending, it re-crosses the south boundary of township 41 north, in range 2 east, between sections 33 and 34; thence curving north-westerly, with a radius of $6\frac{1}{2}$ miles, it crosses the town line between ranges one and two east, $1\frac{3}{4}$ 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, in town 45, range 2 east; thence curving with a radius of $6\frac{1}{2}$ 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 Nebesh 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 Sant de Ste. Marie; thence irregularly over the granite formations, and in conformity to the littoral features of Goulais and Batchewananung 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.⁵⁵

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

The course it would now take in the diminished part of the lake, approaching the straits of Mackinac would be somewhat analagous, it is presumed, to that in the straits of Ste. Marie. This fact is proved from observation, first on the island of Mackinac, on the west, and along the north-east and east shore of the peninsula, south of and opposite Drummond Island. It makes a large curve, which approaches the end of the lake, without touching Mackinac, and receding from it, descends south-easterly to the termination on the coast, of the town line between ranges four and five east, in town thirty-six north, where the variation is $1^\circ 55'$ 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

⁵⁵The hour should be noted as 10 o'clock a. m. for observations on this line.

Presque Isle, it is imperceptible. On Thunder bay point it is 45' east, the line of no variation, passing between the light-house on the outermost Thunder bay island, four miles from the shore, and this point; its course thence is to the outlet of the lake, near Fort Gratiot, where it crosses into Upper Canada.

From the fact that the line of no variation passes through a part of our state, we are in some measure better able to determine the *rationale* of another system of curves found elsewhere on the peninsula, particularly on its western side, at the Great and Little Pointe aux Sable, where a greater 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 $1^{\circ} 10'$ 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, $1^{\circ} 10'$ west; one mile south of Monusco bay, the distance of one and a quarter miles east of it, the variation is 1° west; five miles west, $2^{\circ} 35'$ 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. Burt 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 principal of which was, the definite course obtained of the line of no variation, and the consequent illustration of other lines on either side of it being also irregular; demonstrating a system of curves, and a series of distinct and separate centres of attraction. This has been effected over no very limited space, and is free from all that might be considered empirical.

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

It has been pretty well determined by Professor Loomis, of Western Reserve college, Ohio, that the "present annual changes of variation, caused by the retrograde motion of the needle, which commenced everywhere as early as 1819, and in some places as early as 1793, is about 2' for the southern states, 4' for the middle and western states, and 6' for the New England States." This is true in general of the magnetic lines in this state where they are at a distance from the line of no variation, as at Detroit. Here the decrease or amount of retrograde motion is 4-10' 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 parallellism 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. 3° 24' 30" west, from Washington.

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

1839	Thermometer			Weather		Magnetic variation				
	Day	5 ½ A. M.	1 P. M.	6 ½ P. M.	A. M.	P. M.	Winds	5 ½ A. M.	1 P. M.	6 ½ 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, 53 ½ } { at 6, 58 }	73°	64°	Cloudy	Light showers	N. W.	1° 32'	1° 28'	1° 28'
	16	55°	71°	66°	do.	Some cloudy	W. N. W.	1° 38'	1° 38'	1° 30'
	17	52°	80°	69°	Clear	Clear	W. N. W.	1° 30'	1° 28'	1° 30'
	18	55°	85 ½°	83°	do.	do.	S. W.	1° 28'	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°	82 ½°	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° 40'	1° 23'	1° 36'
	24	72°	86°	77°	Rain	do.	W. S. W.	1° 43'	1° 23'	1° 35'
	25	69°	83°	80°	Clear	do.	N. W.	1° 40'	1° 15'	1° 32'
	26	66°	88°	79°	do.	Cloudy	N. W.	1° 40'	1° 30'	1° 35'
	27	50°	80°	76°	do.	Clear	W.	1° 40'	1° 30'	1° 37'
	28	64°	86°	80°	do.	Showers	W.	1° 42'	1° 24'	1° 30'
	29	66°	87°	78°	do.	do.	W.	1° 41'	1° 21'	1° 30'
	30	69°	90°	79°	Cloudy	Showers	W.	1° 41'	1° 25'	1° 33'
	31	62 ½°	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 statute⁵⁶ 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,

⁵⁶Part first, title second, chapter third, section sixty-nine, revised statutes. In all surveys made as aforesaid, the course shall be stated, according to the true meridian, and the variations of the magnetic meridian shall also be stated, with the day, month and year.

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

it is obvious that time must be devoted to an observation of some star to obtain the variation, if it be a clear night, or if otherwise, the survey must be suspended until a more favorable time. Besides all this, his pay is fixed at a stated price per-mile, and that price barely a compensation. Now, either to make the business desirable, and at the same time to fulfill the conditions of the law, he must have a ready method of getting the variation, or must spend his time in so doing, without an equivalent for his labor; and while the law remains as it is, no instrument besides the solar compass can enable the surveyor, with profit, completely to fulfill the intent of the statute.

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

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

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

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

ELEVATION AND DEPRESSION OF THE WATER IN THE GREAT LAKES—*the maximum for 1838, 1839, and 1840—lowest stages of water of longer continuance than the higher stages—evaporation—semi-annual alternations—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 ratio 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, in as much as they have no equalizing under-currents.

The quantity of rain must have been much less, and the evaporation more, than for many years past, to have produced the decrease mentioned below. This decrease amounts in the first year to one-quarter of the total rise, and in the second to

one-half, making the proportion each year as thirty-three to forty-four nearly.

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

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

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

33 inches; evaporation will reduce it to 44 inches, when fully exposed to the sun and air. One season of extreme drouth would, upon the expanse of these lakes, produce an extreme depression, while the contrary would have the effect of producing a corresponding rise. It cannot be a matter of so much astonishment that such expanded areas of water, subject to such influences, should be greatly affected; 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

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 foilage waves over the tall grass beneath, and which borders the very margin of this timbered belt, at times receding like deep indented bays, and again projecting in detached islands, and peninsula points, not unlike the meanders of an actual arm of the sea or lake—the level grassy surface being substituted for their waters.

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

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

those islands, bays, and peninsula points we have alluded to, to give an indescribable beauty to the landscape.

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

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

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

The benefit of these marshes to the country, consists not altogether in their picturesque and verdant appearance, or in the rural charm with which nature clothes them, so far from being practically useless, they, in 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 exten-

sive 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 reproduced, 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 of some travelers from London, on their journey to the north, who, on arriving at Dumfriesshire, 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 of technical terms used in this report is omitted here, being practically a duplicate of that printed after Bela Hubbard's report dated Jan. 26, 1839. See ante.

REPORT OF THE STATE GEOLOGIST RELATIVE TO THE COUNTY AND STATE MAPS

(*House Documents, 1841, No. 35*)

OFFICE OF STATE GEOLOGIST, }
Detroit, February 4, 1841. }

To the Speaker of the House of Representatives:

Sir I have the honor to acknowledge the receipt of a resolution from the house of representatives, calling upon "the state geologist to furnish a statement of the forwardness of the maps in the topographical department, saying what maps are finished and what are unfinished, and at what time a copy of the state map can be furnished to the members of the house.

The above resolution, which I suppose to have been intended to elicit general information with respect to the topographical maps of our state in progress, may be most conveniently answered by a consideration of the subject under three somewhat distinct heads, viz:

First. The state of forwardness of the field work.

Second. The condition of the work in the drafting office, and

Third. The progress which has been made in the engraving and publication.

In order that the relation which these several portions of the work bear to each other may be clearly understood, it may not be misplaced to allude briefly to the several relations which the officers of the two departments bear to each other, together with their separate duties.

It should be borne in mind, that the act of 1836 and 1837, which directed a geological survey of our state, did not include either a topographical survey or the projection of any map excepting such as were strictly of a geological character. As the work progressed, it was found that those who were engaged in the geological surveys could, by the addition of the necessary duties, carry forward not only a geological, but also a topographical survey of the state, and without any very considerable additional expense, excepting the salary of a draftsman or topographer. Since the services of a draftsman would be required more or less in the geological department, it was deemed to be for the best interests of the work, to add to the department an officer to perform those duties, and at the same time to direct the preparing of county maps for future publication. This step was taken by the honorable legislature, during the session of 1837 and 1838.

It will thus be seen that the topographical part of the department consists simply of a draftsman, who never engages in field work, and whose duties are wholly confined to reducing to form, the field notes as returned by the several officers of the geological department proper. The topographical part of the work is, therefore, completely dependent for all materials, upon the geological department, or in other words, the two duties, although nominally distinct, are performed by the same persons.

The above remarks, it is conceived, will sufficiently explain to you the reasons for the consideration of the subject under the three heads.

1. *The state of forwardness of the field work.* That portion of the labor connected with the construction of accurate topographical maps, which involves the principal duties, requires the longest time for its accomplishment, and upon which the value of the maps, for accuracy and fullness of detail, must depend, has wholly to be performed in the field; and until the field work is fully completed, the final drafting and publishing of these maps would be comparatively of little value, nor for the interests of our people or for the credit of the state, as well as those engaged in the work, should it be required. In other words, it should be the desire of all, that those plans be fully carried out by which these maps may be made to possess as great a degree of accuracy as the nature of the work will admit.

The field work in all the counties, of which it is proposed to publish separate maps, is very nearly brought to a close, but there are portions of some of the counties, which still require a considerable amount of labor in the field, before they can be safely published. This is more particularly the case in several of the counties east from the meridian, and has arisen from the fact, that in consequence of the very erroneous manner in which the original United States surveys were made, in a portion of the country east of the meridian, the topographical duties have so far increased as to render it impossible for those engaged in the work, perfectly to accomplish both works at the same time. Added to this, the intricacy of the work in the border counties, upon the east, is vastly increased by the constant succession of "old land claims".

Of those counties of which there is field work still to be done, the principal are Monroe, Wayne, Macomb, St. Clair, Oakland, Lapeer, Genesee and Saginaw; in addition to which, there are occasional townships in the more western counties, not yet completed.

2. *The condition of the work in the drafting office.* The topographer has drafted, so far as the same can be done, all the field work returned up to the commencement of the last year, as also much of that which has been returned for the year 1840. The topographer will be enabled to furnish drafts of those counties in which the field work is completed, more rapidly than the engravers will be able to complete their portion of the work, at the same time that the topographer will be enabled to progress steadily in bringing up the other unfinished drafting which is now before him to be done.

3. *The progress which has been made in the engraving and publication.* By an act approved March 28, 1840, a sum "not exceeding two thousand dollars was appropriated for the purpose of" publishing a "map of the state and the several counties therein, as the manuscript maps of the same shall be completed", &c.

The second section of said act directs that the "said money shall be expended under the direction of the state geologist, in the employment of an engraver or engravers, and in the purchase of the necessary implements and materials, or in the contracting for and engraving of plates for maps", &c.

The third section of said act provides that the state geologist "shall cause to be executed and published, a map of the lower peninsula, as soon as practicable *after* the completion of the United States survey", &c.

And the fourth section of said act directs the disposition which shall be made of the maps when published, and the manner in which the same shall be done.

In order to carry out the instructions contained in said act, I visited, with as little delay as possible, the principal establishments for map engraving, in Washington, Philadelphia and New York, and after careful examinations in each of these cities, I made a conditional agreement with Mr. Stone, of Washington city, who is the chief engraver of the United States topographical bureau, and whose work is believed to be unexcelled by any in our country. Mr. Stone as well as all

those to whom I made proposals, was unwilling to make any permanent arrangement for the engraving of so large an amount of work, until, he had engraved at least one of the county maps, and I was unwilling to do so, until I had seen specimens of his engraving upon the character of the work which was to be done.

Under the conditional agreement which was made, I forwarded Mr. Stone, immediately upon my return to this city, a map of Lenawee county, with directions to have proof forwarded me so soon as the engraving should be so far advanced as to permit it. The map had scarcely been forwarded, when I took my departure for Lake Superior, and during a space of something over five months, I had no means of communication with either the topographer or Mr. Stone; the result of which was, that during this time no further action could take place. The county was in that time engraved, and the first proof corrected and returned to Mr. Stone, immediately after I reached Detroit, on my return from Lake Superior; with which proof I also forwarded maps of the counties of Washtenaw, Jackson and Calhoun, the engraving of which, as I learn from Mr. Stone, has been nearly completed, but of which no proofs have yet been received. The counties of Hillsdale, Branch, St. Joseph, Cass, Berrien, Kalamazoo, Ingham and Eaton, are in such condition, as that the matter can be furnished more rapidly than the engraving can be faithfully executed.

The difficulties and embarrassments connected with these publications, if the work be well done, are very great, and the most careful, minute and repeated corrections of the proofs are required, all of which require time and labor; for unless this be done, the maps will be little less than a bundle of errors.

Mr. Stone writes me that he will be able to furnish the proof of one county, for each two or three weeks, which will enable you to judge of the progress which can be made in the work. He says, at the same time, that he is desirous to keep the several persons who are engaged upon the separate por-

tions of the same map as steadily at work as possible, in order that they may preserve a perfect uniformity of style, and, as he quaintly expresses it, "keep their hand in".

The third section of the act, authorizing the publication of these several maps, directs a state map of the lower peninsula to be published as soon as practicable *after the completion of the United States surveys therein*. Although the United States surveys are not yet complete, (for which reason the present publication of the state map would be contrary to the *express instructions* contained in the act referred to,) I have nevertheless caused to be projected, upon the scale contemplated by said act, a state map of so much of the peninsula as the present condition of the United States surveys would permit. In order to accomplish this, I have been compelled to send to the general land office, at Cincinnati, Ohio, for a perfect transcript of all those surveys which had been drafted, but not yet returned to the several land offices of Michigan.

This state map has been drafted from the township plats that have been carefully filled up, and corrected, during the progress of the geological survey, and will, I trust, prove minutely accurate. The draft of this map now extends to the north boundary of township thirty-one north, and with the exception of some few important data, not yet received from the general land office, the materials are on hand for the completion of the whole map, with the exception of thirty-three townships in which the United States surveys are not yet completed. These United States surveys, will, as I am informed, be completed early in the coming spring.

The time requisite for the engraving and final correction of the proof of this map, will probably not be less than three months, and although it is desirable that what has already been drafted should be forwarded to the engraver at as early a day as possible, I am deterred from so doing for the reason that the engraving of the state map, added to the several county maps which are in readiness to go forward, will involve liabilities exceeding the amount which has been placed at my

disposal for that purpose. Under this contingency, and even doubting whether in the strict letter of the act, I would be authorized in commencing the engraving of the map in question, until the United States surveys are completed, I have determined to await your pleasure upon the subject.

So fast as the several maps are completed, it is proposed to present them to the public for sale, and there can be no doubt, if the whole be judiciously conducted, that they will yield a very handsome return of profit to the state. But, in order to do this, the same careful economy must be pursued that an individual would pursue under similar circumstances. All purchases of materials should be made in quantity, and the paper, which will be the greatest item of expense, should not only be purchased of the manufacturer, but should also be purchased in quantity sufficient for the entire work. This will not only insure uniformity of appearance, and prevent disappointment from the use of an inferior article, but will also save some 30 per cent of cost. Stocks of paper, of the kind required, of a uniform quality, and in sufficient quantity, could scarcely be obtained in any of the cities of our United States, and the engraver advises as a matter of economy, that the paper be *manufactured* to order.

A map of the southern peninsula of our state, cannot, under any circumstances, be in readiness short of three or four months from the time the draft is placed in the hands of the engraver, and in that event the map would be defective in the thirty-three townships before mentioned, which, by a delay of some eight or ten weeks farther, might be added.

Since the act authorizing the publication of these maps does not direct in what manner I shall communicate with the honorable legislature in relation thereto, I have taken the opportunity offered by the resolution from your honorable body, to answer those inquiries somewhat more at length than the resolution would seem to call for, and in order to embrace the whole in one communication, I will simply add that of the amount which has been placed at my disposal for the above

purposes, I drew from the treasury, on the 14th day of November, 1840, and sum of \$500, of which sum, but a small portion has as yet been expended, and that the remaining \$1,500 has not been drawn from the treasury.

All of which is respectfully submitted.

DOUGLASS HOUGHTON,
State Geologist.

1842

REPORT OF THE STATE GEOLOGIST RELATIVE TO THE STATE SALT
SPRINGS

(*House Documents, 1842, No. 2*)

OFFICE OF STATE GEOLOGIST, }
Detroit, January 5, 1842. }

*To the Honorable Senate and House of Representatives of
Michigan:*

I have the honor to lay before you the accompanying statement of the progress which has been made in improvements at the state salt springs, since the date of the last report, from this department on that subject.

In conformity with the provisions of a joint resolution of your honorable body, approved March 6, 1841, relative to the improvement of the state salt springs, (see joint doc. 1841, pages 235 to 254,) the contracts to which said resolution refers were fully confirmed, and the work, which for a space of more than eighteen months had been arrested, was again commenced, and up to a very recent day has been continued according to the provisions of the contracts.

At the salines on Grand river, Kent county, the work so far as contracted for was completed and accepted on the 23d day of December last. The work consisted of the furnishing a cast iron tube, having a diameter of nine inches, and sinking the same to the surface of the rock at a depth of 40 feet; and of 260 feet of rock boring, making the entire depth of the well 300 feet.

At the salines on Tittabawassa river, Midland county, where the amount of earth boring was originally computed at 100 to

150 feet, very great difficulties and embarrassments have been encountered in sinking the iron tubes, in consequence of the character of the materials passed through, and the contractor, after a space of nine months of continuous labor has only been able to reach a depth of 139 feet.

The character of improvements required for developing the salt deposits of our state, have been so fully laid before you in the several reports from this department, that it is scarcely necessary again to call your attention to this subject, except to refer to the fact that, to render these works fully available, it will be indispensable to continue the borings until the shafts shall have passed very nearly through the lower salt rock, for it has already been stated that water possessing the maximum strength cannot be looked for in the upper deposits. At the point selected for the state well on Grand river, it is estimated that the shaft should be sunk to a depth of seven hundred feet, and at Tittabawassa river to a depth (in round numbers,) of six hundred feet.

At the state salt springs on Grand river, the upper salt rock has been perforated and an abundant supply of salt water flows from it, but since there has been no expectation of obtaining water of sufficient strength to rest upon from these upper rocks, there has been no attempt to separate the salt water from admixture of fresh springs, by tubing or otherwise. The amount of salt water flowing naturally from the nine inch tube of the state well, when the borings had been carried to a depth of three hundred feet, was shown, by *actual measurement*, to be one hundred and thirty gallons per minute, an amount almost incredibly large, and unequalled by any rock boring within my knowledge, in any *other* portion of the United States.

The salt water thus discharged, though much reduced by the influx of fresh springs, nevertheless contain a larger proportion of salt than could have been reasonably looked for at this depth; an amount which, were it properly separated from admixture with the fresh water springs, would be considerably

more than that contained in the water originally used for the manufacture of salt in the great salt district of Kanawha, Va.

A careful analysis of this mixed water, taken when the state well had been sunk to a depth of 235 feet, shows that one hundred and ten gallons and a half, nearly, of the water, contains a bushel of salt.⁵⁷ No analysis of the water of this well has been made since it has been sunk below the depth above given, but admitting the amount of salt in it to be no greater at 300 feet than at 235 feet, the water which is discharged contains an amount of salt very far beyond what could reasonably have been looked for, and which if properly separated would be amply sufficient to supply the present population of the entire western portion of our state.

These facts alone, it is conceived, are sufficient to sustain the original position assumed relative to the salt deposits in this portion of our state; but there are still further proofs of the correctness of these estimates, for during the time that work upon the state reserves was suspended, individual enterprise was directed to a determination of the same subject. At a point about three miles distant from the state salt well, Hon. Lucius Lyon commenced boring upon private lands, and after an unremitting labor of eighteen months succeeded in reaching a depth of 661 feet. In boring to this depth the well has passed through the upper salt rock, the intermediate fresh rock, and into the lower salt rock, and although the boring has not yet been carried to a sufficient depth in the lower salt rock, there has nevertheless been a good supply of salt water obtained, and this of a quality which when freed from the admixture of fresh water, from the upper springs, by tubing, will admit of the profitable manufacture of salt.

The amount of water discharged from this well, although it has not been determined by actual measurement, may be estimated to exceed in quantity that discharged at the state spring. The salt water from Mr. Lyon's well is very largely

⁵⁷I deem it unnecessary, for the purpose of the present report, to give details of the entire composition of the waters from the several springs referred to.

mixed with fresh water which enters in springs, from the immediate fresh rock, and the partial tubing which has thus far been done, has not, I conceive, been sufficient to prevent its reducing the maximum strength of the brine very considerably.

A jet of water flowing from this well is so great as to render it nearly impossible to sink any vessel, unconnected with drilling poles to such a depth as to procure brine free from fresh water of the upper springs, and in order to procure water as concentrated as circumstances would permit, for analysis, an open tube, of a diameter considerably less than the well, was sunk to a depth of 415 feet, and, the upper end of the tube (at an elevation of about 15 feet above the point where the boring was commenced,) was closed with a faucett, which was afterwards opened and turned so as to permit a discharge of three hundred gallons of water per hour, by measurement, and from this, water was obtained for analysis. Of the salt water thus obtained about eighty-two and a half gallons contain a bushel of salt.

At the salt well on Tittabawassa river, where as yet the boring has been confined to earth, or alternating strata of clay, sand, gravel and bowlders, with which were mixed fragments of coal, the character of the water has undergone considerable changes as the tube which was sunk passed through the several strata furnishing the water. Thus at one time the water would be nearly free from, and at another very much impregnated with saline materials. At the last dates, and when the well had reached a depth of 139 feet, every 221 $\frac{1}{3}$ gallons contained a bushel of salt. At a depth of 98 feet the water contained about one-fourth more salt than at 139 feet, but by sinking the tube all the springs excepting that at the very bottom of the tube have been shut off.

The above statements relative to the well on Tittabawassa river are made simply for the purpose of exhibiting the state of forwardness of the work, and it should be borne in mind, as has been stated in previous reports upon this subject, that no

salt water of very considerable strength can be expected from simple earth boring.

In referring to the amount and character of salt water discharges from the several wells to which reference has been made, it should be recollected that the prevalent opinion that this is simply an increase of the water formerly discharged from springs at which the improvements were commenced, is wholly incorrect, for at neither of the points where these borings have been made was there any spring apparent upon the surface previous to the sinking of the wells.

To enable you to compare, in a satisfactory manner, the strength of the salt water from several of the salt districts of our country, with that already obtained in this state, the accompanying table exhibits the number of gallons of water required for the manufacture of a bushel of salt in these several districts; but in comparing these, it should be borne in mind that with the salt wells of New York, Ohio and Virginia, a long series of years has been required to procure water of the strength exhibited, and that the wells in Ohio furnishing the water referred to, are sunk to a depth varying from eight hundred to one thousand feet. The fresh water in these wells has been completely shut off, while the salt water from the wells of Michigan is reduced by the influx of a very large amount of fresh water, that there has as yet been no attempt to exclude. And again, it should be recollected that the borings in our state have not yet reached a depth at which we should look for salt water of a maximum strength. In the well of Mr. Lyon, this point has already been so nearly reached, that water of sufficient strength has been obtained to be profitably used for the manufacture of salt, and which, when separated from the upper fresh springs, by tubing, will without doubt considerably exceed that used in the great salt district of Kanawha, Va., in 1834.

	41 to 45 gallons of water	
At the best salt wells in New York	give a bushel of salt.	
do salt wells of Kanawha, Va., (average,)	70	do
do salt wells on Muskingum river, O.,	50	do
do springs on Grand river, Arkansas,	80	do
do Lyon's salt well, Grand river, Mich., at 66 ft., (fresh water not separated,)	82½	do
do state salt well, Grand river, Mich., depth 239 feet, (fresh water not separated,)	110½	do
do state salt well, Tittabawassa river, Mich., earth boring, 139 feet,	221½	do
do Conemaugh, Pennsylvania,	300	do
do Nantucket, (sea water,)	350	do

Since the fund appropriated to the improvement of the salt springs is not disbursed by the department over which I am placed, any particular reference by me to the condition of the appropriation would be uncalled for. Under the provisions of the contracts before referred to, I have certified to the performance of an amount of work by the contractor at Grand river, sufficient to cover the sum which was directed to be expended at that point. Of the amount set apart for the improvement of the springs on Tittabawassa river, there remains in the treasury the sum of \$2,586.57, not covered by estimates.

The improvement of our state salines has now, it is conceived, progressed so far as to satisfy the most skeptical, who will examine the subject, of eventual perfect success, and under these circumstances, it is hardly necessary to call your attention to their great importance, or the necessity of a speedy completion. At Grand river, the work is now in such a state of forwardness, and the machinery in such condition, that if continued without interruption or unforeseen accident, it may be completed early in the coming summer, and at a comparatively small expense; but if the work, at this stage, be delayed, a very considerable additional expense will be in-

curred. The work at the well on Tittabawassa river cannot be completed at so early a day.

The plan which was adopted by your honorable body, of contracting for the work to be done at the salines, has been productive of good effect; but while I would recommend a continuance of this plan, there should be some provision made for such contingent expenses as may from time to time arise. During the time that the work on these springs was lying still, a space of eighteen months, I was compelled to keep men in employ to preserve the machinery, &c., from destruction, and to provide means for their subsistence and compensation, and by the provisions of the act directing the letting of the contracts, I was required to advertise for proposals, have contracts drawn, &c., for the expense of which sufficient provision was not made; and now that the contract for that portion of the work contracted for at Grand river has been completed, I am held responsible for the preservation of the property, without the power to apply a dollar to that specific purpose, and would respectfully ask your direction in the matter. So also it has been necessary in order to secure some portions of the works from danger of destruction, to do several items in the way of repairs, which were not included in the original contracts, and to which no part of the appropriation could be applied. Nothing of this kind has been done which could with safety be avoided, and nothing but what would have subjected me to just censure had I omitted to have done. For these accounts, though the sum be small, provision should be made, together with instructions as to the disposition that shall be made of the springs when the work is carried to completion.

DOUGLASS HOUGHTON,
State Geologist.

REPORT OF THE SELECT COMMITTEE, IN RELATION TO THE REPORT
OF THE STATE GEOLOGIST*(House Documents, 1842, No. 19)*

The select committee to whom was referred the report of the state geologist, would respectfully report:

That your committee have had under consideration the several subjects referred to in the report of the state geologist, together with the condition of the geological survey of our state, and are happy in being able to say, that the field work, together with the drafting, and other parts of the survey upon the plan originally contemplated, are nearly completed; and that the point is now nearly reached when these labors may be laid before the public. It will be seen by reference to the report of the state geologist, that the duties required to be performed by the assistants in the survey, has been so nearly accomplished that all those engaged in the work have been discharged excepting the topographer and draftsman, and it is estimated that the amount of surveys required to close up detached portions of the work, together with the chemical analysis and drafting, may be accomplished by the geologist and topographer, without further assistance during the current year.

It further appears that the fund applicable to this object has been exhausted, a circumstance attributable in part to a diversion by the legislature, of a portion of the funds to objects not legitimately belonging to the geological survey. In order to reap the full benefit which it is conceived will be derived from this work when the details are made public, your committee deem it indispensable to the best interest of the state, to make such provision for the completion of the works as the circumstances may require, viz: an amount sufficient to cover the salaries of the geologist and topographer, together with the incidental expenses of the office.

The committee have also had under consideration the subject of the publication of the maps of the several counties referred to in the report of the state geologist, a subject which your committee consider of deep interest to the citizens of our state. It appears that the publication of these maps has been delayed in consequence of the difficulties connected with the remittance of moneys to the engravers and paper makers; but these obstacles, we are informed by the state geologist, he hopes to overcome at an early day, for which reason no legislation will be required upon this subject.

In the opinion of your committee, the geological department has discharged its various and complicated duties in a highly satisfactory manner; and the disbursements of the different appropriations made for the prosecution of the geological survey, has been made with a wise and judicious economy which forms a pleasing contrast with most of the expenditures in other departments of the state.

The unfinished maps of the different counties alluded to, will, when completed, contain the most desirable information, and give a minute description of every section of land; the measured length of every fractional line; the exact course of every meandered and other streams, defining the boundaries of all swamps and marshes, designating the oak openings, prairies and timbered lands, and the more prominent ranges of hills. Also, an index to all beds of marl, peat, coal, sand and limestone, gypsum, iron and other ores, with a profile of each town and county above the levels of lakes Huron and Michigan, besides many other descriptions not found upon any previous engravings, and more minute, perhaps, than is found upon the maps of any other country.

The importance of a small appropriation for the completion of this work, was made sufficiently manifest to your committee from the fact that in addition to the revenue which the treasury will receive from the sale of these maps, they may be completed and published by some individual for his personal benefit, and thus deprive the state not only of the money which it

has already expended, but of one of its few remaining sources of income.

In conclusion, your committee would submit the following resolution, making the necessary appropriation for the completion of the geological survey, and embracing a remuneration to the state geologist for his services as superintendent of the state salt springs, a labor which belongs not legitimately to his official duties as state geologist, but which he has heretofore performed without any compensation.

Resolved, That the committee on ways and means be instructed to include in their general appropriation bill, the sum of twenty-two hundred dollars for the completion of the geological survey, and for the supervision of the state salt springs.

F. C. ANNABLE,

Chairman of Select Committee.

ANNUAL REPORT OF THE STATE GEOLOGIST

(Joint Documents, 1842 No. 9)

OFFICE OF STATE GEOLOGIST, }
 Detroit, January 25, 1842. }

To the Hon. Senate and House of Representatives of Michigan:

I have the honor to lay before you the accompanying report, relative to the progress which has been made in the geological and topographical surveys of our state, since the date of the last report from this department. In this communication my remarks will be confined almost exclusively, to the condition and wants of the department, leaving the details of what has been accomplished for the final report, upon the whole work.

During the current year the geological and topographical surveys have progressed steadily toward completion, though in consequence of the reduction of the number engaged in the work, which became necessary in consequence of the compara-

tively small amount of funds applicable to that object, the amount of work accomplished has been somewhat less than that of the preceding year. The labor so applied has been chiefly devoted to the westerly portion of the upper peninsula, including a part of that which may be designated as the mountainous district of our state, while the smaller portion of the labor has been directed towards the closing up and completion of the surveys upon the lower, or southern peninsula.

In connection with duties assigned me relative to the boundary line between our own state and Wisconsin, I have been enabled to complete a very perfect Geological section of nearly 180 miles in length, crossing from the mouth of Montreal river of lake Superior, to the mouth of the Menominee river of Green Bay, a district highly interesting both in its geological and topographical features. This section crosses the upper peninsula somewhat further west than any of the sections I have heretofore made.

In addition to this a large amount of work has been performed in the mountainous region stretching from Montreal river to Ontonagon river, and extending southerly from lake Superior, a distance of some forty miles, including what may be termed the *westerly* portion of the copper district, within our state. This district had been but partially examined the preceding year, the examinations of that year having been more particularly directed to a district of country lying east from it.

Several geological sections have been completed across this intricate region, and notwithstanding the many obstacles imposed by the mountainous and wild character of the country, the surveys of this district have been completed with as much minuteness as an adherence of the original plan of the survey would permit. In addition to the several geological sections completed, all the rivers entering lake Superior between and including the two streams mentioned, have been carefully examined to their very sources, and the Porcupine mountains have been traced out through almost their entire range.

These surveys of the westerly part of the upper peninsula have added much valuable information to that before collected respecting the geology and topography of that interesting portion of our state, and have served to add confidence to our previously expressed opinion respecting its value for its minerals and for agricultural purposes. The *general* geological and mineralogical character of this country was so fully given in a previous report, that it is not conceived to be necessary, at this time, to make further allusion to it, except to add that the copper ores associated with the altered conglomerate and sandstone rocks, in *this* portion of the range have been found to be more extensive than was originally supposed. In character these ores closely resemble those heretofore described as existing in the Keweena [sic] point range; but associated with these ores, or in the rocks of the immediate vicinity, several minerals have been found in abundance, which have been comparatively rarely noticed in other portions of the range. Among these are prehnite, stellite, lomonite, heulandite, harmotome, &c., the first mentioned having been noticed in veins varying from 16 to 18 inches in thickness.

The *southerly* range of mountains traversing the upper peninsula, and which in a previous report has been referred to, as commencing a point a little north-westerly from the mouth of Chocolate river of lake Superior, has been found to be continued in a south-westerly direction, with a gradually diminished altitude across the Menominee river of Green Bay, into the territory of Wisconsin. This chain of mountains through a portion of its course has a direction nearly parallel to that of Green Bay, and frequently approaches to within 25 or 30 miles of the coast of that bay. It will be recollected that the northerly portion of this mountain range was described as being composed of sienitic and gneissoid granites, flanked to the south by mica, talcose and chloritic slates and quartz rock, the separate members of the group being frequently traversed by dykes of trap, and with occasional knobly hills of the latter rock. Presque Isle of lake Superior, made up of trap and

altered sandrock, in which rocks were found numerous small ramifying veins of the sulphurets of lead, copper and iron, was referred to as a portion of this mountain range.

This southerly chain of mountains, with its hills and dykes of trap, though the elevation in a south-westerly direction is considerably lessened, preserves very nearly similar geological characters to that portion before described, and the rocks, in the vicinity of the trap, were frequently found to contain similar minerals to those observed in the vicinity of lake superior. The direction of this range is such as to leave no doubt but the low knobs of syenitic granite in the vicinity of Puckaway lake of Fox river, and the more elevated knobs of trap and altered rock lying a short distance to the north, in Wisconsin, belong to the same system of rocks, and since the hilly district of the Wisconsin river would fall within this range, it may be fairly inferred that the disturbance of the stratified sandstones and limestones of this region may have originated from the same causes which have produced the more elevated mountains on the south of lake Superior.

This subject possesses a high degree of interest, from the fact that within the limits of this range would fall the lead district of Wisconsin and Iowa, and this inference is rendered the more probable from the remarkable similarity in the character of the contained minerals.⁵⁸ Thus far I have been unable to trace any portion of the great limestone formation of the upper peninsula, to any near proximity to this range, where the same traverses that portion of Michigan, and thus far in tracing the range westwardly no considerable deposits of lead have been found until the lower rocks are covered by heavy deposits of limestone; which would lead to the inference that these upper deposits have performed an important part in *arresting* and *fixing* the minerals referred to, and which

⁵⁸It should be recollected that the outer or northern range of mountains of lake Superior constitutes what has been called the true copper district, and that in this district no lead and none of the ores of which sulphur is a constituent, have been noticed, while in the southern range, in Michigan, the ores are almost entirely sulphurets, and lead occurs more abundantly than copper.

minerals may fairly be inferred to have had their origin from the lower rocks, to which reference has been made. If the position thus assumed be tenable, we can scarcely look for heavy deposits of lead within that portion of the southerly range of mountains traversing the upper peninsula of Michigan, for the reason that the upper formations are wanting, at least they are so through all that portion of the district that has been minutely examined.

In the surveys of the upper peninsula east from Chocolate river, I have derived very great assistance from Hon. Wm. A. Burt, who, during the last two years has been engaged in surveying the United States township lines, for through his kindness I have been enabled to locate and determine, much more minutely than could otherwise have been done, the range of the several rock formations over a very large district of country.

The field work of the geological and topographical surveys, upon the plan originally contemplated, is now mainly completed, on a few detached portions remaining, where points have not been sufficiently settled, and since the completion of these will not require the service of assistants, the board has been so far reduced that there now remains attached to the survey only the assistant in the topographical department.

Although, as has before been stated, the amount of field work remaining to be done is comparatively small, there still remains much to be done, in arranging the materials accumulated, for a final report upon the entire work. For the chemical analysis there was originally no provision made, and this duty which in the geological surveys of most of the states has been performed by a distinct officer, in this state has devolved upon the principal of the survey. Heretofore the press of business in the other departments of the survey has prevented a proper attention to the analytical portion of the work, much of which is still unfinished and will require a considerable amount of labor for its completion.

The drafting from field notes, returned from the geological survey proper, has progressed as rapidly as circumstances

would permit, but since in the topographical department there has been only a single assistant, the amount of drafting has continued to accumulate upon his hands, and there yet remains an amount to be done which can scarcely be accomplished in an entire year.

The fund applicable to these objects is now absorbed, and there will be required for the completion of the limited amount of field work, drafting, analysis and contingent expenses, a small appropriation.

By an act of the honorable legislature, approved March 28, 1840, the state geologist was directed to "cause to be published a map of the state, and of the several counties therein," and the sum of two thousand dollars was appropriated to that object. Immediate steps were taken for carrying out the provisions of this act, and most of the separate organized counties of the state have been drawn, upon a scale of four miles to the inch, and are now ready for the engraver. Of these, six counties have been engraved, viz: Hillsdale, Lenawee, Branch, Calhoun, Jackson and Washtenaw, and the maps would have been thrown before the public, as fast as the engraving would permit, had not the condition of the treasury made it impossible for me to place funds in such shape, without submitting to a rate of discount which would be unwarrantable, to enable me to procure the materials necessary for the publication. Had these circumstances not prevented, in addition to the counties before mentioned, those of St. Joseph, Cass, Berrien, Monroe, Allegan, Kalamazoo, Van Buren, Oakland, Livingston, Ingham, Eaton, Barry and Shiawassee, would all, or nearly all, have been published before this date.

By the act authorizing the publications referred to, "the state geologist, auditor general, and state treasurer, are authorized to adopt such measures for the sale and distribution of the maps as to them may seem expedient," and it is confidently believed that the sales of the same will speedily replace in the treasury the amount which may be drawn for their publication. Under whatever circumstances this sub-

ject may be viewed, it is deeply to be regretted that the amount appropriated for this purpose cannot be realized in such a way as to secure the publication at once, for it is conceived that the best interests of the state call for a dissemination of the information which these maps contain, and that this should be done as speedily as possible.

No portion of the fund set apart for the publication of maps has been drawn since the date of my last report upon *this* subject, and there remains in the treasury, applicable to that object, the sum of fifteen hundred dollars.

Under the provisions of a joint resolution, approved February 2, 1841, I was instructed by the executive of the state, to act as commissioner upon the part of this state, in relation to the boundary line between Michigan and Wisconsin, and this duty has been performed so far as circumstances would permit the same to be done. The resolution, which contemplated the performance of this duty by the state geologist, made no provision for such expenses as would be incident thereto, and, in consequence, it became necessary, in order to carry the provisions of the resolution into effect, to divert a portion of the funds set apart for the geological survey, to that purpose. In addition to the injustice which is thus done in charging to the account of the geological survey, expenditures which do not legitimately belong to it, the effect has been to absorb an amount which was absolutely required for the operations of the department.

All which is respectfully submitted.

DOUGLASS HOUGHTON,
State Geologist.

1843

ANNUAL REPORT OF THE STATE GEOLOGIST

(*Joint Documents, 1843, No. 8*)

OFFICE OF STATE GEOLOGIST, }
Detroit, January 31, 1843. }

To the Hon. Legislature of Michigan:

I have the honor to submit the following report of the condition of the geological survey of our state, and the progress which has been made towards the completion of the same.

Since the date of my last report, upon this subject, I have been chiefly engaged in arranging and putting in shape, the immense amount of details, both geological and topographical, which have been accumulated during the progress of this work; in analyzing and studying the immense collection of specimens illustrating the geology and mineralogy of our state, a large portion of which specimens had remained unopened until the past summer; and in the chemical analysis of our soils, minerals and rock specimens. This work, preparatory to the final report upon these subjects, involves a much larger amount of labor than had been estimated, a labor which no one, unless intimately connected with this work, could fully appreciate.

In addition to the office work above mentioned, a small amount of field work has been done, consisting chiefly, of closing up and connecting points where the work was incomplete.

The field work for the entire survey is completed, with the exception of some few points where the work still wants connecting, and which will not involve any material expense.

The work in the topographical or drafting office, during a portion of the year, was suspended, in consequence of the

absence of the topographer, who was engaged for several months in "locating" lands for the state. Notwithstanding this delay, a large amount of drafting has been accomplished, and that portion relating strictly to the topographical survey, is so far advanced that a very large portion of the work is now ready or may soon be made ready for the hands of the engraver. There remains in addition to the amount of drafting yet to be done for the topographical and geological maps, a very considerable amount of drafting, such as geological sections, &c.

The publication of the state and county maps, as directed by the legislature, was long ago commenced, and the engraving of several of these maps had been completed before the date of my last report, but the inability to procure such funds as would enable me to purchase paper for striking them off, has caused much delay in the publication, and in fact for a time virtually suspended all action upon this subject. Notwithstanding this embarrassment in procuring such funds as could be applied to this purpose, such arrangements were made as led me to hope that I would have been enabled, before this time, to lay before the public, for sale, according to the provisions of the act directing the publication, an edition of 1000 each of six of our most populous counties. The reception of these maps was prevented by the early closing of navigation, and although such arrangements had been made as led me to hope they would be transmitted by the overland route, they have not yet come to hand.

This series of state and county maps, it is hoped and believed, will be more full and perfect than any which have heretofore been published, of any equal portion of our United States; and there can be no doubt but when once spread before the public, showing as they do the general character of soil, timber, &c. &c., they will do much to disseminate a knowledge of the immense capabilities of our state, and the advantages which she offers to the emigrant; and that they will in that way afford efficient aid towards increasing her population.

The delay which has occurred in the publication of these maps has been a source of deep mortification and regret to me, but circumstanced as I have been, it has been utterly out of my power, until within a few months past, to make such arrangements as would enable me to move forward with the work. When the maps already engraved shall have been thrown before the public, it is hoped and believed that a sufficient amount will be received from their sale, to enable me to proceed with the engraving and publishing of the balance without further embarrassment, and that they will more than pay the expenses incident to their publication.

The selection by the state of extensive tracts of land in some of the newer counties, and proposed early disposition of these lands by sale, renders it highly important that maps of the counties where these selections have been made, should be completed at the earliest day possible; and I have made arrangements to carry this into effect. Although the older counties have legitimate claims for the first publication of their county maps, it is conceived the interests of the whole state will be advanced by the course proposed.

The engraved plates of these maps will remain nearly as perfect after the proposed edition shall have been worked off, as they were at first, and as other editions may, from time to time, be wanted, the names of newly organized towns, new roads, &c., may be added without difficulty, and at an expense nearly nominal.

I deem it unnecessary, at this time, to lay before you the details of work done, or to give further description of portions of our country which have been passed without notice, in the very general reports which have heretofore been made to you, for I hope in due time to offer a final and systemized report, that shall embrace, in a condensed form, all that has been accomplished.

The geological and topographical surveys of our state which have been carried forward by a corps, few in number compared with that furnished by many of the other states, and

extending as it does over an area greater than that claimed by any of them, has been a work of immense labor. To accomplish the end desired, the most constant and untiring industry has been required, added to which it has been necessary, during protracted periods, in a wilderness country, to dispense with the ordinary comforts of life; but suffering as I have from the severe duties incident to this work, the labor has been rendered light by the hope that in aiding to develop the resources of our state, in placing on maps her geology, topography and the character of her timber and soil, her settlement might be increased, and something added to her prosperity and wealth.

The condition of the fund placed at my disposal for this department is as follows, viz:

	Dr.	Cr.
By amount in my hands at close of last fiscal year		\$1.42
Amount appropriated for 1842.....		400.00
		<hr/>
		\$401.42
To amount paid sundry bills connected with surveys in upper peninsula, chiefly for 1841.....	\$250.61	
Rent of topographical office and contingent expenses for the same.....	50.33	
Drafting paper, stationery and binding of platt books for topographical office	74.83	
Postage	19.47	395.24
	<hr/>	<hr/>
Balance in hands of state treasurer.....		\$6.18

There will be required for the current year, an amount sufficient to cover incidental expenses, of a character similar to those above enumerated, which may be estimated at three hundred dollars.

I have already laid before you a general report upon those attached duties connected with the improvement of the state

salt springs, which cannot be considered as forming any part of the geological survey. These duties, which have cost me much labor and anxiety, have drawn deeply upon that time which should have been more directly occupied in the geological survey. At present, however, these attached duties interfere comparatively little with the other portions of the work, but heretofore they have done much to retard its progress.

All which is respectfully submitted.

DOUGLASS HOUGHTON,
State Geologist.

REPORT OF THE STATE GEOLOGIST, RELATIVE TO THE STATE SALT SPRINGS

(Joint Documents 1843, No. 9)

OFFICE OF THE STATE GEOLOGIST, }
Detroit, January 23, 1843. }

To the Hon. Senate and House of Representatives of Michigan:

In conformity with the provisions of an act placing in charge of the Geologist the state salt springs, I have the honor to submit the following report of their present condition, and the progress which has been made in their improvement.

At the state salt springs on Grand river, Kent county, the work has been steadily progressing in the manner directed by the legislature, and had not a serious accident occurred, which gave rise to a delay of more than three months, the work at this point would have been mainly completed.

The character of the improvement at this point has heretofore been so fully detailed to you that it would seem unnecessary, at this time, to say any more upon that subject, and I will only add that the plan originally proposed has been

rigidly adhered to. The entire depth of the well at the date of the last estimate for work performed under the contract for boring, was 786 feet, and at this date it may be estimated at something over 800 feet; of which 40 feet is earth boring, secured by an iron tube nine inches in diameter; and the balance rock boring.

Since the date of my last report upon this subject, the quantity of water discharged from the top of the iron tube, in the well on Grand river, has been very considerably increased, and now exceeds two hundred gallons per minute; in addition to which there is good reason to conclude that a considerable amount is discharged laterly through an opening in the rock, and that it reaches the surface at a distance from the well, and not only has the quantity of water been augmented but it has also been very considerably increased in strength.

As the water now flows from the iron tube it is mixed with all the fresh water entering the well above the upper salt rock, by which its strength is very much reduced, a difficulty which will be easily overcome by properly tubing the well.

The borings at the present time are in what has been dominated the lower salt rock, which is that formation from which we hope to obtain the best salt water. The rock has thus far proved to be of so close a texture as to admit a comparatively small amount of water to pass through it, for which reason the increase in strength and quantity of water has not been as great as had been looked for, but notwithstanding this compactness a vein furnishing a very tolerable supply has been struck in this rock.

In continuing the work, it is of the utmost importance that the borings be carried entirely through the lower salt rock, to the underlying formation, a task which, if no unforeseen accident occurs, will soon be accomplished; after which the tubing out of the upper and comparatively fresh water will be completed, and then and not till then, can the capacity of the well be fully and entirely determined.

It is now satisfactorily shown that the place of the salt water in the sub-carboniferous rocks is as was originally set forth, and that the supply of water is abundant; and it is further shown that the character of the water is such as will admit of the manufacture of salt at such rates as will enable our citizens to compete with that manufactured abroad. As has been before stated, the precise strength and quantity of water that can be furnished by the state well, on Grand river, cannot be fully determined at this time, for which reason I have not deemed it advisable to enter into detail upon this subject.

At the state salt springs on Tittabawassa river, no farther progress has been made in sinking the well, and no disbursements have been made except such as were required for keeping the machinery in repair, and in securing property from decay. The reasons for this suspension of work are contained in sections seven and eight of "An act relative to the state salt springs, and the lands granted for the use of the same," approved February 16, 1842.

In conformity with instructions contained in an act making appropriations for the improvement of the state salt springs, nearly the entire of the work has been done by contract, and certificates for the amount due on such contracts have, from time to time, been issued by me, according to the provisions of the contracts, the contractors receiving from the Auditor General warrants for the same.

The amount of unexpended appropriations will be amply sufficient to complete what will be required for the improvement of the salt springs, and the act relative to the same, approved February 16, 1842, is believed to place in the hands of the Executive sufficient power to enable him to direct all that will be required to make the springs available.

In conclusion, permit me again to call your attention to the present condition of our seventy-two sections of salt lands, a very large portion of which will never be required for the purposes for which the grant was made. It is a fact well known

that a portion of these lands were selected for their intrinsic value as farming lands, in connection with their advantageous situation. Some of these lands are under cultivation, as farms, and have in this way been considerably improved, while, on others, there has been wanton destruction of timber, without adding to the value of the lands by cultivation.

It is conceived that the present condition of these lands is such that they are drawn back upon the country where they are located, at the same time that they are exposed to constant waste of timber by depredation. True economy would dictate the necessity of some action in relation to these lands. [Last paragraph and schedules A and B omitted].

DOUGLASS HOUGHTON,
State Geologist.

1844

ANNUAL REPORT OF THE STATE GEOLOGIST

(Joint Documents, 1844, No. 11)

OFFICE OF THE STATE GEOLOGIST }
Detroit, February 15, 1844 }

To the Hon. Senate and House of Representatives of Michigan:

I have the honor to lay before you the accompanying report of the condition of the geological and topographical surveys of our state, and the progress which has been made towards the completion of the same during the past year.

A portion of the season has been devoted to connecting the work upon the upper peninsula, and completing the skeleton of the surveys of that part of our state, but by far the greater amount of work has been performed in the office, in compiling and arranging the materials for the final report upon the geology and topography, and in the completion of the maps, together with the figuring of sections and fossils illustrative of the several group of rocks of our state.

The drafting of the several county maps, according to the plan directed, has mainly been performed, and excepting some slight additions, these are now ready for the engraver. Of the county maps, four have been engraved and struck off, and are now in market. Ten additional counties have been placed in the engravers hands, and I had reason to hope that these would have been completed and ready for sale before the close of navigation. In this I have been disappointed, but now hope to be able to lay these additional ten counties, making, in all, maps of fourteen counties, together with the state map, before the public at an early day in the ensuing spring.

The best interests of our state render it of much importance that the maps of those counties in which her lands are now

offered for sale are situated, should be published at the earliest day possible. The engraving of some of these is now in progress, but to hasten this work, it will be important that a small appropriation be made to cover the first cost of some portion of the engraving, paper and press work. An appropriation of \$1,000 to \$1,500, will cover all that will be required to be paid out of the treasury before a sufficient amount will be realized from sales to enable the work to progress without further demand upon the treasury, and I confidently believe that the proceeds of the sales of these maps will fully refund to the state the cost of their publication.

This series of state and county maps, it is hoped and believed, will be more full and perfect than any that have heretofore been published of any equal portion of our United States, and there can be no doubt that when placed before the public, showing as they do the general character of the soil, timber, &c. &c., they will do much to aid in disseminating a knowledge of the immense capabilities of our state, and the advantages which she offers to the emigrant, and that thus they will afford efficient aid towards increasing her population.

In addition to the ordinary duties of the geological survey, the extra duty required, at your last session, of furnishing the state land office with township maps, has been performed, so far as calls have been made by the commissioner, and these duties have occupied much of the time of the topographer.

I have already stated that the field-work of the geological and topographical surveys of the lower peninsula is completed. The final report upon this portion of the work, together with all the maps and sections, will, I trust, be ready for the press during the coming summer. The engraving of the geological sections, fossils, &c., will occupy some time, and it is desirable, in order to prevent delay in this respect, that this portion of the work, preparatory to the final publication, should be commenced at the earliest day possible. In order to hasten this, I have made a temporary arrangement for the wood cuts, with a wood engraver who is fully compe-

tent, and who is now engaged in this duty, but in order to continue this work, some provision will be necessary.

The surveys of the upper peninsula have been completed less perfectly than those of the southern or lower peninsula, and while the grand outlines have been arrived at as fully as will be required, it is very desirable that these outlines should be filled up with more minuteness than has hitherto been done. The geology and topography of that portion of our state, lying south from Lake Superior, is much more complex than that of any other portion of our state, while, at the same time, it possesses a very high degree of interest, not only in a scientific point of view, but also in consequence of the intrinsic value of its mineral resources. To develop minutely its topography, geology and mineralogy, in such a manner as its great importance makes desirable, would require a larger amount of expenditure than our state is well able to appropriate to that object, and we can only hope to accomplish it by some extraneous or indirect means. The United States linear surveys afford a fine opportunity for accomplishing this in a way which will render the work exceedingly perfect, and at the same time will be attended with little expense. All that would be required would be simply a permission from the commissioner of the general land office of the United States, to the geologist of Michigan, to require the deputy surveyors to make certain observations during the progress of their survey, of a character which would connect the geological survey of our state with the linear survey of the United States. I hope to perfect such an arrangement in this particular, as will enable me to produce more perfect geological and topographical maps of the upper peninsula than have ever been constructed of the same extent of territory in our United States.

Of the amount of \$300 appropriation placed at my disposal for the geological and topographical survey, there has been expended during the fiscal year the sum of \$220.47, chiefly for rent and expenses of the topographical office, paper, postages, &c., the vouchers for which are deposited in the office of the

auditor general. In addition to such provisions as you may see fit to make for the engraving of the several county maps, the wood engraving and publication of the final report, there will be required for current expenses of the survey, during the ensuing year, an amount not exceeding \$400.

All of which is respectfully submitted.

DOUGLASS HOUGHTON,
State Geologist.

1846

REPORT FROM GEOLOGICAL DEPARTMENT

(Joint Documents, 1846, No. 12)

OFFICE OF STATE GEOLOGIST, TOPOGRAPHICAL DEPARTMENT. }
Detroit, 7th January, 1840. }

To the Hon., the Senate and House of Representatives:

I have the honor to report the completion of the catalogues and maps of the school lands contemplated by the act approved March 1st, 1845, which is as follows:

Sec. 1. *Be it enacted by the Senate and House of Representatives of the State of Michigan,* That the State Geologist be and he hereby is authorized and directed to ascertain the quantity of land the State of Michigan is authorized to select in addition to, or in lieu of the sixteenth section under the act of Congress entitled "an act to appropriate land for the support of schools in certain townships and fractional townships not provided for, approved May 20, 1826, and the act of June 23, 1836, admitting this state into the Union, and report to the next session of the legislature."

It will be seen by the report of M. E. Van Buren, Esq., to whom this work was given in charge, that the quantity of land the state is entitled to in lieu of fractional section sixteen, and for townships deficient in section 16, of the lower peninsula, is twenty-nine thousand seven hundred and twenty-nine acres. And to this amount must be added such deficiency as may be found in sixty-nine unsurveyed townships which remain.

In the statement under the head of "available school lands", and following remarks, the total school lands of the lower peninsula, amount to seven hundred and fifty-nine thousand five hundred and eighteen acres.

If to this we add the school lands of the upper peninsula, which will amount to nearly half a million acres, we have a truly noble fund.

As in consequence of the lamented death of Dr. Houghton, late state geologist, some legislative action will be called for in relation to the future disposition of the state survey, and in the absence of the annual amount from the head of that department, I have deemed it proper to accompany this report with some observations which may be important under present circumstances. With this view I applied to Bela Hubbard, Esq., late assistant to Dr. Houghton, in the department of geology proper, and have received from him such information as was deemed of most importance. Mr. Hubbard had undertaken in part the preparation of the final report on the geology of Michigan, under the direction of Dr. Houghton, for which purpose all the field notes and other information collected during the progress of the state surveys, were placed in his hands, and he is now engaged, at the request of the administrators, in the supervision of the geological portion of the returns of the late surveys made by Dr. Houghton, under contract of the U. S. government.

It is doubtless well known to your honorable body, that the period originally contemplated by the act for accomplishing a geological survey of this state expired in 1843; since which time the state geologist, under a greatly reduced appropriation, has been actively engaged in carrying forward the work to its completion, more particularly in that portion of the state denominated the upper peninsula, in the prosecution of which work he has fallen a martyr to his zeal, perishing at his post, and when almost in full view of the attainment of objects so anxiously sought, and so dear to the interests of Michigan. The immense amount of labor required to be performed in the progress of this survey, and its great importance to the people of the state, as also the important results it was developing in the region on lake Superior, necessarily retarded the completion of the work beyond the period first contemplated. This

delay, however, so far from prejudicing the work, has only tended to perfect the information already obtained, as well as to add to this amount.

The annual reports from the geological department, have from time to time given information of the progress of the survey, together with some of the practical results; though necessarily in a very partial and imperfect manner, it being intended to combine, in a condensed form, the whole amount of information collected into the final report, at the close of the whole work.

So far as regards the lower peninsula, all the field work has been for some time completed, and all the field notes, specimens and other materials are on hand, the results of an extended and laborious research, and forming a mass of materials, which are now in readiness to be compiled for final publication.

Materials are also on hand for the final report of the Upper Peninsula, so far as the surveys have extended, in that very complex and interesting region, and the whole is far advanced towards completion.

A large amount of engravings and lithographs for the final report are completed, and the whole, it is thought, can be finished within another year. Most of these are, in a style of art, superior to anything of the kind ever executed in this country.

The great importance of this work, so worthy of an enterprising, enlightened and free state, is no doubt fully realized by your honorable body. That by it the varied resources of the state are better developed and made known, and in particular the character of its superior agricultural and mineral advantages, and the manner in which those advantages can be best secured and perpetuated. While the knowledge now shut from the public eye, or confined to but few, will thus become widely disseminated among the people who are rightly interested in its possession, and additional inducements will be offered to new settlers, such a work will form a noble monu-

ment of enterprise and liberality which Michigan will be the first of the western states to achieve.

Connected with this subject are other considerations, showing the value of the materials which have been amassed, by those associated in this department, and the importance of their preservation in such form as to continue to be made available to further the interests of the state. I will only now allude to the completion of the locations of state lands, under the appropriation by Congress, a portion of which it has been proposed to locate in the mineral district, under the direction of the state geologist; the furnishing of information to the legislature relative to the lands, minerals or other resources and interests of the state, in matters of importance annually arising, (of which the information herewith presented relating to the school sections is an example,) and for which annual calls have generally been made upon the department; the completion of the series of state and county maps, which had been commenced under the direction of the head of this department, the drafts of many of which are now in the hands of engravers, and the materials for all of which are drawn in a good degree from the private notes and maps of those engaged in the survey, and are now in readiness for publication. Under proper direction, the department will be constantly receiving accessions of information, and of geological and other specimens, and it will be at once perceived that the suitable, systematic, preservation and arrangement of all these materials will, of itself, be of exceeding importance to the people of the state, and will demand the continued consideration of your honorable body. All of which is respectfully submitted.

S. W. HIGGINS,

Principal Assistant, and Topographer of the Geological Survey.

Detroit, January 5th, 1846.

To S. W. Higgins, Principal Assistant, and

Topographer of the Geological Survey:

Sir:—By the act of March 1st, 1845, the State Geologist was authorized and directed to ascertain the quantity of land the State of Michigan is entitled to in addition to or in lieu of the sixteenth section, and to subdivide fractional sections sixteen into such lots and fractions as may be suitable and convenient for sale, and to make maps of the same.

In compliance with the instructions of the late Doctor Douglass Houghton, I took charge of the work above referred to. His melancholy decease makes it proper, that to you, his principal assistant, I should report the result. Though this, as every other work in which he was engaged, lost in Dr. Houghton its directing mind, yet I believe the results as given in the accompanying books, maps, tabular statements, &c., are correct, and embody all the information desired upon this subject.

My attention has been confined entirely to the lower peninsula, and the accompanying statements have referred to it alone. The survey of the upper peninsula, is but commenced, and although an immense amount of work was done the past season under the direction of the late Dr. Houghton, and the energetic Surveyor General, Hon. Lucius Lyon, yet a vast amount remains unsurveyed, and it was therefore deemed advisable not to include it in these statements.

The books, maps, &c., above referred to, comprise the following, viz:

1. Two registers of all the school lands of Michigan.
2. Two volumes of maps, each containing one hundred and seventy maps of fractional sections sixteen, sub-divided.⁵⁰
3. A tabular statement of all the townships of the lower peninsula, with reference to section sixteen, marked A.
4. A tabular statement of all the school lands of the lower peninsula, marked B.

⁵⁰One volume not finished, yet to be lettered and bound.

5. A tabular statement of the available school lands of the lower peninsula, marked C.

6. A condensed tabular statement of the quantity of land the state is entitled to in lieu of fractional sections sixteen, and for townships deficient in section sixteen, of the lower peninsula, marked D.

7. A statement in detail of the same, marked E.

8. Letter from the Hon. Jas. Shields, Commissioner of the General Land Office at Washington, relative to Indiana reservations, marked F.

9. Letter and statement of "locations", in lieu of fractional sections sixteen, &c., from Hon. D. V. Bell, Commissioner of State Land Office, at Marshall, marked G.

The registers are duplicates, and are intended, one for the office of the State Geologist, and the other for the State Land Office. They are calculated for all the school lands of the State, whether *sections sixteen* or *locations made in lieu*, and are divided into *two parts*—the *first* is headed "Description of section sixteen in *all* the townships of the State of Michigan;" and *second*, "Fractional townships deficient in section sixteen, and fractional sections sixteen, in the State of Michigan." Under the *first head* are exhibited:

1st. Each township in the state, (completed for the lower peninsula.)

2nd. Quantity in each township—whether it is a "*full*" township or "*three-quarters*," or "*half*," &c.

3rd. Quantity in section sixteen.

4th. Deficiency in section sixteen.

5th. Amount to which entitled to in lieu.

6th. Deficiencies, where located.

7th. Deficiencies, (location in lieu of,) when confirmed.

Under the *Second Head*, all the fractional townships deficient in section sixteen, and all the fractional sections sixteen, are recapitulated, with the same details of quantity, &c., as given under the first. When the deficiencies now reported are located, and the survey of the Upper Peninsula finished,

and the deficiencies there ascertained, and locations made in lieu, and all entered, these registers will comprise complete catalogues of all the school lands of the State.

The two volumes of maps are also duplicates, and are designed, one to accompany each of the registers. They contain each, one hundred and seventy maps of fractional sections sixteen, exhibiting the meandered lakes and streams, and the contents of each fractional subdivision. The meanders of the lakes and rivers, and the calculations of the contents of the sub-divisions, are all based upon the original field notes in the office of the Surveyor General, in this city.—These calculations were a work of great labor and care, not only from the important interests involved in them, but also from the careless and imperfect manner in which many of the early surveys were made. In your report of 1840, you had occasion to remark that the "fairest portion of the State was sub-divided with evident want of skill, and with a carelessness in the first surveyor, (Wampler,) which has already resulted in a vast amount of trouble and absolute loss to a portion of our citizens. This carelessness and want of skill is very evident in the meanders of the rivers and lakes; in many instances, "the variation between the actual and proposed course is so great, as to render it nearly impossible to make the work close."⁶⁰

The Tabular Statement marked A., shows the whole number of full and fractional townships of the Lower Peninsula to be *twelve hundred and sixty-eight*, and the statement of "all the school lands" is made up from the table according to the following provisions of the act of Congress of May 20, 1826:

"There shall be reserved and appropriated for the use of schools—

"For each township or fractional township, containing a greater quantity of land than *three quarters* of an entire township—one section.

"For a fractional township, containing a greater quantity

⁶⁰Dr. Houghton's Report, 1839.

of land than *one-half* and not more than three-quarters of a township, *three-quarters of a section*.

"For a fractional township containing a greater quantity of land than *one-quarter*, and not more than one-half of a township, *one-half section*.

And for a fractional township containing a greater quantity of land than *one entire section*, and not more than one-quarter of a township, *one-quarter section of land*."

The quantity of land the state is entitled to in lieu of fractional sections sixteen, and for townships deficient in section sixteen, of the Lower Peninsula, is *twenty-nine thousand seven hundred and twenty-nine acres and sixty-eight one hundredths*, as shown by statements D and E. To this amount must be added such deficiencies as may occur in *twenty-eight* townships not yet sub-divided, and *forty-one* townships of the surveys of Riley & Rosseau, which, if they were ever made, have been found so incorrect, that the Commissioner of the General Land Office has ordered them to be cancelled and the ground re-surveyed.

The statement of "Available School Lands" includes, of course, such as may have been sold and the fractional sections sixteen which have heretofore been withheld from sale as they were not sub-divided, all difficulty on that score being now removed. They amount to *six hundred and eighty-six thousand one hundred and nine acres*.

By reference to the statement (B,) it will be seen that the whole amount of school lands of the Lower Peninsula is *seven hundred and fifty-nine thousand five hundred and eighteen acres and 69-100ths*, and when those of the Upper Peninsula, which are estimated at fully one-half as much, or about *three hundred and eighty thousand, four hundred and eighty-one acres, and 31-100ths*, are added, we have for the total school lands of the state, *one million, one hundred and forty thousand acres, (1,140,000,)* which, at the minimum price as fixed by law, of five dollars per acre, would proclude the sum of *five millions and seven hundred thousand dollars*, and that again at

the legal interest of *seven per cent* would yield an *annual income of three hundred and ninety-nine thousand dollars*. Although these lands may not all bring the fixed price of five dollars per acre, yet as nearly all of them are of the first quality for agricultural purposes, or valuable for their timber or mineral resources, their product may be anticipated to approximate very nearly to the sum named, and it must afford high satisfaction to the hardy pioneers who first reared their cabins amidst the uncultivated wilds of the "beautiful Peninsula", and endured all the hardships and privations incident to new settlements, to see their children thus amply provided for in that great essential under a free government—*education* and the enterprising emigrant from the eastern states, accustomed to look upon the advantages of schoolhouse and academy as more than counterbalancing the disadvantages of a stubborn soil and rigorous climate, may turn with confidence to Michigan, satisfied that from her prolific and easily tilled soil, he will receive an abundant return for his labor—that in her richly endowed schools and university, means of education are provided for all.

A great deal of the work was done in the office of the surveyor general, and it gives me pleasure to acknowledge the kindness of the late and present surveyor generals, and the clerks in the office, who afforded me every facility in their power. [Tabular statements A, B, C, D, E, F, and G, omitted, also certificate of true copy by Thos. H. Blake of the Gen. Land Office].

M. E. VAN BUREN.

1. The first part of the report discusses the general situation of the country and the progress of the work done during the year. It also mentions the results of the various investigations and the conclusions drawn therefrom.

2. The second part of the report deals with the specific details of the work done in each of the various departments. It gives a detailed account of the work done in each of the various departments and the results obtained therefrom.

3. The third part of the report discusses the financial position of the country and the progress of the work done during the year. It also mentions the results of the various investigations and the conclusions drawn therefrom.

4. The fourth part of the report deals with the specific details of the work done in each of the various departments. It gives a detailed account of the work done in each of the various departments and the results obtained therefrom.

5. The fifth part of the report discusses the financial position of the country and the progress of the work done during the year. It also mentions the results of the various investigations and the conclusions drawn therefrom.

INDEX

INDEX

(Index compiled by R. A. Smith, State Geologist)

- Alluvions, 470, 595-598.
Alluvium, 580.
American Fur Company, headquarters at Sault Ste. Marie, 42; trading store of at Knaggs' reservation, 24; at L'Anse, 42; at LaPointe (Wis.), 64.
Amphibia, list of by Abm. Sager, 219.
Apple Trees along Tittabawassee River, 36.
Area of the Lower Peninsula of Michigan, 636.
- Birds, list of by Abm. Sager, 212, 218.
Bog iron ore and ochre, 424, 462.
Botanical and zoological departments, 201, 204.
Boulders, 282, 423, 438.
Brine springs, occurrence of, 108, 125.
Building and flagging stone, 283.
Byron, settlement of, 22.
- Calhoun County, general remarks on, 417; marl details of, 420.
Carp and Chocolate Rivers, description of rock in vicinity of, 58.
Carrolton, settlement of, 36.
Chicago Turnpike or Trail, 406.
Chippewas, bands of the, 23.
Chocolate and Carp Rivers, description of rocks in the vicinity of, 58.
Clay, 198, 282; containing kidney ore of iron, 607; Van Buren, Allegan, Ottawa, and Wayne counties, 296, 435; Monroe County, 321.
Clay iron-stone, occurrence of in Branch, Kalamazoo, Jackson, and Oakland counties, 71, 390.
Clays and sands, 422.
Clays, Tertiary, 184, 452.
Coal, occurrence of, 106, 199, 200, 285, 428-432, 602, 604.
Coal bearing rocks of Southern Michigan, 426.
Coal Measures, 601, 605; in Ingham, Eaton, and Shiawassee counties, 25.
Compass, variations of, 409, 571, 624.
Conglomerate rock, 454, 497, 498, 513, 515.
Copper, occurrence of great boulder near Ontonagon, 63.
Copper Harbor, explorations in vicinity of, 59.
Copper mines of county of Cornwall, England, production at, 549.
Corniferous limestone, 586.
Corunna, discovery of coal near, 25; settlement of, 25.
Coureurs de bois, or agents of the fur trade, 43.
Crag, or conglomerate rock, 281-282, 435.
- Deer licks, 588.
Deposits, tertiary and diluvial, 184, 185, 451, 599.
Diluvial deposits, 451, 591.
Douglass, C. C., report of, 275-287.
- Eaton County, marl details of, 420; remarks on, 417.
Elevations of lakes, 271-274.

- Expenditures by Douglass Houghton, 75-92.
- Explorations along Shiawassee River, 22; of lake shore from Saginaw to Port Huron, 35.
- Fish, list, 219.
- Flagging stones, 283.
- Forests, see Timber, Woods.
- Furs, fish, and harbors of Lake Superior, 563.
- Geological information, questionnaires to, 140-148.
- Geological and topographical departments (Third Annual Report), 396.
- Geological survey, first annual report by Douglass Houghton, 67; second annual report of, 69-71; third annual report of, 71; fourth annual report of, 72; fifth annual report of, 74; sixth annual report of, 76; seventh annual report of, 78; organization of, 20, 67, 68; reorganization of, 68.
- Geological surveys in the Upper Peninsula, 74; see Upper Peninsula.
- Geology, economic, 386, 523.
- Geology of salt bearing rocks, 125; of Southern Peninsula, 579; of Upper Peninsula, 374, 494.
- Glacial striae, 326.
- Glossary of geological terms, 327-338.
- Grand Marais harbor, 49.
- Great Lakes, change in elevation of waters of, 187-195, 637; depth of, 260; elevations of, 258; periodic rise and fall of, 263-266.
- Gypsum, 186-187, 425, 619; discovery of in Saginaw Bay near Au Gres River, 37; occurrence in northern part of State, 84; occurrence of, 108.
- Gypsum and marl, 394.
- Harbors of Lake Superior, 563.
- Higgins, S. W., report of topographic survey by, 251-275.
- Houghton, Douglass, appointment of as State Geologist, 67; biography of, 9-13; contract of with U. S. Land Office, 16; drowning of, 12-13; description of, 30; memorials and portrait of, 13; nature and importance of work of, 15; see State Geologist; Summary.
- Hubbard, Bela, 20-40, 287-327.
- Indian lands, Chippewas in Shiawassee River Valley, 24.
- Indian memorials, 37.
- Ionia County, marl details of, 421; remarks on, 417.
- Iron, 618.
- Iron formations, kidney, 448.
- Iron ore (bog), 135-136, 197, 281, 425; in Monroe and Wayne counties, 303-305, 325.
- Iron, bog, occurrence of, 84.
- Iron ore, report on, 164-167.
- Jackson County, marl details of, 418.
- Kalamazoo County, bog iron ore, analysis, 425; marl details of, 420; remarks on, 417.
- Kawkawlin River, 36.
- Kent County, marl details of, 421; remarks on, 417.

- Keweenaw Bay, to Carp and Chocolate Rivers, description of rocks of, 58.
- Lake Huron, clay slates and flags of, 609.
- Lake ridges, ancient, 464.
- Lake Superior, exploration of shores of, 41-66.
- Lake Superior sandstone, 378; position of, 71.
- Lakes, Great, depths of, 260; elevations of, 258, 271, 414, 461, 637, 641; inland, 262, 404.
- Lands, extent of timber, 441.
- LaPointe, Wis., description of trading station of American Fur Co., 64-66.
- LaGrand Sable, dune sands of, 49.
- Levels (elevations), 271.
- Lime in Monroe County, 321.
- Limerock and shales, 380-381; see Upper Limerock.
- Limerock in Monroe County, 317-321; in Wayne County, 298-300.
- Limestone, occurrence of, 103-104, 317-321, 583, 587, 588; stratum below Coal Measures, 601; of Lake Erie, 610; of Little Traverse Bay, 586.
- Lower Peninsula, report on streams for, 167-172, 184, 390, 415, 426; see names of counties.
- Mackinac limestone, 584.
- Magnetic needle, variation of, 411, 634.
- Mammalia, list of by Abm. Sager, 211-212.
- Maps, progress of, 400; publication of State and county, 77-78; 274-277, 402.
- Marl, 186, 196, 280-281, 418; deposits of, 135; in Monroe County, 322-323; in Wayne County, 300.
- Marl and bog-lime or tufa, 456.
- Marshes, 642; and swamps, 278; and wet prairie of Monroe county, 315-316.
- Midland, settlement of, 33-35.
- Minerals and mineral veins, 526; of the conglomerate, mixed rock, and red sand rock, 528; of the Metamorphic group of rocks, 526; of the Primary rocks, 526; of the trap rocks, 527; of the Upper or Gray sandstone, 559.
- Mineral resources, occurrence of, 84.
- Mollusca, list of, by Abm. Sager, 220-223.
- Monroe County, bog iron ore in, 325; clay in, 321; glacial striae in, 326; lime in, 321; limerock in, 317; marl in, 322-323; marshes of, 314-315; peat in, 316-317; report on, 311-327; sand in, 321; soils and timber, 313-315; streams in, 324; sulphur springs in, 323, topography of, 311.
- Northern Peninsula, see Upper Peninsula.
- Ochre and bog iron ore, 462.
- Ontonagon, adventure near, 60-64; occurrence of copper near, 63.
- Peat, 422, 460; fibrous, 196; in Monroe County, 316-317; in Wayne County, 302-303.

- "Pictured Rocks," description of, 51-58.
- Plants, list of by John Wright, 226-251.
- Point Au Barques, 37.
- Point Au Gres, limestone at, 582.
- Pontiac, description of vicinity of, 22; early history of, 21.
- Port Huron, settlement of, 40.
- Portsmouth, settlement of, 36.
- Prairies, wet, of Wayne County, 292.
- Public Surveys, origination of Federal and State idea of cooperation in, 16.
- Quarries, sandstone, 98, 102.
- Report, Annual, relative to progress and advantages of the Geological Survey, 83-89; of State Geologist for 1837, 96; from Geological Department, 1846, 683; of a select committee of the Board of Regents on a zoological collection of the State Geologist, 90-91; of Bela Hubbard, 287-327; 439, 589; of committee of the Senate on manufacturers, 338; of contracts from documents accompanying Governor's special message on State salt spring lands, 482; of C. C. Douglass, 275-287, 416, 574; of Frederick Hubbard, 570; of Geological assistants, 207; of John Wright, botanist, 223-225; of progress from State Geologist to Wm. Woodbridge, 1840, 473; of progress on work of Geological Survey, 167; of S. W. Higgins, topographer, of Geological survey, 399, 622; of select committee in relation to report of State Geologist, 662; of State Geologist for 1838, 153-161; of State Geologist relative to State salt springs, 346, 655, 675; of State Geologist on County and State maps, 1841, 647; of topographical survey, 251-275; on iron ore, 164; on Northern part of Lower Peninsula, 169-208; on Southern part of Lower Peninsula, 195-208.
- Reptilia, lists of by Abm. Sager, 218-219.
- Rivers of Michigan, 266-269; see Streams.
- Roads and highways, 405; in Wayne County, 309-311.
- Rock formations of Lower Peninsula, description of, 173, 184, 426.
- Rocks, below coal basin, 612; dip of, 612; of Lake Huron, 582; of Lake Michigan, 579-584; of Upper Peninsula, 375, 495, 497, 502, 511, 523.
- Sager, Abm., geological report of, 209-223.
- Saginaw, early settlement of, 28.
- St. Mary's River, Strait, Sault Ste. Marie, 43-47.
- Salt, 619; production and quality of in Saginaw Valley, 33; statistics of production and value of in New York, 126; tables of content of in Michigan brines, 127-133.
- Salt brines, borings for, 159.
- Salt lands, selection of, 87; State, 200-201.

- Salt River, examination of salt springs along, 33.
- Salt springs, 108-125, 306; and State salt lands, 200-201; early knowledge and investigation of, 20; investigation of on the Tittabawassee River, 32; occurrence of, 84; origin of, 154; reports relative to the improvement of, 72, 73; special report on improvement of, 161-164.
- Salt well, boring of, at Grand Rapids, 33, 73, 75, 76, 614, 615.
- Sand, occurrence of, 134-135; in Monroe County, 321.
- Sands, Allegan, Van Buren, and Ottawa counties, 436.
- Sandstone, Lower, occurrence of along shore of Lake Huron north of Port Huron to Pt. Aux Barques, 105; fossiliferous and ferruginous, 499; red, in Ionia County, 433; red or variegated, 605.
- Sandstones of Point Aux Barques, 606; of Van Buren County, 434.
- Sandstone and shales, red, Upper Peninsula, 518.
- Scenery, 51-58, 442.
- Section, general of Michigan, 612; of coal basin, 606.
- Shale, black, 582, 585; blue and light gray, 585.
- Shales, of Flint River, 603.
- Shiawassee River, exploration of by Douglass Houghton, 22.
- Shiawassee town, 25.
- Sink holes, 326.
- Slate, black bituminous aluminous, 610.
- Soil, 277-278, 442; see correlative topics.
- Soils and timber of Monroe County, 313-315; of Upper Peninsula, 560; of Wayne County, 289-291.
- Southern Peninsula, see Lower Peninsula.
- Springs and underground water courses, 454.
- Springs and wells, 279, 280, 307.
- Springs, brine, 306; chalybeate, 305; mineral, 136; sulphur, 305-306.
- State Geologist, communication of, 340; current account of for year 1839, 353; special communication from as to direct benefits to agriculture of geological surveys, 149-152.
- Stone, building and flagging, 283.
- Strait of St. Marie, or St. Mary's River, 43-47.
- Streams, 280; in Monroe County, 324; report on for Lower Peninsula, 324.
- Sulphur springs, 305; in Monroe County, 323.
- Summary, comprising general observations on the economical results of the survey, 617; of State's account with Douglass Houghton. State Geologist (1839), 366.
- Survey, progress and condition of, 568.
- Surveys, Federal rules and regulations for mineral and land by Douglass Houghton, 18; United States, 270-271.
- Swamps and Marshes, 278.
- Table of elevation and depression in waters of lakes com-

- pared with that of June 1, 1839, 414, 461.
- Table of Latitudes St. Marie Riviere and Lake Superior, 571; of magnetic variations (Riviere de Ste. Marie and Lake Superior), 573.
- Tables of salt content in Michigan brines, 127-133.
- Thunder Bay limestone, 582.
- Timber, 277.
- Timber and soils of Monroe County, 313-315.
- Topographical department, 205; survey, 70-71; report of, 251-275.
- Topography of Monroe County, 311; of Wayne County, 288-289.
- Trap Rocks, Upper Peninsula, 495, 505.
- University, collections for, 204.
- Upper limrock, localities and description, Jackson, Eaton, Kent counties, 430; Upper Peninsula, 383; or gray sandstone, Upper Peninsula, 499, 522; exploration of coasts of Lake Superior, 41-66; sandstones of Lower Peninsula, 98-103; occurrence along Grand River valley, 98-102; occurrence in Kalamazoo River valley, 102.
- Upper Peninsula, 41-66, 74, 368, 370, 374, 386, 394, 523.
- Van Buren County, general remarks on, 434.
- Veins, mineral, 526.
- Water, wells and springs, 279, 280, 307.
- Wayne County, bog iron in, 303-305; clay of, 296-298; lime rock in, 298-300; marl in, 300-302; marshes of, 292; peat in, 302-303; report on, 288-311; roads in, 309-311; soil of, 289-292; topography of, 288-289.
- Wells and springs, 279, 280, 307.
- White Fish Pt., description of and vicinity of, 48.
- Woods, natural, of Michigan, 407.
- Zoological and botanical departments, 201-204, 395.