GEOLOGICAL SURVEY OF MICHIGAN

ALFRED C. LANE, STATE GEOLOGIST

VOL. VII

PART II

GEOLOGICAL REPORT

ON

HURON COUNTY

MICHIGAN

BY

ALFRED C. LANE

ACCOMPANIED BY ELEVEN PLATES AND TWELVE FIGURES
(INCLUDING TWO COLORED MAPS

PUBLISHED BY AUTHORITY OF THE LAWS OF
MICHIGAN
UNDER THE DIRECTION OF
THE BOARD OF GEOLOGICAL SURVEY

LANSING
ROBERT SMITH PRINTING CO., STATE PRINTERS AND BINDERS
1900

DOUGLASS HOUGHTON, State Geologist.

Reports from 1838-1846 were published with Legislative documents as follows: S. D. means Senate document; H. D., House document; J. D., joint document. State Geologist is abbreviated S. G., and State Geological Survey, S. G. S.

1838. Report of a select committee of the Board of Regents of the University on the collection of the S. G.
H. D. Vol. I, p. 1-2; S. D. No. 1, p. 1. H. D. No. 55 is duplicate of No. 1.
Statement of the expenditures on account of the S. G. S. for the year 1837.
H. D. No. 8, pp. 115-118; S. D. No. 21 (First annual account of the S. G.), pp. 315-318.
Report of the S. G. (first annual).
H. D. No. 24, pp. 276-317; S. D. No. 16; separately, No. 14, pp. 1-39.
Communication from the S. G.
H. D. No. 46, pp. 457, 460.

1839. Report of the S. G. in relation to the improvement of State Salt Springs.
H. D. No. 2, pp. 39-45; S. D. No. 2, pp. 1-8.
Report of the committee on the S. G.'s report in relation to the improvement of the State Salt Spring.
H. D. No. 4, pp. 123.
Report of the S. G. in relation to the iron ore, etc., on the school section in town five south, range seven west, in Branch county.
H. D. No. 21, pp. 342-344.
Second annual report of the State Geologist.
H. D. No. 23, pp. 380-507; S. D. No. 12, pp. 264-391; also separately H. R. No. 23, and S. R. sometimes misprinted No. 13 and No. 23, pp. 39 and appendix of sub-reports 123 pp.
Report of the Committee of the Senate on Manufactures, to whom was referred the communication of the S. G. relative to salt springs and the salines of the State.
S. D. No. 3, pp. 85-86 (parallel to H. D. No. 4).
Communication from the S. G. relative to the G. S.
S. D. No. 25, pp. 463-466; J. D. No. 3, app.

1840. Report of S. G. relative to the improvement of the Salt Springs.
H. D. No. 2, Vol. I, pp. 18-23; S. D. No. 8, Vol. II, pp. 153-158.
Annual report of the State Geologist (third, map of Wayne county).
H. D. No. 27, Vol. II, pp. 206-293; S. D. No. 7, Vol. 2, pp. 66-153; separately, H. R. No. 8, pp. 1-124.
Report of the select committee to whom was referred the several reports of the S. G.
H. D. No. 46, Vol. II, pp. 455-461.
Report of the majority of the Committee of Finance on the communication and accounts of the S. G. for 1839.
Report of the minority of the Committee on Finance on the same subject.
Report of the select committee on S. G.'s report and accounts relative to improvement of Salt Springs, etc.
S. G.'s account for the year 1839, the same being the subject matter of the three preceding reports.
S. D. No. 15, 16, 17, 18, pp. 209-224.

1841. Special message concerning State Salt Springs.
H. S. and J. D. No. 5, pp. 235-254.
Annual report of the S. G. (fourth).
H. S. and J. D. No. 11, pp. 472-607; separately H. D. No. 27, pp. 1-184; S. D. No. 16, pp. 1-184.
Report of the S. G. relative to county state maps.
H. D. No. 35, pp. 94-98.

[18]42. Report of the S. G. relative to the State Salt Springs.

1842. H. D. No. 2, pp. 15-21; S. D. No. 1, pp. 1-9.
Report of the select committee in relation to the report of the S. G.
H. D. No. 19, pp. 77-79.
Annual report of the S. G. (fifth).
H. D. No. 14, p. 6; J. D. No. 9, pp. 436-441.

1843. Annual report of S. G. (sixth).
H. D., S. D., and J. D. No. 8, pp. 398-402.
Report of the S. G. relative to the State Salt Springs.
S. D. No. 9, pp. 402-408.

1844. Annual report of the S. G. (seventh).
S. D. No. 11 (three pages).
Maps of Washtenaw, Calhoun, Jackson and Lenawee counties were published separately.

1846. Report from Geological Department by S. W. Higgins, principal assistant.
J. D. No. 12, 22 pp.
Report of the joint committee relative to the Geological Survey.
J. D. No. 15, 8 pages.
D. Houghton undertook an arrangement with the Linear Survey of the U. S. Land Office by which a certain amount of geological work was done, which was never published by the State, the results of which appear largely in the township plats of the Land Office, and in the report of C. T. Jackson, 1849, U. S. S. Ex. Doc. No. 1, pp. 371-935, H. Ex. Doc. No. 5, Vol. 3, Part 3, including sub-reports of W. A. Burt and Bela Hubbard on the geology of the subdivisions of the Linear Survey, First Session 31st Congress, and of Foster & Whitney, U. S. Geologists, Part I, H. Ex. D. No. 69, pp. 1-224 and 12 Plates, First Session 31st Congress; S. Ex. D. No. 2, Vol. 2, p. 147, Second Session 31st Congress; Part II S. Ex. D. No. 4, Vol. 3, p. 3, Special Session 32d Congress.
See also:
Reports on the Mineral Region of Lake Superior, with a correct map of the same and a chart of Lake Superior (first title page). Reports of Wm. A. Burt and Bela Hubbard, Esqs., on the geography, topography and geology of the U. S. Surveys of the Mineral Region of the South Shore of Lake Superior, for 1845: By J. Houghton, Jr., and T. W. Bristol, Detroit, 1846 (second title page).
A second edition was published the same year in Buffalo by J. Houghton, Jr., the title being "The Mineral Region of Lake Superior."
"Memoir of Douglas Houghton," Alva Bradish, Detroit, 1889; reprints the early reports almost in full.

A. WINCHELL, State Geologist.

1861. First biennial report of the progress of the G. S. of M. Embracing observations on the Geology, Zoology and Botany of the Lower Peninsula. Made to the Governor Dec. 31, 1860.
The Walling Tackabury State Atlas contains a paper with geological and topographic maps by A. Winchell, reprinted separately under the title "Michigan."

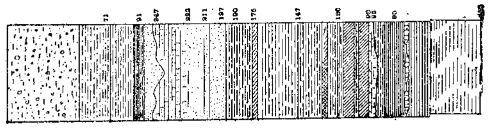
1869. Report of the Joint Committees on Geological Survey, made to the Legislature of Michigan, Lansing, W. S. George & Co., Printer to the State, pp. 1-15.

1871. Report of the progress of the S. G. S. of M., pamphlet, pp. 1-64.

1873. Vol. 1. Upper Peninsula, 1869-1873. Accompanied by an Atlas of maps. Edition 2,000.
Part I. Iron Bearing Rocks (Economic), T. B. Brooks. Of this an extra edition of 500 with thirteen accompanying atlas plates (1 to 13, No. 2 is misnumbered 11) was issued.

GEOLOGICAL COLUMN IN HURON COUNTY.

(Adapted so far as possible to a well 2270 feet deep at Caseville and one 1920 feet deep at Harbor Beach.)



CORRELATIONS.	NAMES.	COLUMN.	TYPICAL EXPOSURES.	LITHOLOGICAL CHARACTER.	NOTES.
	PLEISTOCENE		Port Crescent White Rock Ubly	Lake sands, lake clays and till	Section very different in different localities. For fossils of shell marls see Chapter X
CARBONIFEROUS CONGLOMERATE	JACKSON COAL MEASURES		Sebewaing coal mines and shafts	Black, white and blue shales, coal and sandstone	Distance from coal measures to Napoleon given by wells which start in Maxville limestone and run into it, *e. g.*, on Sec. 36, T. 17 N., R. 9 E., sandstone at 264'; Sec. 31, T. 17 N., R. 10 E. at 270'
LOWER KASKASKIA AND UPPER SAINT LOUIS	GRAND RAPIDS — Maxville		Bayport Shebeon Charity islands	Sandy yellow limestones, crossbeded white sandstone, little dolomite	*Lithostrotion canadense, L. proliferum, Allorisma clavata, A. elongata, Syringopora ramulosa, Spiriferina spinosa, Seminula argentea, Phillipsia longispina*
K AND BURLINGTON	GRAND RAPIDS — Michigan			Light grey shale with gypsum and pyrite; salty blueish shales; argillaceous hydraulic limestones	Macpherson's well, Sec. 30, T. 17 N., R. 11 E., strikes bedrock at 40', but has no good water until 210', in white sandstone Leipprandt's well, Sec. 13, T. 17 N., R. 10 E.; gypsum at 55' and 100', Napoleon white sandstone at 228' Sec. 25, T. 17 N., R 9 E., plaster at 10' to 25', flow at 140' Gypsum is 155' above top of Napoleon at Midland, 110' at Alma, 140' at Bay City
SHALES	C		Soule Sec.24, T.17 N., R. 11 E. Sec.19, T.17 N., R. 12 E.	Blue to black micaceous shale	*Spirifer forbesi?, Productella arcuata?* Thickness of Coldwater from base of Marshall to top of Berea shale, 896' (Harbor Beach), 845'+ (New River), 965?' Port Austin, 816' (Port Hope)
			Forestville		

Rest of column not exposed

CORRELATIONS.	NAMES.	THICKNESS.	NOTES.
BUENA VISTA FLAGS			
BEREA SHALE		103 feet (Harbor Beach)	Top, 999', Bottom, 1061' Harbor Beach, 1000', 1055' White Rock, 1020', 1060' Forestville, below the base of the Marshall
BEREA GRIT		75 feet	
BEDFORD SHALE		50 feet	
CLEVELAND SHALE	OHIO OR SAINT CLAIR	3 feet	From base of Berea grit to top of Traverse (1120–664) 456 to (2270–1750 Caseville) 520 feet
ERIE SHALE		133 feet	
HURON SHALE		270 feet	
HAMILTON, MARCELLUS	TRAVERSE	605	15 feet very hard limestone at 1400', compare Alpena at 153' and Bay City at 2910 feet, Encrinal limestone?
CORNIFEROUS	DUNDEE,	119	95' more to bottom of Harbor Beach, well strong bitterns; see analyses
SALINA	MONROE	2,000?	Unexplored
NIAGARA		400?	
CLINTON TO UTICA SHALES		750?	Total to Trenton from base of Marshall, about 5000 feet Total to Trenton from base of coal measures, about 5800 feet
TRENTON			

GEOLOGICAL SURVEY OF MICHIGAN

ALFRED C. LANE, STATE GEOLOGIST

VOL. VII

PART II

GEOLOGICAL REPORT

ON

HURON COUNTY

MICHIGAN

BY

ALFRED C. LANE

ACCOMPANIED BY ELEVEN PLATES AND TWELVE FIGURES
INCLUDING TWO COLORED MAPS

PUBLISHED BY AUTHORITY OF THE LAWS OF
MICHIGAN
UNDER THE DIRECTION OF
THE BOARD OF GEOLOGICAL SURVEY

LANSING
ROBERT SMITH PRINTING CO., STATE PRINTERS AND BINDERS
1900

OFFICE OF THE STATE GEOLOGICAL SURVEY,
LANSING, MICHIGAN, Sept. 15, 1900.

To the Honorable, the Board of Geological Survey of Michigan:

HON. HAZEN S. PINGREE, *President.*
HON. PERRY F. POWERS.
HON. JASON E. HAMMOND, *Secretary.*

GENTLEMEN—Herewith I transmit as Part II of Vol. VII, a report on the geology of Huron county, the Thumb of Lower Michigan. Like Part I, 500 copies are issued separately, while 1,000 are bound in the complete volume. Of Chapter IX, 100 copies have been printed for Prof. C. A. Davis, and the same number of § 2 and of § 3 of Chapter X for my co-adjutors Bryant Walker, Esq., and Mr. W. F. Cooper.

I trust this report may aid the residents and well drillers of the county in getting good water supplies, may save money in proving up the resources of the county in coal, gypsum, limestone, and grindstone, and may call attention to the probable value of the shale deposits. Just at the moment I notice items in the daily press concerning lead, a subject which I have also examined.

To my fellow geologists it may be interesting to see what can be done with the sub-surface geology, when outcrops are very rare, by means of records and tests of farmer's wells.

It will probably be of use to them also to have the Marshall of this region more fully treated, and a definite and detailed geological column made out, covering the dividing line between Devonian and Carboniferous.

I feel that I ought to call attention here as well as in the text to the important help which I have received from Messrs. Davis, Gordon, Walker and Cooper, whose names ought almost to have appeared on the title page, and also to the fact that the work of preparation of this report, though always in my charge, was largely done during the administration of my predecessor, Dr. Hubbard.

With great respect I am your obedient servant,

ALFRED C. LANE,
State Geologist.

TABLE OF CONTENTS.

CHAPTER I.

INTRODUCTION.

CHAPTER II.

GEOLOGICAL COLUMN.

CHAPTER III.

PHYSICAL GEOGRAPHY OF HURON COUNTY.

CHAPTER IV.

FORMATION OF THE SOILS AND SUBSOILS (PLEISTOCENE).

CHAPTER V.

STRATIGRAPHY, DISTRIBUTION, AND STRUCTURE OF THE ROCKS.

CHAPTER VI.

WELLS AND BORINGS.

CHAPTER VII.

ECONOMIC GEOLOGY OR RAW MATERIALS OF THE COUNTY.

CHAPTER VIII.

NOTES ON MINERALS.

CHAPTER IX.

BOTANICAL NOTES BY C. A. DAVIS.

CHAPTER X.

LIST OF ILLUSTRATIONS.

PLATES.

FIGURES.

TABLES.

ERRATA.

Page 2, line 24, dele inger.
Page 2, line 4, from bottom, for Grove read Gore.
Page 3, line 4, from top, for A. C. Poor read A. G. Peer.
Page 6, line 3, at end, read H. for F.
Page 12, line 31, for Grand Repids read Grand Rapids.
Page 13, line 1, for siliceous read silicious.
Page 17, line 7.
Page 21, line 9 and line 28, and on page 25, line 1, for Rhynconella read Rhynchonella.
Page 23, line 19, for Prœtus read Proetus.
Page 26, lines 13 and 17, and the foot note. Sand Beach is now Harbor Beach.
Page 27, lines 13 and 22, and on page 29, line 2, Sand Beach is now Harbor Beach.
Page 27, line 2 from bottom, for VII read VIII.
Page 28, line 17, for Hazard read Haskell.
Page 37, line 7, for N. W. read N. E.
Page 49, line above foot note, for S. O. P. read S. Q. P.
Page 53, line 4 from bottom, for askers read eskers.
Page 50, line 3 from bottom, for 1886 read 1896.
Page 74, line 6 from bottom, for S. T. and H. R. K., read R. R.
Page 77, line 16 from bottom, for north, northwest, read north northeast.
Page 79, line 3 from below, for Gannet read Gannett.
Page 80, line 1, for Geo. W., read Geo. J.
Page 96, line 16, for Lounsberry read Lonsberry.
Page 100, line 19, for Sec. 7, read Sec. 6.
Page 106, line 4, for 19139, read 19189.
Page 117, line 14, read Lepidodendron.
Page 130, line 4 from bottom, for following read flowing.
Page 134, line 15 from below, for Raither read Rather.
Page 136, line 10, for Ayers' read Ayres.
Page 142, line 8 from bottom, for Miss. read Missouri.
Page 145, line 4 from bottom, for W. C. read W. T.
Page 171, last line, for Co_2 read CO_2.
Page 171, line 2 from bottom, for W. B. read A. B.
Page 178, last line, for Mozier read Mosher.
Page 183, line 5 from below, for Cody read Codey.
Page 183, line 16 from below, for Mozier read Mosher.
Page 211, line 2 from bottom, strike out the word New.
Page 246, line 7, for Douglas read Douglass.
Page 255, line 16, for 18263 read 19263.
Page 267, line 18, for Solon read Solen.
Page 268, line 16, at the beginning read *O. rushense*.
Page 298, Table VII is misnumbered VI.

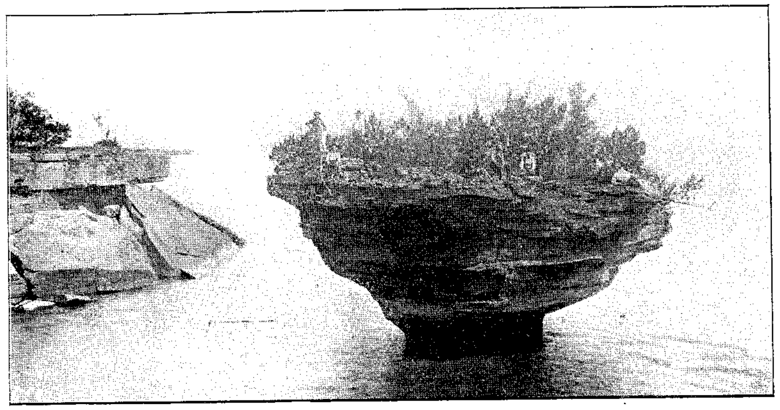


Fig. 1.—The Flagstaff (or Bowsprit) at Point aux Barques. The Thumbnail of Michigan, illustrating the undercutting action of the waves.

CHAPTER I.

INTRODUCTION.

§ 1. Historical.

The lower peninsula of Michigan has been likened to a man's hand. In such a comparison Saginaw Bay must be supposed to separate the thumb from the rest of the hand. Huron county is the end of the thumb thus formed, so that we may look upon the ledges which line its northernmost margin (Fig. 1), as representing the projecting thumbnail.

Few counties of the lower peninsula have more rock outcrops exposed than Huron county; and none, perhaps, have a greater variety of mineral industries. Coal, limestone, grindstones, and salt, are among the substances which have been already marketed, while pyrite, plaster, cement rock and mineral waters yet await development.

It is not surprising, therefore, that this region early attracted attention. Schoolcraft in his narrative* speaks of the coarse gray loosely compacted sandstone, after passing Elm Creek in the ad-

*"Summary Narrative of an Exploratory Expedition to the source of the Mississippi River in 1820; with appendixes, comprising all the official reports and scientific papers of both expeditions. By Henry R. Schoolcraft. Philadelphia, 1855," pp. 54 and 310. There are two other editions.

vance to Ship Point (Pointe Aux Barques). He continued up into "Saganaw" Bay to "Point Aux Chênes," i. e. Oak Point, and then crossed the bay, stopping at an island "which the Indians called Shawangunk," composed of a dark colored limestone, of dull and earthy fracture and compact structure. It presents broken and denuded edges at the water level." He observed in it nodular masses of chalcedony and calcspar. "The margin of the island bears fragments of the boulder stratum."

This must be Charity Island, as he says it is about midway of the bay, and he says it is the largest of a group of islands, and southernmost in position. Usually there are but two islands placed upon the map, but when we were there in 1896 there was a small bar just out of water about half way between, and as we see from Plate V, at the time of Schoolcraft's expedition the lake was very low, and between that and 1856 some wearing away may have been done. We cannot understand how Schoolcraft called the largest island "southernmost." By a not unnatural mistake in an early explorer coasting along the shore he identified this limestone with that around Thunder Bay. For a long time investigation like settlement was superficial, and mainly along the shore of the county, and waited for the ax of the woodman to strip it of its covering of pine and lay it bare for exploration.

§ 2. Previous geological reports, Houghton, Winchell, Rominger. inger.

The very first annual report of the State Geologist* mentions the cliffs of Point aux Barques, whose picturesque beauty, reminding one of the prows and sterns of vessels, drawn up on the shore like the Greek fleet before Troy, suggested the name of the point to the fancy of the early voyageur (Pl. II).

Houghton's second annual report refers to the limestone of the Charity Island,† and the fourth annual report contains in Bela Hubbard's sub-report further details, and a correlation of the Point aux Barques sandstones with the Waverly sandstone of Ohio.‡ In the state library are two old Mss. maps which I have used and think belong to Houghton's survey.§ With the untimely death of Doug-

*Douglass Houghton: Report of the State Geologist, 1838, H. R. No. 14, p. 9. Also H. D. No. 24, pp. 276-317 and S. D. No. 16.

†Second Annual Report of the State Geologist, 1839. H. D. No. 23, pp. 386-507, S. D. No. 12, pp. 264-391, H. R. No. 23 and S. R. No. 23 (misprinted No. 13).

‡1841, p. 567 of H. S. and J. D. No. 11, pp. 472-697. This report was also issued separately as H. D. No. 27.

§For the magnetic variation on the coast at Sec. 17, Grove Township, is given at 1° 10′ 0″ E., whereas in 1858 the Lake Survey found it to be 8° 30′ E. at nearly the same point. Also a Mss. note refers to the state of a ledge in 1842, and there are many geological notes.

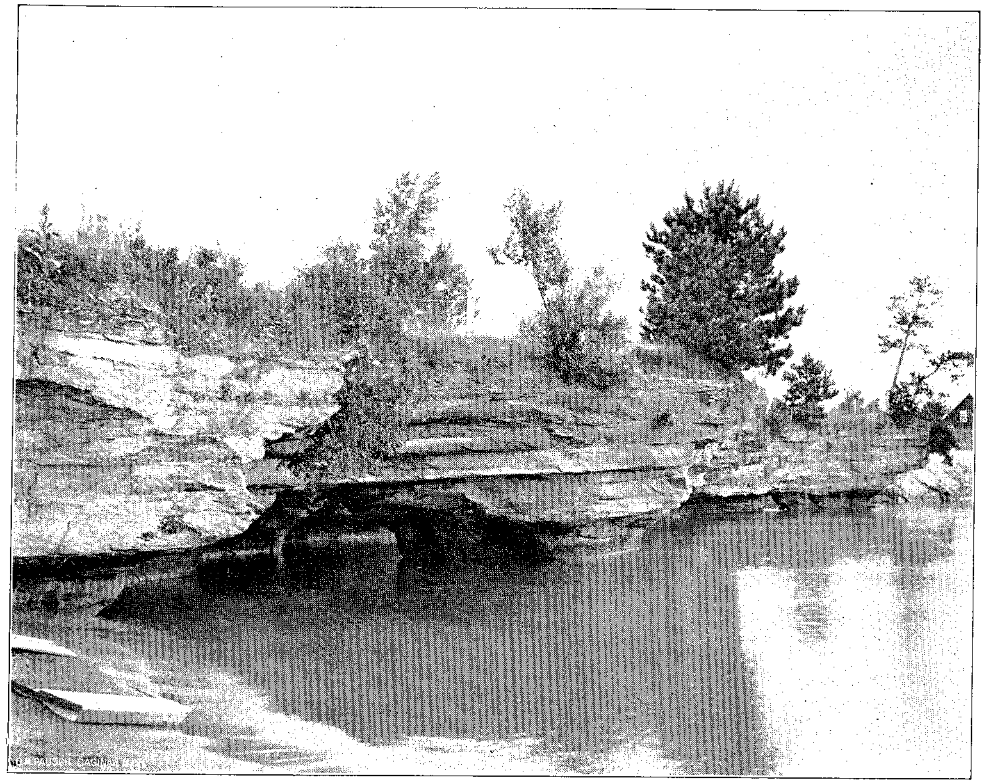


PLATE II.

Illustrates the resemblance of the cliffs at Point Aux Barques to the sterns of steamers, a small tree frequently playing the part of a flagstaff; the cliffs are composed of Lower Marshall sandstone and their upper level is determined by the Algonquin terrace.

(Reproduced through the courtesy of the F. & P. M. R. R.)

lass Houghton the Geological Survey stopped, and we have a period during which there is little recorded advance in local geological investigation. Yet during this time in 1850 the famous grindstone quarries were opened by Capt. A. C. Poor, and the product soon became widely known.

In the latter part of the fifties Alexander Winchell, Michigan's most eminent geologist, began his work and in his first report* we find a careful description of the rocks exposed along the shore. On page 75 he describes the rocks around the Point aux Barques lighthouse, and the grindstone quarries. On pages 80 to 82 he gives a description of the rocks of the Marshall group from Hardwood Point, on Sec. 35, T. 19 N., R. 12 E., past Flat Rock Point, "Point au Pain Sucré," to Point aux Barques. On page 88 he describes Pt. au Chapeau, on Sec. 7, T. 18 N., R. 12 E., as belonging to his Napoleon Group. The "Michigan Salt Group" he divined, without actually seeing it exposed, to be near the mouth of the Pigeon River, i. e., Caseville. This conclusion which we have verified, is a marked illustration of his sagacity as a geologist.

The Carboniferous limestone he recognized (p. 100) near the Shebeon, "Cheboyong" Creek, on the S. W. ¼ of Sec. 22, and the N. W. ¼ of Sec. 13, [Sic.] T. 16 N., R. 9 E., and on the shore of Wild Fowl Bay and its islands, viz.: on "Shungwoigue," otherwise called Stone Island, and on "Ashquaguindaigue," now known as North Island.

Finally he estimated that the coal formation should strike the lake near Sebewaing,—and the position of the Sebewaing coal mines, located as they are near the margin of the coal basin verifies his prediction (p. 121). Winchell was much interested in the rocks of Huron county, especially from a palæontological point of view, and he continued for many years publishing papers† in which fossils

---

*First Biennial Report of the Progress of the Geological Survey of Michigan. Dec. 31, 1860, Lansing, 8-vo., pp. 339.

†1862. Descriptions of Fossils from the Marshall and Huron Groups of Michigan. Proc. Acad. Nat. Sci., Phila., XIV, 1862, pp. 405-430.

1862. Amer. Jour. Sci. and Arts, 2d Series, XXXIII, p. 353.

1863. Descriptions of Fossils from the Yellow Sandstones lying beneath the "Burlington Limestone" at Burlington, Iowa. Proc. Acad. Nat. Sci. Phila., XV, 1863, pp. 2-24.

On the Identification of the Cattskill Red Sandstone Group with the Chemung. Amer. Journ. Sci. & Arts, 2d Series, XXXV, 1863, pp. 61-62.

1865. Descriptions of New Species of Fossils, from the Marshall Group of Michigan, and its supposed equivalents in other states. Proc. Acad. Nat. Sci. Phila., XVII, 1865, pp. 109-133.

1865. Some Indications of a Northward Transportation of Drift Material in the Lower Peninsula of Michigan. Amer. Journ. Sci. & Arts, 2d Series, XL, pp. 331-338.

1869. The Mineral Fertilizers of Michigan, Report Department of Agriculture, Washington, Second Session, 44th Congress.

1871. On the Geological Age and Equivalents of the Marshall Group. Proc. Am. Philos. Soc., XI, 1871, pp. 57-82, 385-418.

1871. Notes and Descriptions of Fossils from the Marshall Group of the Western States, with Notes on Fossils from other Formations. Proc. Am. Philosophical Soc., XI, pp. 245-260.

collected from Huron county were described or compared, which we can only refer to here, leaving their fuller discussion to the palæontological part of the report, Chapter X.

Beside the papers mentioned in the foot note, which relate more particularly to the palæontology, other papers bearing more or less on the physical geography or geology of Michigan are as follows:

In 1871 he published an article in Harper's Monthly on the climate of the Great Lakes (XLIII, p. 279-281), to which we shall have to refer. In 1873 he prepared for Walling's Atlas (republished in 1883 by R. M. and S. J. Tackabury) a number of articles which were reprinted under the title "Michigan, Being Condensed, Popular Sketches of the Topography, Climate and Geology of the State" (8vo., pp. 121).

In 1875 he published a rectification of the geological map of Michigan, that he had prepared for Walling's Atlas,* and in 1878 prepared the chapter on Michigan in J. Macfarlane's "Geological Railway Guide," which gives the geological formation supposed to underlie each station. This book was revised in subsequent editions up to 1890. While, however, there is some progress indicated in these publications in the general conceptions of the geology of the state, there is nothing added to the detailed geology of Huron county which calls for especial mention.

In the meantime Dr. Carl Rominger had published in 1876 his principal work on the geology of the Lower Peninsula,—Volume III of the Reports of the Geological Survey of Michigan. That volume also contains a very valuable appendix by Dr. Garrigues, State Salt Inspector, on the various deep borings and their brines. In that report, which we do not summarize here as it is of the same series as this report, many outcrops not before noticed and many new deep borings, were described from Huron county, and a number of fossils, the two forms of Lithostrotion being figured. All these will be referred to in due place. Dr. Rominger added much to our detailed knowledge of Huron county and as we shall see took a somewhat different view of the stratigraphy around Port Austin from that taken by Winchell.†

The opening of the Sebewaing coal mines in 1890-1891 was announced in the reports of the Commissioners of Mineral Statistics, for 1890 and for 1891‡. On the map accompanying Rominger's report this area was indicated as outside the Coal Measures.

*Proc. Am. Ass. Adv. Sci., XXIV, Part 2, pp. 27-43.
†Loc. cit., p. 76.
‡C. D. Lawton, 1890, p. 66; J. P. Edwards, 1891, p. 119.

§ 3. Recent work.

In 1892, when the present writer under the direction of the then State Geologist, M. E. Wadsworth, began editing the well records and other material which had been collected by Dr. Wadsworth's predecessor, C. E. Wright, his attention was naturally called to the discrepant views of earlier geologists, and, especially by Hon W. L. Webber of Saginaw, to the advances that had since been made in the development of the county. Beside the coal mining and grindstone quarrying there had been considerable quarrying around in the neighborhood of Wild Fowl Bay, the large Bayport quarries being opened in 1888. Thus, though the report of Volume V gave the data then at hand, the county was recognized as one where farther field work promised economic and scientific rewards. The writer made a preliminary visit in December, 1895, and in 1896 the summer was spent in field work there. During part of the time he was assisted by Dr. C. H. Gordon, and by Prof. C. A. Davis of Alma College. Prof. Davis and the writer have worked Ranges 12, 13 and 14 together, and the botanical notes are entirely, and the plan of the chemical work largely, due to Prof. Davis. The western Ranges 9, 10 and 11, have been more particularly studied by the writer who is also generally responsible for the assembling of the data, the language of the report, and the construction or preparation of the illustrations.

During the same summer Messrs. F. B. Taylor and G. K. Gilbert of the U. S. Geological Survey made a rapid visit to the county, being engaged in tracing the old lake shores. The result of Mr. Taylor's work was given to the public that summer at the meeting of the Geological Society of America, and published in an important paper to which we shall have frequent occasion to refer.* A map from this paper we have with his permission reproduced in Plate VI, as it gives a good idea of the general relations of Huron county geographically as well as its position and relations during the Champlain epoch and in general we are guided by Taylor in naming and correlating the beaches.

The county has also occasionally been visited by other geologists, whose notes so far as we are informed have not been given to the public.

This report was chiefly written in the winter of 1896-97. In the fall of 1897, incited thereto by the writer, who sent a short unpub-

*Bull. G. S. A., 1897, Vol. VIII, pp. 31-53.

lished abstract of his results to the meeting of the A. A. A. S. in Detroit, that fall, the county was visited by W. F. Cooper, who has done much work on similar beds in Ohio, and by Mr. George F. Girty of the United States Geological Survey. The writer guiding Mr. Girty also revisited the county, especially studying the eastern part around Harbor Beach which he had not previously visited, and doing some additional work on Ranges 14 and 15, and studying the rate of erosion on the eastern shore. Mr. Girty and Mr. Cooper have added to our palæontological knowledge of the county, and material by Prof. A. Winchell and by Mr. Cooper add much to the value of the palæontological chapter.

At the same meeting Mr. Gilbert read a paper on the change of level of the land around the Great Lakes,* which incorporates some observations which he made or had made in the county. Other work has prevented anything but a cursory revision, prior to publication, in the fall of 1899. Some work for the survey on the clays and shales by H. Ries and on coal by H. J. Williams has been included.

§ 4. Acknowledgments.

While Messrs. Gordon, Davis, Cooper and the writer have been directly employed by the Survey, the value of this report is largely due to the records carefully kept and freely furnished them by others, whose disinterested love for science and appreciation of the importance of scientific facts deserve a word of mention here. Too often are records and samples which are of great scientific value, and may later be of money value, thrown away because of no immediate importance.

Among those who have thus furnished valuable material to the Survey, Hon. W. L. Webber of Saginaw may first be mentioned, for the whole determination of altitudes rests primarily on lines of levels freely furnished by him, without which the work would everywhere be distinctly less accurate. Not only this, but he has also given access to records of various explorations, and rendered the work of the Survey every assistance in his power.

The officials of the Pere Marquette Railroad Company have also been most courteous, both in response to inquiries, in loaning illustrations and in other ways. Much information has also been derived from well drillers, who have always shown a willingness to help the Survey in its work. For example Mr. John Russell of

*Nat. Geog. Magazine, Sept. 1897, VIII, pp. 233-247; also 18th Annual Report U. S. Geol. Survey, 1898, Part II, p. 624.

Unionville, to whom is largely due the credit for the development of the Sebewaing coal mines, gave access to the records of borings for water which he has been carefully keeping for years, and he and Messrs. Hofmeister, Bullock, Smith and others have saved samples of the wells they were engaged upon. Want of space forbids a detailed enumeration of all those residents of the county who have assisted us. Their names will, to a large extent, be found scattered through the report as authority for the various data. In return for their courtesy it is hoped that this report may do something toward advancing the interests of the county, assisting in more intelligent and economical development of its water supply, in more extended use of its other varied natural resources and in more interesting teaching of physical geography and natural history by illustrations drawn from natural features near at hand. Outside the district the Survey is under obligations to Bryant Walker, Esq., of Detroit, who has determined the shells of the shell marl, with the exception of the Pisidia; to Dr. Victor Sterki, who determined the latter, to the U. S. Geological Survey for numerous favors, and to the U. S. War Department for loan of original field sheets to be photographed.

§ 5. Maps.

The maps in the State Library referred to are interesting as recording forgotten names and islands which have vanished.

The only geological maps of Huron county are those incorporated in some general map like those issued by Winchell in Walling's Atlas (loc. cit.) and by Rominger and Lane, in Volume III, respectively V, of this series of reports. As to the topographical maps, the early maps prior to the U. S. Land Survey in 1845 and 1848, are sufficiently well represented by Jeremiah Greenleaf's Universal Atlas of 1848. They are far from accurate. White Rock is half way down in Sanilac county. Willow Creek, called Black River, empties into a marked bay between Rogers Point and Pt. aux Barques, which is about where Burnt Cabin Point should be. Sugar Point is perhaps Flatrock Point, and the Pigeon River masquerades as Sugar River. Oak Point is Pt au Chenes. Charity Island is Shawangunk, and the islands off Wild Fowl Bay are rolled up into one mythical I. au Traverse and planted square across Saginaw Bay.

1856. Farmer's map in 6 sheets, $7\frac{1}{2}$ miles to the inch, summarizes the result of the United Land Survey, and was a most excellent map. This was issued and reissued, in various scales and at various dates.

1871. Walling's County Atlas of Michigan, already mentioned, contains beside the geological map of the state, a separate map of Huron county, which is interesting historically, in showing streams lakes and roads now no more, and occasionally it is more accurate than recent maps. We used blue prints of this to some extent. It was derived from the notes of the United States Land Office, and shows the original courses of the streams which have in some cases been much changed by ditches. The Land Office maps also show the original swamp areas.

1872. I have a sectional map of this date with no author nor publisher given which seems to follow Mss. maps in the State Library at the Capitol, that are independent of the U. S. Land Office, already referred to.

1875. In this year a large county map on the scale of two inches to one mile was issued by F. W. Beers of Philadelphia. This map showed ownerships.

1883. The Walling atlas was reissued with added railroads by Tackabury.

1890. An Atlas of Huron county was published by E. R. Cookingham and Company, with a general map of the county on a scale of one-half inch to one mile, with township maps on a scale of two inches to one mile, and village plats mainly on a scale of four hundred feet to one inch. These were largely constructed from deeds in the County Records, and have been the principal base of our map. Some use has also been made by us of the profiles of drains filed in the office of the County Drain Commissioner.

In 1856-7. The United States Lake Survey carefully surveyed the coast of Lake Huron in this region, and the Chart of Saginaw Bay, published in 1860, gives the results on a scale of 1: 120,000, very nearly one-half inch to the mile. As above mentioned we have been permitted to use photographs of the field sheets, which were on a scale of 1: 16,000.

The following list of names which have been applied to the geographical features may be of service. There are three types of names,—those of English, of French, and of Indian derivation. In many cases one is a translation of the other.

TABLE I.—GEOGRAPHIC NAMES OF HURON COUN
NAMES ARE ITALICIZED. THE ORDER IS GEOGR
THE S. W. CORNER.

English.	Authority.
White Rock	C., L.O.,T,Ro., R.R
White River	C., T.H.
Elm Creek	C., T., L.S
Purdy Bay, Sec. 5, White Rock Tp.	L.S
Sharpe Bay, Sec. 35, T. 16 N., R. 16 E.	L.S
Allen Creek	T., L.S.
Rock Falls	C., L.O.
Spring Creek	T.
Center Harbor	L.S
Crane Point	
Drowned Point	
Forest Bay	L S
Hardwood Point Creek, emptying on Sec. 15, Rubicon Tp.	L.S
Whiskey Harbor	S.
Diamond Creek	T.
{ Section 29 Gore Tp.	M.H.
{ Poplar Pt.	
Rogers Pt., Sec. 12 Huron Tp.	H.W., R.R.
{ *Willow River*	T.S
{ Black River	M., H.
{ New River	T., R., L.S., M...
{ Pine River and Bay	H
Burnt Cabin Pt.	L.O., Wi., Ro., K.
Eagle Bay	
Ship Point	S.
Grant Creek	C.
Birds Creek	C.
Flat Rock Point	L.O., T., Wi., Ro.
Hard Wood Point	Wi., L.S.
{ Partridge River	L.S
{ Pigeon River	H.
{ *Hat Point*	L.O., Ro., L.S...
{ Or Loosemore Point	Local
Rush Lake	C., L.O., T., L.
Little Oak Point	L.S
Oak Point	L.O., T., L.S., H
Pigeon River	L.O., Wi., R.R.,
{ *Charity Island*	T.L.S.
{ Great Charity Island	Wi.
{ North Charity Island	
{ *Little Charity Island*	Wi.
{ South Charity Island	
{ *Sand Point*	L.O., T., R.R., L.
{ Fishing Point	
Mud Creek	
Wild Fowl Bay	L.O., T., Wi., R
North Island	C., L.O., T., L.S
{ Stone	Wi.
{ *Stony*	L.O., L.S.
{ Spooney	R.R
{ Heisterman	C.
{	
{ Heinzelman?	Ro
Warner	R.R.
N. Pond Island	R.R., M.
S. Pond I.	R.R., F.
Pond I.	H.

Abbrevations:
Schoolcraft's Narrative, S.
U. S. Land Office. L. O.
U. S. Lake Survey, L. S.
Walling Atlas, and Tackabury's reissue, 1883, T.
Cookingham's Atlas, C.

Valling's County Atlas of Michigan, already mentioned, eside the geological map of the state, a separate map of nty, which is interesting historically, in showing streams roads now no more, and occasionally it is more accurate t maps. We used blue prints of this to some extent. It d from the notes of the United States Land Office, and original courses of the streams which have in some cases changed by ditches. The Land Office maps also show l swamp areas.

have a sectional map of this date with no author nor given which seems to follow Mss. maps in the State Li- e Capitol, that are independent of the U. S. Land Office, erred to.

this year a large county map on the scale of two inches e was issued by F. W. Beers of Philadelphia. This map nerships.

he Walling atlas was reissued with added railroads by

n Atlas of Huron county was published by E. R. Cook- l Company, with a general map of the county on a scale inch to one mile, with township maps on a scale of two ne mile, and village plats mainly on a scale of four hun- o one inch. These were largely constructed from deeds ty Records, and have been the principal base of our map. as also been made by us of the profiles of drains filed in f the County Drain Commissioner.

. The United States Lake Survey carefully surveyed the ke Huron in this region, and the Chart of Saginaw Bay, n 1860, gives the results on a scale of 1: 120,000, very half inch to the mile. As above mentioned we have been o use photographs of the field sheets, which were on a 16,000.

wing list of names which have been applied to the geo- features may be of service. There are three types of ose of English, of French, and of Indian derivation. In one is a translation of the other.

TABLE I.—GEOGRAPHIC NAMES OF HURON COUNTY, SHOWING EQUIVALENTS USED BY SUNDRY AUTHORITIES. PREFERRED NAMES ARE ITALICIZED. THE ORDER IS GEOGRAPHICAL FROM THE S. E. CORNER OF THE COUNTY AROUND BY THE NORTH TO THE S. W. CORNER.

English.	Authority.	French.	Authority.	Indian.	Authority.
White Rock	C., L.O., T., Ro., R.R., L.S., F.	Roche Blanche	S. H.		
White River	C., T.H.	R. Blanche H.			
Elm Creek	C., T., L.S.			Zappapoie R.	M. H.
Purdy Bay, Sec. 5, White Rock Tp.	L.S				
Sharpe Bay, Sec. 35, T. 16 N., R. 16 E.	L.S				
Allen Creek	T., L.S.				
Rock Falls	C., L.O.				
Spring Creek	T.				
Center Harbor	L.S.				
Crane Point					
Drowned Point					
Forest Bay	L S				
Hardwood Point Creek, emptying on Sec. 15, Rubicon Tp.	L.S	R. Sansom M., H.			
Whiskey Harbor	S.				
Diamond Creek	T.				
{ Section 29 Gore Tp.	M.H.				
{ Poplar Pt.					
Rogers Pt., Sec. 12 Huron Tp.	H.W., R.R.				
{ *Willow River*	T.S				
{ Black River	M., H.				
{ New River	T., R., L.S., M.				
{ Pine River and Bay	H.				
Burnt Cabin Pt.	L.O., Wi., Ro., K., L., S.F.				
Eagle Bay		{ Point of Barques	Ro.		
Ship Point	S.	{ *Point aux Barques*	C.L., O., Wi.		
		{ Pointe aux Barques	T.L.S., M.F.H.		
		{ Point au Barques	M.		
Grant Creek	C.				
Birds Creek	C.				
Flat Rock Point	L.O., T., Wi., Ro., L.S.	{ Point au Pain Sucre	Wi., F.		
		{ Pointe au Pain de Sucre	H.		
Hard Wood Point	Wi., L.S.				
{ Partridge River	L.S	{ Point of Barques R.	R., L.O.	{ Pinnegog	Ro.
{ Pigeon River	H.	{ R. aux Tourtes	H.	{ Pinnepog	T., R.R.
				{ *Pinnebog*	C., M.
{ *Hat Point*	L.O., Ro., L.S.	Point au Chapeau	M., Wi.		
{ Or Loosemore Point	Local	Pointe au Chapeau	H.		
Rush Lake	C., L.O., T., L. S., F.				
Little Oak Point	L.S.				
Oak Point	L.O., T., L.S., H.	{ Point aux Chênes	S.M.		
		{ Pointe aux Chênes			
Pigeon River	L.O., Wi., R.R., S.F.	R. Croche	M., H.		
{ *Charity Island*	T.L.S.				
{ Great Charity Island	Wi.			Shawangunk	S., Greenleaf.
{ North Charity Island					
{ *Little Charity Island*	Wi.				
{ South Charity Island					
{ *Sand Point*	L.O., T., R.R., L.S.	{ Point Charities	C.		
{ Fishing Point		{ Pointe aux Sables	M.		
		{ Pointe au Sables	H.		
Mud Creek					
Wild Fowl Bay	L.O., T., Wi., Ro., R.R.			{ Ash-qua-guin-dai-gue	F.
North Island	C., L.O., T., L.S.			{ Ash-qua-quin-dai-gue	Wi.
				{ Ashe-quai-gwin-dai-gue	H.
				{ Ashe-quai-gwin-dai-que	
{ Stone	Wi.			{ Shungwoique	H.
{ *Stony*	L.O., L.S.			{ Ching-Qua-Ka	T.
{ Spooney	R.R.			{ Shung-woi-gue	Wi., F.
{ Heisterman	C.			{ Shong-woi-que	M.
				{ Kate-choi	M.
{ Heinzelman?	Ro			{ Ka-te-chai	C.F.H.
				{ Ka-te-chay	L.S.
Warner	R.R.	{ Maisou	C.	{ Ka-te-chi	T.
		{ Maison	T., R. R.	{ Ka-te-shay	L.O.
N. Pond Island	R.R., M.			{ N. Mineshas	L.S.
				{ *N. Minishas*	L.O.
S. Pond I.	R.R., F.			{ S. Mineshas	L.S.
Pond I.	H.			{ *S. Minishas*	L.O.
				Shebeon	C.
				Cheboyong	Wi.
				Sebewaing	{ C.T., Wi., R.R., L.S., M.
		R. du Fil. M.F.		Sibbewing	}

Abbrevations:
- Schoolcraft's Narrative, S.
- U. S. Land Office, L. O.
- U. S. Lake Survey, L. S.
- Walling Atlas, and Tackabury's reissue, 1883, T.
- Cookingham's Atlas, C.
- Winchell's Geological Report, 1860, Wi.
- Rand McNally; Railroad Folders, etc., R. R.
- Rominger's Geological Report, 1869-1873, Ro.
- Sectional Map of Michigan, 1872, M.
- Farmer's map, F.
- Mss. Maps of Houghton's Survey, H.

CHAPTER II.

GEOLOGICAL COLUMN.

§ 1. Pleistocene, i. e., unconsolidated materials, soils, and subsoils. (a)*

Although repetition is involved, it is best to give at once a general account of the principal materials which make up the frame of the county, geologically speaking, whether rocks in the popular sense, or soils, or subsoils. At the same time we may give some reference to their nearest representatives elsewhere, for so one will be able to understand more intelligently references to them scattered through the text. A more detailed account of their character may be gathered from the chapter devoted to their distribution.

An imaginary section down into the earth's crust, showing the various materials of which it is composed at any place, is called the geological column at any place. Plate LXXIII of Vol. V, of these reports, gives such a geological column for the Lower Peninsula. We proceed therefore, to give an account of the geological column under Huron county (Pl. I).

Our first division includes the materials most recently laid down, or even now in process of formation. Such are the finer material, called sand, and the coarser material,—called shingle and gravel,— of the present shore lines. Along the west coast the sand is frequently blown back from the beach into undulating mounds known as dunes. Off shore and in shallow waters muds and oozes are forming. The streams deposit "alluvium," that is silt and sands and even gravels, especially along their courses upon their flood plains in times of freshet. In the smaller lakes and in the great lake in sheltered stretches we find shell marls forming, mixtures of mud, decayed vegetation and the cast off shells of fresh water snails and similar animals with precipitated lime. Such shell marls make, if drained, a wonderfully fertile soil and are also coming into

*This letter and corresponding letters in parentheses below, have the same meaning as in Plate LXXIII of Vol. V.

demand for the making of cement. Such a lake, once known as Bear Lake, has been drained just southwest of Port Austin and the land is said to yield unusually large crops of timothy. Out from the edges of the lakes, as is well seen around Rush Lake, the marsh creeps slowly but surely, fills them up, and makes deposits of muck or peat, converting them into swamp. Occasionally masses, or irregular sheets, of bog iron ore are formed, the iron ore being leached by organic acids out of the surrounding sands, which are left unusually white, the iron being later reoxidized and deposited.* Waters thus charged with dissolved iron become covered with an iridescent scum on becoming exposed to the air. Such scums are well marked on the shore west of Caseville, and are sometimes mistaken for oil, by those who do not observe closely, but they lack the characteristic odor, and the sheet of scum breaks up into angular forms. A similar type of chemical deposit is that formed by the deposition of lime from calcareous springs when they reach the surface. Such deposits of calcareous tufa or travertine, as they are called when they form exposed to the air, were observed around a spring in the bank of Willow Creek, while if they form beneath lakes or bogs they produce marl or bog lime. Similar materials to those now forming in these different ways we also find where they cannot have been formed under present conditions. Thus rolling ridges of dune sand swing southwest from Caseville to Bayport, cutting off Sand Point, far from the present shore line. Thus, too, south of Badaxe beds of shell marl exist under the muck, where there is no longer any pond, and even the marsh is fast being drained. Again near Huron City cliffs overlook benches of shingle, where no storm could now sweep the waves of Lake Huron. Around Pigeon, Elkton, and Badaxe, and often elsewhere we find beds of clay evidently deposited in a body of water. In fact all over the county ridges of sand and gravel are found, and long trains of boulders, which are like the present shore line formations.

These we still class as recent deposits, but we see that we must look far enough back into history for the time of their origin, to find a somewhat different physical geography from the present. In the county we also find deposits, still unconsolidated, and not rock in the popular sense, but often firmer and more solid than those already mentioned and classed as "hardpan," whose origin we can

*Prof. Davis observed a good instance of this leaching of iron oxide on the southeast ¼ of Sec. 36, T. 15 N., R. 10 E., Sp. 19174.

ascribe to no agent now working in the county. The deeper cuts in the hills around Verona or Ubly show well these deposits. All water deposits show some banding and stratification and in them the material is assorted according to grain, and especially is the very fine clayey material (0.005 mm. in diameter or less) washed out from the coarser and deposited separately. The coarser stones are also more or less rolled and rounded. But in the material we are considering, whose shortest name is "till,"* we find stones of various sizes and irregular, frequently of angular or grotesque shape, firmly compacted together with a clayey cement. The stones and boulders which we find in this deposit, and also strewn over the surface of the county, are not derived altogether from rocks which are to be found in ledges in the county, but come from far away in Canada,—a conspicuous jasper conglomerate with blood red bits of jasper sprinkled here and there in the white quartz, masses of vein-quartz, heavily loaded with pyrite, granite, hornblende and staurolite schist, etc. This material is such as is deposited under glaciers, and the glacially grooved surfaces of the limestone in the Bayport quarries (Pl. IX) also give evidences of the presence of a vast sheet of ice that once came down from Canada, and crept heavily over the country down to the Ohio River. The period of this ice sheet is known geologically as the Pleistocene, or Quaternary. Contemporaneous with the presence of the ice sheet, deposits like those now forming were laid down in front of its margin, as it retired.†

§ 2. Coal measures of Sebewaing. (b)

The formation known as the Woodville sandstone, a reddish sandstone, separated off by Winchell, but not by Rominger, is not represented. It may perhaps once have existed, for we find the unconsolidated deposits resting on an uneven surface with stream valleys cut into it, which now are entirely filled and hidden. Such a surface indicates what is known as an unconformity between the deposits above and those below. From what has been learned elsewhere we know that this unconformity is a sign that for many more years before the ice period, than have slipped away since that time, this rock surface was a land surface which stood above sea level and was carved and eroded away by running streams. Possibly during that time the Woodville sandstone and others of the uppermost rocks were entirely wasted away.

*The term "boulder clay" is not a very happy one for Huron county for the ground moraine often has not many large stones, and is typically rather a gravelly clay.

†Taylor, loc. cit.

Passing now to what we have left of the Coal Measures, the well records of Sections 7, 8, 17, 18, of Sebewaing township, from about 50 to about 125 feet down, show the character of the rock. Rominger's remark* is quite applicable; "the whole series is a constant alternation of shale and sandstone beds, and every natural or artificial section teaches us that an immense variety exists in this alternation." It will be observed that red colors do not prevail, but white and bluish to black. The shale is in streaks black and bituminous. At two horizons, at least, occur seams of coal, one of which tends to be about 4 feet thick, but may be somewhat thicker, and often is cut out entirely. Sandstones run from white to gray in color. The whole formation is more or less charged with pyrite. Carbonates of iron, magnesia or lime occur in nodules or thin bands and zinc blende (ZnS) may occur in similar form. The clay beds under the coal are often called fire-clay, but the clays like the other beds vary rapidly in short distances. For example the heavy clay in Bauer's well and that in Miller's well, both in Sebewaing were quite different, the one being much "fatter" than the other. Black bits of fossil rushes are not uncommon in them. There are from 50 to 75 feet of clay above the principal coal deposit and less than twenty below it. I assign to this group, say, in all—75 feet.

At the bottom of the Coal Measures a sandstone is separated off by Winchell under the name of Parma sandstone.† But the dip of 45°, which he gives, shows that there is something abnormal about it, and Rominger fails to recognize it as a separate horizon.‡ Only a trace of it is found in Huron county, e. g., in Bauer's well, Sebewaing, from 101-104 feet, though it seems about Bay City and Saginaw to be well marked, but even there it belongs, I conceive, rather with the next group lower.

§ 3. Maxville limestone of Bayport.

The Grand Repids Series (c), in Huron county, can be easily divided into two parts: the upper being the limestone of Bayport, equivalent to the Maxville limestone of Ohio.

This formation is composed of limestone, alternating with, and at times frequently replaced by beds of white sandstone, thus resembling the Kaskaskia of Indiana.§ The sandstone is often calcareous and very fossiliferous, and the limestone is inclined to be very cherty with rounded siliceous concretions. The lower beds are often brown and dolomitic. The first fifty feet of the Bayport limestone quarry section,—on Sec. 5, T. 16 N., R. 10 E. (Fig. 8), is the most detailed division of the formation that we have. It dwindles to some 20 feet around Sebewaing (Sec. 8, T. 15 N., R. 9 E.). As above said, I believe that this formation in its sandy phase is the Parma sandstone, and we have not been able to follow in detail the subdivisions made by Winchell. It is a good source of water. It is the equivalent of the Maxville limestone of Ohio, which has been identified with the St. Louis-Chester (or, as it is now called, the Kaskaskia), as is evident from comparison of the fossils with those of Plates IX and X of Whitfield's paper on the Ohio Subcarboniferous.* For geographic reasons explained a page or two beyond I correlate it with the upper St. Louis, as long ago suggested by Winchell from the palæontology. It is also equivalent to the limestone at Grand Rapids, as is evident from a comparison of their fossils. The most abundant genera are Allorisma, Lithostrotion† and Productus. Good natural exposures are found, as stated by Winchell and Rominger.

*Loc. cit. p. 128.
†Loc. cit., 1860, pp. 112, 138.
‡Loc. cit., p. 128.
§20th Annual Report, State Geol. of Indiana, 1895, pp. 330-331.

It is liable to be eroded by underground water channels, which cause sudden drops in the drilling, as at Sebewaing, Sec. 8, T. 15 N., R. 9 E. For a round number, near the maximum we may call its thickness 50 feet.

§ 4. Michigan series (c, 2).‡

This group of rocks is in general soft and forms valleys in the rock surface, as we see from the map (Pl. VIII), and is therefore little exposed. Just off Oak Point and near Soule the lower part of the formation lying on the more resistant sandstone beneath is brought within reach of erosion, and thus exposed to daylight. Light grey and greenish shales, very fine grained, somewhat sandy or micaceous and pyritiferous, predominate but at various levels as around Soule, at about 70 feet above the coarse underlying Napoleon

*Geology of Ohio, Vol. VII.
†The Lithostrotion and Zaphrentis have already been figured by Rominger, Vol. III, Plate LV; other forms will be illustrated in reports on Kent county and Arenac county.
‡I would suggest that from Winchell's name the word salt be dropped. While the group is a source of brines, perhaps, rock salt has hitherto been found in it only as a mineralogical curiosity, the really characteristic mineral being gypsum. Moreover, as there is no other group of strata called simply Michigan the term salt is unnecessary. Finally this group in its characteristic gypsiferous facies occurs extensively in Michigan, and, so far as we know, not outside the State, so that the name Michigan series will be very appropriate. If a local name were desirable the town of Alabaster has best claims to the honor of naming it.

sandstone, occur beds of impure clayey bluish magnesian limestone, weathering buff, which closely resemble those used at Milwaukee for cement.

Toward the bottom of the series (cf. Dufty's and Sovereign's wells in Lake township) the shales are darker and more bituminous. In the shales also occur lenticular beds of gypsum, which is white when pure, but when impure bluish and hardly to be distinguished from shale. About 80 to 120 feet from the bottom of the formation and not far above the cement rock of Soule is the most marked gypsum horizon (see also well on Sec. 36, T. 17 N., R. 11 E.) and at this level and a little higher the water is very bad. There are signs of another gypsum bed about 20 to 30 feet below the top of the shale. In general the water from this formation is scanty, characteristically highly charged with sulphates, and often cathartic, or almost too salt for use. Unfortunately we have no good characteristic set of samples from the thicker part. Bauer's well, Sec. 8, Sebewaing, from 127 to 249 feet and Deeg's well on Sec. 35, Sebewaing, from 66 to 130 feet, are the most complete records we have, but are from its thinner part. Collison's well (Sec. 14, T. 16 N., R. 9 E.) probably gives only the lower part, while it is probable that under Bayport and to the north this Michigan series is two hundred feet thick and perhaps a little more, with argillaceous dolomitic limestone at the bottom and about one-third the way up, and gypsum beds halfway up and also less marked near the top, being thus quite as thick as at Grand Rapids.*

The base of the Michigan series near Soule appears from the wells to be of micaceous shales like those in the Marshall, while near Oak Point, Rominger describes beds like the Soule cement rock directly above the sandstone. Winchell† seems to include some part of these micaceous shaly beds in the Napoleon.

The general correlation of this group we can fix very nicely from geographical considerations. The gypsum beds must have been laid down in a nearly enclosed sea. Hence the adjacent country must have been out of water, and our correlation for these beds must be with some series that is wanting in adjacent regions. Now in just the proper part of the geological column in Ohio there is a group which is wanting in northern Ohio and southern Michigan. "By atrophy or overlap" the Logan Group "is wanting in the Cuy-

*Vol. V, Pl. XXI.
†Am. J. S. XXXIII, 1862, p. 353.

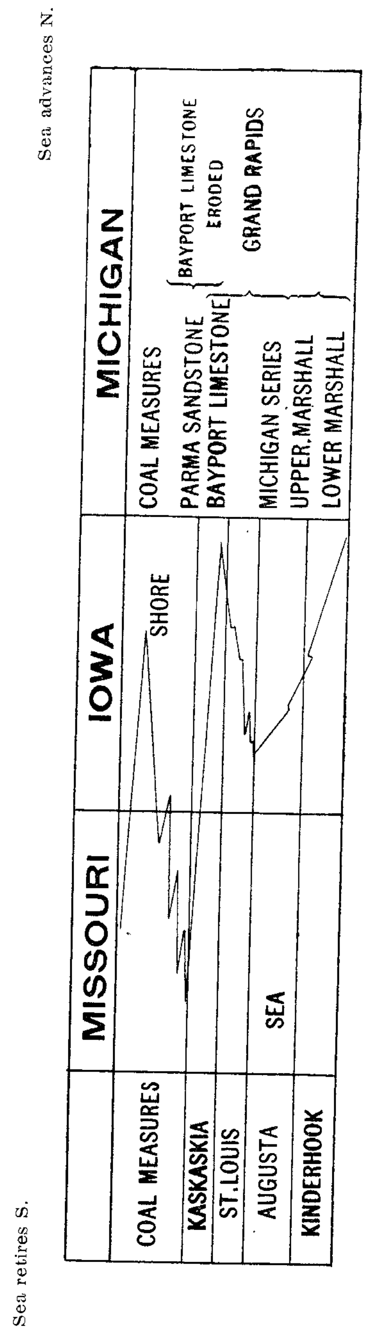


Fig. 2.—After Keyes (Geol. Survey of Iowa, Vol. II, p. 114), showing how the shore line advances to south and returned north during and before the deposition of the coal measures, and connecting the Missouri, Iowa and Michigan beds. The irregular line is as given by Keyes. For the relations of the shore line in Michigan, see text.

ahoga Valley, or is at least very inadequately represented there."* Again if we turn to Indiana we find† that the Burlington has not been satisfactorily identified in that state. In each case the missing part of the column lies close below the St. Louis and Maxville limestones, respectively, which we have identified with the Bayport limestone, and so to anticipate a little we suppose that the general continental emergence which culminated in the heavy sandstones of the Catskill in New York and the Napoleon in Michigan (the former being formed before the latter, as the shore line advanced west and the emergence progressed) finally lifted Ohio and Indiana largely out of water, while part of Michigan remained as a closed basin between these lowlands to the south and the great mass of land to the northeast and (for the indications are that Wisconsin was also out of water) northwest. In the sea thus enclosed the "Michigan Salt Group" was formed, while the Logan Group formed on the other side of the low land which extended through northern Ohio and southern Michigan.

Even as far away as Iowa‡ there are corresponding facts. (Fig. 2.) "In some portions of the Mississippi basin there were very considerable alterations in the coastal

*Geol. Ohio, VII, p. 32; cf. also pp. 510 and 515.
†Geol. and N. H. Survey, 15th Ann. Report State Geologist, 1885-6, p. 12.
‡Iowa Geol. Sur., I, 1892, p. 66.

contour of this broad shallow gulf during the latter part of the Lower Carboniferous, and it is known that there were even greater changes in the coast line in the other parts of this region during the same period. During the Keokuk the waters over portions of Iowa, Illinois, Missouri and Indiana, became greatly diminished in depth, and the land of the same area was considerably extended. While the St. Louis beds were being deposited the sea again encroached upon the land, extending in some places more than 200 miles northward, beyond the former Keokuk waters."

This is illustrated by Fig. 2 and is in complete accord with what we find in Michigan, only we must remember that the effects of an elevation of the Canadian continent would be felt sooner near by in Michigan than in Iowa farther from the old Laurentian land mass, and the effects of depression later. Thus the Bayport limestone will represent the farthest extension of the St. Louis depression,—the top of the St. Louis,—while the beginning of the Michigan (Salt) Series will be earlier than the Keokuk. In other words the Michigan series is closely equivalent to the Augusta, i. e., Burlington and Keokuk formations which are stratigraphically very closely allied.* The palæontological evidence sustains this conclusion. (See Chapter X, § 4.) Its thickness is not out of harmony with our conclusions, for to match with 230 feet of the Augusta in Iowa and 150 feet of the Logan in Ohio, we may estimate the thickness of the Michigan group from the Bayport well, at 232 feet.

§ 5. Marshall series. (d)

Beneath the cement rock series comes an extensive sandstone series which forms the points which project from the north shore of the county from the Babbitt sandstone quarries (Lot 3, Sec. 15, T. 18 N., R. 11 E.), to the grindstone quarries. Of these points Hat Point, Flat Rock Point, and Point aux Barques, are supposed by Rominger to represent the same horizon (loc. cit., p. 75), while Winchell supposes a general descent in the series as we go east. The reasons why I consider Winchell's conception of the column to be more nearly correct are as follows:

The coast of Huron county was lined with saltworks, supplied by deep wells which appear to have drawn their brine largely from the same source, namely the Berea grit. If we compare the depths of these wells we find them steadily deepening to the west through the

*Geol. Sur. Iowa, 1892, I, p. 59.

disputed area, as described below under Chapter V, in a way which does not seem to indicate the anticlinal and synclinal supposed by Rominger. Moreover we can trace the individual beds of sandstone in the shallow wells for water until they run under one another, and by thus showing that they cannot be identical, confirm the presumption raised by the salt wells. For example, the heavy sandstones of Flat Rock Point and Port Austin can be traced in wells and by outcrop (Sec. 3, Dwight, T. 18 N., R. 13 E.) to Sec. 13, Dwight, where Robinson's well starting at their outcrop, runs down 101 feet to draw its water supply from the Point aux Barques sandstone, which can be similarly traced through sections 22, 23, 26 and 35, Port Austin, T. 18 N., R. 13 E., and Sec. 1, Dwight, T. 18 N., R. 13 E., to its outcrop on Willow River (S. 28, Huron township).

It is true, indeed, that about Hardwood Point abnormal dips to the northeast and possibly a fault are indicated, and a much greater maximum thickness for the Marshall series must be allowed than was assumed even by Winchell.* Thus we are somewhat puzzled where to put the base of the Marshall, so as to agree best with his idea, who is the geological sponsor for the word. He speaks, indeed, of the fossils of Hardwood Point (Sec. 35, Port Austin) as the first undoubted Marshall fossils,† and in the same report describes the "gritstones" and grindstone quarries (p. 75) in connection with the underlying shales of the Huron group. On page 80 he alludes to the conglomerate 235 feet below the top of the Lower Marshall as containing some of the fossils of the overlying group, and in the table on page 139 he makes this conglomerate the base of the Marshall and separates the Napoleon from the Marshall, placing the former in the Carboniferous, the latter in the Devonian; later, however, he speaks of the Marshall as "outcropping in the sandstone bluffs of Point aux Barques,‡ and on his map and in his fossil lists and publications he includes in the Marshall the fossils of the grindstone quarries of the Huron gritstones. If we put the base of the Marshall at the base of the Point aux Barques sandstone it would be the best place to have it, in order to make his statement hold true that in the Marshall brachiopods, except Rhynconella are rare. For immediately below comes the zone of [*Camarotœchia R.*] *camerifera* and *Romingerina* [*Centronella*] *julia*, crowded with brachiopods and

*Am. Jour. Sci., 2d Series, Vol. XXXIII, 1862, p. 353, 296 feet; in a later publication 283 feet.
†Report, 1860, p. 80.
‡Walling's Atlas, 1873, p. 41.

with a different faunal aspect from the beds above. However, inasmuch as Winchell distinctly includes these and the fauna of the gritstones,* among his Marshall forms, we are constrained to bring the base down so as to include the quarry beds around Grindstone City, with the associated conglomerates.†

These gritstone beds moreover, seem in their outcrop on Willow River to be coarser and more massive, and more like the Point aux Barques sandstones and in fossils and lithology close allies of the beds above.

Rominger says that Winchell put the base of the Marshall still farther down, just above the conglomerate that underlies the lighthouse (loc. cit., p. 75). This does not appear to have been Winchell's view for we have not only his maps and the numerous references already given, but he distinctly says (Proc. Acad. Nat. Sci., Phila., 1862, p. 406) that the bed in question is intercalated in argillaceous shales of the Huron group and excludes the fossils thereof from the lists of Marshall forms. The other point of Rominger's criticism, that at least 500 feet of rock beds below this horizon present the faunal characteristics of the Cuyahoga shale of Ohio, which forms the upper division of the Waverly group (Subcarboniferous) is well taken, though we must remember that Herrick would divide these shales and assign the lower part of them to the Devonian. There is a practical advantage in drawing the line where we do, in that it may be more easily traced in the well records, and is at the same time of more practical importance. For wells into the Marshall as thus defined are pretty sure to strike good water. Limiting the Marshall thus, it is at maximum 560 feet thick, and we may subdivide it, following Winchell's earlier work into Napoleon or Upper Marshall and Lower Marshall.

§ 6. Napoleon or Upper Marshall sandstone (d 1).

We revive this term from Winchell's report, as being applicable to this county.‡ The Napoleon is typically a white sandstone

*i. e. the quarry beds below which were in his time on Sec. 30, T. 19 N., R. 14 E.; cf. Proc. Acad. Nat. Sci. Phila., 1862, p. 305; Am. Phil. Soc. (1870), Vol. XII, p. 386; Report 1860, p. 74.

†As he does in Am. Jour. Sci., 1862, 2d Series, Vol. XXXIII, as well as in the latter publications.

‡Winchell seems to have abandoned it in 1875. The reason probably was that not finding in the deeper wells of the Saginaw valley any well-pronounced sandstone beneath the 109 feet from 633-742 feet, he concluded as suggested on p. 90 of his 1860 report that this one sandstone represented both his Napoleon and Marshall. Whereas the indications are, as will be shown in the chapter on Stratigraphy, that the lower fossiliferous Marshall of Huron county is there represented by the red shales beneath the sandstone and some of the underlying beds, shown in the record of the Bay City well in Vol. V, Pl. VI, of these reports. Winchell's first thoughts were best.

though often with a faint olive or greenish cast. In well samples it is frequently quite pyritiferous, and to the pyrite is doubtless due small brown mottlings, which appear in it where exposed in outcrop. Hat Point (Sec. 7, T. 18 N., R. 12 E.) seems to be near the base of the formation; if so, there must be nearly 300 feet of sandstone without important interruption. This is indicated both by such wells as Mr. Dufty's on section 32, and Lonsberry's on section 35 of Lake (T. 18 N., R. 11 E.), and by the considerable breadth of its outcrop. To the southeast under cover its recognizable depth rapidly diminishes to somewhat over 100 feet, as at Bayport (135 feet), Pigeon (110 feet), etc. It yields an ample supply of fresh water when properly cased. The thickness of 300 feet above mentioned is not obtained directly, and may include, as did Winchell, some of the bluish micaceous sandy shales which we have estimated in the overlying group. Thus it is probably near a maximum, but implies a dip from Hat Point to Caseville closely in accord with that indicated in other ways, as shown in Chapter V, § 1.

§ 7. Lower Marshall series. (d 2.)

This group is in rocks and fossils a transition one, and varies from point to point. Lithologically it is a transition from the heavy sandstone overlying to the heavy shale formation underlying. There are three prominent types of rock:

(a) A conglomerate with small very round pebbles of white quartz, and a copious clayey cement—the same material as types b and c—which when fresh may be bluish or greenish, but is reddish when weathered. The rock then resembles peanut candy. We may call it peanut conglomerate.

(b) A fine grained bluish sandstone or grit, impregnated with more or less carbonates, especially of iron, and thus passing into clay iron stone, which often cements the sandstone into rounded balls or nodules. When weathered they become very rusty, brown or red.

(c) Bluish micaceous shale which may be very clayey (a wide spread lithological type in the middle Kinderhook; cf. Missouri Geol. Sur., Vol. IV, p. 51). Gradations and interlaminations of these types compose the whole formation which has a characteristic bluish to greenish gray color when fresh and a red color when oxidized, and is throughout quite micaceous and ferruginous. These three facies remind one of the Catskill, Chemung and Portage types of

New York State. The uppermost beds of the group we find on the hill back of Port Austin on Sec. 31, T. 19 N., R. 13 E., underlying the sandstone which caps the hill and is, we suppose, the base of the Napoleon sandstone.*

These uppermost beds are a series of thin bedded, fine grained flaggy slabs, greenish when fresh, deep red when weathered, and contain traces of crinoids, and lamellibranchs. We can trace them in the talus around and down the hill to the southwest, and on the road from Port Crescent they appear somewhat more massive—probably a slightly lower horizon, but the terrace opposite the wave-cut bluff along which the road runs shows a fossiliferous shingle (*Leiopteria torreyi*, Pl. XI, Fig. 2) like that on the hill. Passing next to the shore we find a heavier sandstone and then, some 70 feet below our assumed top, the rocks of Hardwood Point, on Sec. 35, T. 19 N., R. 12 E. These are calcareous flags with Solens, *Goniatites marshallensis, Orthoceras indianense, Nuculana*, and other characteristic Marshall forms. Close beneath, say from 73-75 feet below the top, the rocks become shalier and very micaceous and pass into a plastic blue shale, then becoming sandier and more charged with carbonates they pass into a series of flags which contain a fauna identical with that of Hardwood Point, and in streaks contain abundantly Solens and bryozoa, and lie over the more massive sandstones of Flat Rock Point. Next below we have the heavy white sandstones of Port Austin, pure or with small quartz pebbles, highly crossbedded in two or three layers, the cross bedding dipping in the top layer 45° toward N. 38° E., in the layer back of Broken Rocks, 25° toward S. 10° E. and around Kimball Island northeast again. Winchell says that the first of the series is a bluish gray sandrock 12 feet thick, followed by a whitish and grayish, sometimes yellowish, fine grained sandstone, very pure and massive, occurring in beds 10 to 12 feet thick, without pebbles or seams, and moderately coherent. The sandstone appears fairly white and clean along shore, but from some outcrops in section 23, Dwight, of coarse red, friable, highly fossiliferous sandstone with pectinoids, *Athyris Cf. ohioensis* and *Centronella flora*, and a small Schizodus at the same

*For it is at least 68 feet, probably more, above the top of the Skene well, Port Austin, or 68 + 1225 = 1293 feet above the base of the Berea. Thus as the top of the Napoleon is about 1750 — 120 = 1630 feet above the bottom of the Berea in the Caseville wells, Sec. 35, T. 18 N., R. 10 E., the sandstone is not probably more than 337 feet below the top of the Napoleon sandstone, and is more likely to be somewhat less, thus bringing it at the base of that formarion. Moreover its topographic position, capping the hill, makes it likely to be the relic of a heavy overlying protecting formation.

horizon, and other indications, it is likely that this pure white sandstone is only the result of leaching. Its total thickness seems to be somewhat over 20 feet; our column makes it extend from 85-107 feet below the base of the Napoleon. The Skene well apparently just misses it. Just beneath it, opposite Point of Pines, and rising into sight by a slight undulation to the east of Broken Rocks are some thin-bedded ripple-marked flags with a narrow band of peanut conglomerate, which are the first beds met in the Skene well. We find Goniatites again and Rominger says *Rhynconella camerifera* (Pl. X, Figs. 11 and 12). The beds beneath appear to be fine grained, not porous to water, and soft (not resisting erosion) arenaceous shales, the only somewhat doubtful exposure being along the beach toward Point aux Barques (Sp. 19204), with coaly bits of vegetation and lamellibranchs.

The picturesque cliffs of Point aux Barques are the outcrop of a sandstone which may, upon weathering, become white and indurated, but is then probably deprived of cement, is somewhat greenish and pyritic in aspect, and in the lower part may appear red and striped. It is highly cross-bedded, and that fact as well as its general aspect is well illustrated in Plate III.

The thickness of this sandstone may be taken as 18 feet, say from 176* to 194 feet below the top of the lower Marshall. Below, the beds become gradually thinner and finer grained, more like the grindstone, with no sharp break, and are exposed in the bluffs just north of the southeast corner of Sec. 23, T. 19 N., R. 13 E., until finally we have a little blue shale, and at 220 feet from the top of the formation† narrow seams of calcareous sandstone covered with *Camarotœchia (Rhynconella) camerifera* and *Romingerina (Centronella) julia*. This zone is found just north of the road running northwest from Grindstone City, at 1400 paces north and 900 paces west of the southwest corner of Section 26, T. 19 N., R. 13 E., and also on Willow River, and is one of our datum zones. Underneath it come slabby micaceous green flags and grindstones, with blue shale and perhaps streaks of limestone for some 15 feet until we come, at 235 feet, to a band of peanut conglomerate, probably not persistent, which lies on top of the present grindstone quarries on

*From the Skene well 105 feet + 2.63 miles at 27 feet to the mile = 176 feet; similarly from the Carrington well 1330 feet—1198 feet = 132 feet + 9400 feet distance to Carrington's well × dip of 27 feet to the mile, derived from comparing Grindstone City with Port Austin wells = 180 feet.

†From the Skene well 105 + 4.3 miles at 27 feet dip per mile.

Sec. 23, whence come the famous whetstones. Fifteen feet below, outcropping near the shore at Grindstone City, seems to be another band, similar but richer in fossils, and the whole thickness of the grindstone beds seems to be about 25 feet, making the thickness of the whole Marshall as we have taken it 560 feet. These last twenty-five feet are generally very even grained, and not generally cross-bedded, though occasionally that defect appears and injures the quality of the stone. Sometimes calcareous concretions, i. e., concretions of sandstone more firmly cemented with carbonates of calcium and iron occur, in which fossils, especially Goniatites, may be found. Fish fragments, both teeth and bones and spines are frequent and the surface of occasional seams is strewn with small fragments of woody matter turned into coal, and of fish teeth, which are also blackened.

The formation as defined is prevailingly sandy, while the one subjacent is prevailingly shaly. Bits of land plants, beachworn and battered shells, Solens and lamellibranchs generally, indicate a littoral facies.

The correlation of the Marshall has been, as previously noted, the subject of much discussion. A list of Winchell's papers has been already given, and he gives an elaborate account of the bibliography up to his time, in the article in Vol. XI of the Proceedings of the American Philosophical Society already referred to. Rominger, as we have said, refuses to attempt any very exact correlations, and raises objections to those of Winchell. These objections are in part well founded, but in part he mistakes, it seems to me, the drift of the argument in Winchell's mind. Winchell appears to me not so much concerned to disprove the Carboniferous character of the formation underlying the Marshall, as he is to reclaim at least the Marshall for the Carboniferous. Late researches would, however, draw the line* nearly where Winchell drew it. Rominger adduces two arguments against dividing the Marshall from the underlying and assigning the former to the Carboniferous, and the latter to the Devonian.† The first argument which is the conformity of rock material and stratification which he cites, though true, is not sufficient, for we know that in many parts of the Mississippi basin, there is a perfect conformity between the Devonian and Sub-carboniferous (Mississippian). The second argument that the underlying formation presents the faunal characters of the Cuyahoga shales of Ohio is also true, but its weight will depend upon the ultimate disposition of these shales. The latest Missouri reports assign what used to be termed Lower Kinderhook to the Devonian. The more important recent papers for Ohio are by Herrick.*

*C. L. Herrick (Geol. Ohio, VII, p. 510 et seq.).
†Loc. cit., p. 75.

We find that Herrick subdivides the old Waverly, and assigns part to the Devonian, and part to the Carboniferous. We are able, I think, to make, with the help of Mr. W. F. Cooper, his former assistant, close correlations with his zones,† and thus so determine our strata, that whenever the line between the Devonian and Carboniferous shall be finally fixed in Ohio, which is a question for the general palæontologist, it may be easily extended.

Our section is more complex and thicker than his, and he mentions that the fauna of the first fifty feet of the shale below his conglomerate I contains many Michigan Marshall forms, though his list of freestone fossils seems more akin to ours, even to those of the *C. (R.) camerifera* zone. His next fauna is obtained largely from calcareous nodules in the Cuyahoga shales, some seventy feet more or less below his Conglomerate I and contains a *Prœtus missouriensis* found at the Point aux Barques lighthouse, numerous Spirifers and an assemblage Devonian in habitus, compared with those above.‡ This lighthouse stratum we make to be some 175 feet more or less below the bottom of the Marshall or about twice as far down as the nodule band in Ohio, but the whole formation down to the Berea black shale we find to be thicker (868 feet) than in Ohio (Geol. Ohio, VII, p. 32; 300 or 400 feet thick), in about the same proportion, so that the base of our Marshall might perhaps be coeval with Herrick's base of Division II, though the Schizodus zone of the lighthouse fauna is more like that of the Waverly freestone as a whole, and Mr. Cooper takes the lighthouse conglomerate to be Herrick's No. I.

Concerning the climate of the Marshall as thus defined we may note, somewhat in contrast to the group lying immediately above, that the abundance of mica and sand, feldspar and small pebbles, shows rapid land waste and rock decay while the abundant bits of vegetation show that there was abundant plant life. Both facts

*Geol. Ohio, 1893, VII, p. 495, et seq., summarizing papers in the Bulletins of Denison University, American Geologist, and American Geological Society. See also Bulletin No. 80, U. S. G. S.; Correlation Papers, Devonian-Carboniferous, by H. S. Williams.
†See Chapter X.
‡This fauna has been recognized by W. F. Cooper at Rock Falls with the characteristic nodules.

point to a relatively humid climate. The abundance of iron suggests that the land waste was from a region full of basic rocks.

§ 8. Coldwater shales. (e, 1)

The term Coldwater is nearly equivalent to Winchell's Chemung shales and to the Cuyahoga of Ohio, but as the New York and Ohio names are receiving remodelling, it may be well to cling to the name used in Vol. V, a while longer. Lithologically it corresponds to the Portage shales, for as the formation above is prevailingly sandy though with occasional minor streaks of blue shale, so, conversely, this formation is prevailingly blue shale, with occasional streaks of sandstone, not generally very persistent nor coarse, and when struck under cover salty. Hence as a recent well in Grindstone City shows, not much water can be obtained from it. The base of the bluffs, south of the old grindstone quarries on Sec. 30, T. 19 N., R. 14, shows the top of these blue shales. After about 30 feet the formation is sandier, as found at the top of the New River well.* These flags also seem to form the crest of the bluffs south of Huron City. We seem to trace this horizon in the Port Austin well at 204 feet depth, which our computations make 49 feet below the top of this group. Of these sandier beds there are according to the Eagle Bay well (Sec. 23, T. 19 N., R. 13 E.), some 24 feet, according to Rominger some 20 feet on the hill, and then we get blue clay shale again. Rominger recognized *(Nucula) hubbardi* therein. Willow Creek, at Huron City, exposes a section about 89 feet below the top of the Coldwater formation.†

The lower part is blue shale with compressed lamellibranchs, while the upper part has several sandier seams of dark greenish blue flags, which show their high per cent of carbonates of iron, etc., by weathering very rusty. We measure, beginning at the top:—

6 inches, dirt;

*1750—1029 = 41 feet; by the Eagle Bay well, Sec. 23, T. 19 N., R.13 E., 54-78 feet below surface is grindstone.

†In placing this section at this point in the column some account is taken of altitude, and a dip is assumed of 55 feet to the mile for a strike of N. 26° W., which dip is derived from comparing Grindstone City and Port Hope wells. The strike is probably veering more to the north and the dip is less in proportion, but so long as we compare two points whose distance apart along the strike is not large relative to their distance at right angles thereto, the error involved will not be great, and checking up on the *(Centronella) Romingerina julia* zone where it crosses Willow Creek—it is found near by in the bottom of a well,—we have the position of the Huron City outcrops in the geological column thus determined: 220 (the depth of the *Romingerina julia* zone below the top of the Lower Marshall)—(1.4 miles which is the distance perpendicular to the strike from the outcrop of *Romingerina julia* on Willow Creek to the Huron City bridge outcrop × 55 feet per mile dip)—(the difference in altitude above lake of the two outcrops just mentioned, viz. 60—10)—260 (which is the thickness of the lower Marshall) = 87 feet for the distance of the section above mentioned below the bottom of the Lower Marshall, which checks very well with other computations.

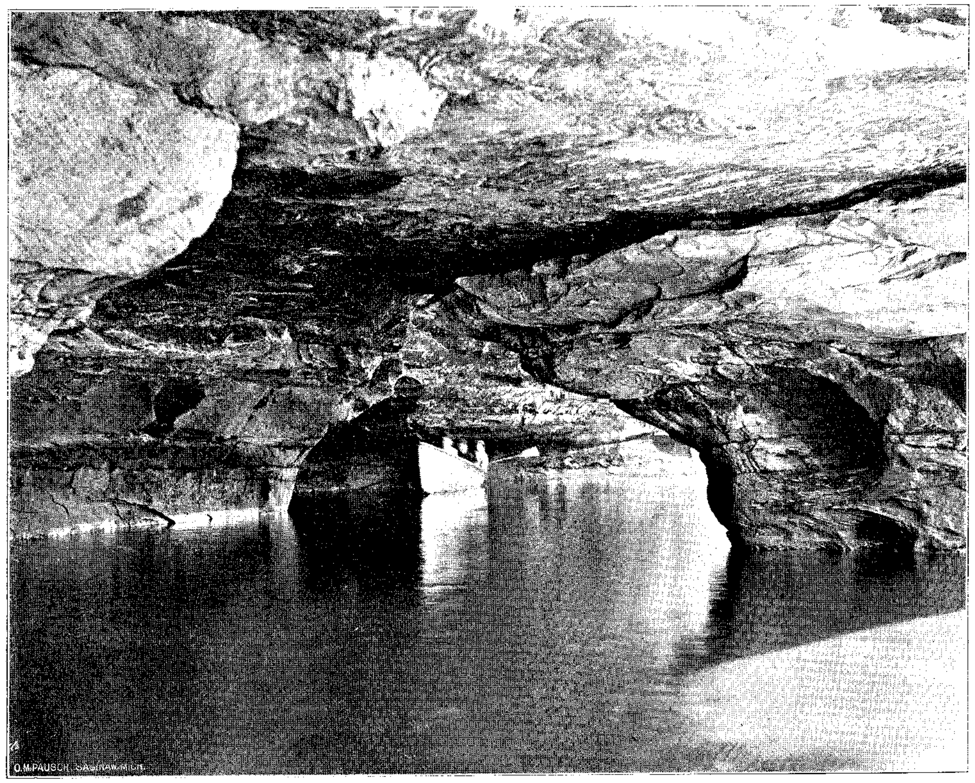


PLATE III.

Illustrates the appearance and cross bedding of the Lower Marshall sandstone at Point Aux Barques; also the undercutting action of the waves and formation of caves.
(Reproduced through the courtesy of the F. & P. M. R. R.)

3 inches, red sandstone seam, with Rhynconella, Sp. 19036, Productus, and Pleurotomaria, Sp. 19039, etc.;

3 inches, barren;

6 inches, sandy;

3 feet blue shale, sparingly fossiliferous; Sp. 19043;

2 feet blue shale; no fossils found.

Below we have arenaceous shales with small seams of sandier nature, fairly continuously exposed until we come to the section given below at the bluffs south of the lighthouse (Fig. 5). I take my section about where the east line of Sec. 11, T. 18 N., R. 14 E., strikes the bluff. Winchell gives slightly different measurements, and his section may have been taken somewhere else. Moreover 40 years has doubtless made a difference in the bluffs, but both sections agree in giving an intermediate portion with a number of seams of sandstone up to two and three feet thick, while blue shales lie above and below. I consider my section of 32 feet to be from 156 to 188 feet below the top of the group as follows:*

A. 11 feet, 3 inches, blue shale;

B. 3 inches narrow band of calcareous sandstone, brown in weathering;

C. 3 feet blue sandy shales;

D. 14 feet 6 inches to 14 feet 10 inches; a compact brown very fossiliferous sandstone, the Schizodus sandstone, which seems to be the principal source of the extensive fauna here collected, Sps. Nos. 19044-19067; at 170 feet from the top of the group;

E. 1 foot 3 inches, blue shale;

F. From 16 feet 1 inch to 19 feet 9 inches, the main bed of sandstone, conglomeratic (pebble of coal!), pyritic, especially the top which is almost a solid layer of pyrite, enclosing and replacing many fossils; at times very calcareous, and again appearing as a white sandstone, the pebbles appearing as small rounded grains of quartz. Sp. 19074 shows the pyritic facies, and Sp. 19068 the conglomerate, and Sp. 19073 the sandstone facies; from 173 to 176 feet from the top of the group;

G. About 12 feet of blue shale to 188 feet below base of Marshall; fossils very rare, but occasional Producti, and Spirifers, and minute forms, (? trilobite larvæ) are to be seen, as illustrated by specimens, Nos. 19076-19084. We may compare the fauna with that

*From *Romingerina julia* zone (3.05 miles × 55 feet deep = 168) + 220 + 60 (altitude of Romingerina zone) — 260 = 188. Compare Port Austin 336 + 105 — 260 = 181, and Caseville 800 to 900 — 120 — 560 = 120 to 220.

of the *Romingerina julia* zone, etc., and find corresponding forms but in the upper zone they are all smaller.

Winchell's section is given on page 75 of the 1860 report.

Though this stratum is so thin, the richness of its fauna, and its apparent persistence and thickening under cover, if, as seems probable, it is the same as that found at 336 feet under Port Austin, and somewhere between 750 and 800 feet under Caseville, in which event it is very likely still more widely recognizable,* make it important, and suggest its correlation with one of Herrick's zones, viz.: Conglomerate I.

Below this the formation grows more and more shaly, with fewer sandy streaks. The outcrops, along shore and south of the mill at Port Hope, of sandy shales, with a fauna like that at Sand Beach seem to be about 283 feet from the top of the formation, and a greenish micaceous sandstone found at 16 feet depth in the Port Hope well may be at 299-305 feet from the top of the formation.†

We may place the horizon of the top of the Sand Beach well near 400 feet below the top of the Coldwater.‡

At about this point in the column are the greenish and bluish micaceous, more or less sandy, shales of the creeks near Sand Beach with Chonetes mentioned by Rominger, (*scitulus?* apparently *pulchella* Win.) and a little lower, 454 to 464 feet below the base of the Marshall, the section of similar shales and shaley sandstones with Chonetes, Goniatites and a Conularia at Rock Falls may be placed. Similar sections are exposed respectively one mile and 4 miles farther south. This is correlated by Mr. W. F. Cooper with the Moots Run section of Ohio. The fauna all along the east shore seems identical, the Chonetes being the most abundant form. The top of the White Rock well must correspond to about 505 feet of the section,§ and this determines the approximate place of the clay

*Vol. V, Pt. II, p. 20.

†1750 — 787 — 680 = 283, or 1680 — 716 — 680 = 284, comparing the Port Hope and Caseville wells, or comparing the Port Hope and New River, 1029 — 787 + 41 — 283, in each case + 16 feet for depth in well.

‡The reports as to the depth of the Berea in this well vary a good deal; a place for the top of the well 368 feet below the base of the Marshall is obtained by correlating 702 feet Sand Beach well with 1750 feet Caseville. Wright's figures, 715, would give 355. Similarly correlating Port Hope 716 with 633 of Sand Beach gives 366 feet, or with 603 feet gives 396 feet, while comparing 787 with 664 would give 406 feet. 664 feet seems to be the more precise figure for the depth of the base of the sandstone in the Sand Beach well, which would make the horizon of the well 406 feet down in the coldwater shales, but it is doubtful if in other wells some 10 feet or so below the sandstone has not also been included in the depth.

§The depths to the different horizons in this well are also variously given. We correlate the bed at 555, White Rock, with that at 664, Sand Beach, making the former 109 feet the lower. If the depth should more correctly be 550, White Rock, we should have the top of the White Rock 114 feet below the top of the Sand Beach well and correlating the top of the Berea, 450 or 495, with 633, of Sand Beach, we

bluffs of arenaceous shale to the south with the indistinct casts of fossils—Goniatites and the like,—which were mentioned by Rominger. To our search they were unfossiliferous and well exposed in a stream bed. They look as though they would make good cement clays.* The well at Forestville, about two miles south of the county line, encounters the Berea at 465-505 feet down and hence its top may be placed at a horizon about 555 feet below the top of this group. But the blue arenaceous shales continue without material change until within some 100 feet of the Berea grit and hence are the lowest rocks outcropping in the county. The rest of the column, Plate I, is only struck in the deeper wells, but to get the full thickness of these bluish green shales we must add to the 396 feet above the Sand Beach well, 500 feet more recorded in the upper part of that well, making 896 feet. Lithologically the rock is equivalent to the Cuyahoga group of Ohio and the shales of Branch county in this State, and is the counterpart of the Portage group of New York, with its sandier beds above and black shales, etc., below, but lying farther westward it doubtless represents a later time when the Michigan part of the continent was undergoing a similar stage of development to that which occurred earlier in New York.

§ 9. Formations not exposed at surface. **Berea shale** (e, 2).

The Sand Beach well gives from 600-603 feet as black shale, with a few feet more of transition, above the Berea grit. The "rotten bad-smelling soft rock" from 800-900 feet of New River doubtless represents the same horizon, and the dark blue shales of Port Hope, from 533 feet down, and the 40 feet of chocolate colored shales above the Berea in the Port Austin well may mark the same horizon. In the Caseville wells it is not reported, but should come, according to our data, from 1548 feet down to the Berea, say 102 feet. This is probably rather more than it really is, though it doubtless exists there, for we find it recognizable in Bay City. But the less we make it, the more we must make the overlying Cuyahoga.

Berea grit (f).

It will be noticed that we assume this famous producer of oil and gas and brine to have been struck in almost all the wells that have been put down for salt, and from it we have computed our funda-

have similarily 117 feet or 183 feet for the difference in horizons between the tops of the wells, while a correlation with the bed at 1225 of the Port Austin well of the bed at 555 feet at White Rock, would give the top of the White Rock well as 142 feet below the horizon of the Sand Beach.

*See Vol. VII, Part I, by H. Ries, for views of and reports of tests on these clays. See also Part III of this volume, on Sanilac county. Plate III.

mental dips. That we are justified in correlating the wells in this way is shown, (1) in some cases by the correspondence of other strata, the Berea shale, the lighthouse sandstone horizon, etc., (2) by the correspondence in the character and thickness of the rock itself, which has been so repeatedly pierced, at such short intervals that there can be hardly a chance for it to escape, as shown by the following succession:

Forestville, 465-505;

White Rock, 495-555;

Harbor (Sand) Beach, 603-664?;

Port Hope, 716-787;

New River, 929-1029—(well penetrates the shales a few feet);

Grindstone City, 1010-1080;

Carrington, Port Austin, 1198 (1100-1200);

Learned, Port Austin, 1160-1225 (well penetrates the shales a few feet);

Hazard, Port Crescent,—1250;

Crawford, Caseville, 1650-1750 (the figures for the base at Caseville vary from 1735 to 1770);

Bayport, 1900 + ? (not reached).

(3) We have also the indirect but most convincing argument that the assumption of this continuous stratum, makes all the other wells and outcrops fall into place as a consistent whole, while the dips derived from this correlation check with those derived independently. (4) The quality of the brine is uniformly better than in strata above or below.

The rock is almost invariably reported as a white, gray or brown sandrock with a plentiful supply of brine. The more reliable measurements show a thickness less than 100 feet, but so near it that in round numbers that figure is generally given. We make it in our column 70 feet.

Only three wells have penetrated deeper than this stratum. From the Caseville well all we learn with any degree of certainty is that between 2200 and 2300 feet, most probably at about 2270 feet, it struck another brine more impure than the one they had been using. The chances are that this is in the top of the Traverse or Hamilton group. So we continue our column with the aid of the Harbor (Sand) Beach well.

Ohio shale (Saint Clair, Huron black, or Black). (g)

(1.) *Bedford shale.* Below the Berea we have in the Sand Beach record 186 feet of light colored shale. In the White Rock record, however, there is given a three foot stratum of gaseous black shale, which if we take it to be the Cleveland shale would then leave about fifty feet above it to be assigned to the Bedford. This we will accordingly do, and this thickness corresponds very well to that assigned to the Bedford shale by the Ohio geologists.

(g 2.) *Cleveland shale.*

The narrow belt of gaseous black shale of three feet between 600 and 610 feet, in the White Rock record is at the proper place in the column for this shale.

(g 3.) *Erie shale.*

The underlying light colored shales, for the remainder of the 186 feet (186 — 53 = 133) through which they occur in Harbor Beach well, may be assigned to the Erie shales, being of the proper color and position. It is highly probable, however, that these alternations of blue and bituminous shales are very inconstant. Still, the Bay City record shows a somewhat similar group in a similar place.

(g 4.) *Huron shale.*

The next 270 feet from 850-1120 of the Harbor Beach well is said to be a dark brown or black slate, which corresponds very closely to Newberry's Huron shale, is the great Devonian Black shale, and is one of the most widespread of lithological datum-planes.

Traverse group (h).

We next have, from 1120-1725, some 605 feet of light slate or "soapstone," i. e., calcareous shales, with 15 feet of extremely hard rock at 1400 feet. This appears to be the Traverse group, which has already thickened enormously, judging purely by lithology, from what it is in the southern part of the state, but this thickening is a characteristic of our column generally. Somewhere in this series which is 456 feet and more below the Berea, the deepest Caseville well may be supposed to obtain part of its brine.

At 1400 is a belt of extremely hard rock, probably a cherty limestone, possibly a pyrite nodule, a premonition of what we are to find below.*

*The "granite" in the Churchill well at Alpena, from 145-153 feet down, seems to correspond. It may be the horizon of the Encrinal limestone.

Helderberg limestones (i, j).

At 1725 feet we seem to have reached that series of limestones which lie at the base of the Devonian and top of the Silurian. At 1844, 119 feet below, where it seemed to be lime and sand mixed, we may possibly be near the horizon of the Oriskany or perhaps the Sylvania sandstone, but the limestones were penetrated 86 feet farther down, to 1920 feet, the rock growing coarser, dolomitic (?). If we may venture a prediction, some 500 feet farther down—2400 feet—would carry the Harbor Beach boring well down to the rock salt formation struck in the deep wells at Goderich, Canada, and in the deep wells of the Saint Clair River. It would probably be not less than 1300 feet farther down to the Trenton. We thus finish our geological column, or account of the rocks of the county in descending order. It may be remarked in conclusion, that since the thickness of the beds varies from point to point, no such column is exactly accurate anywhere. We have tried to make ours fit as closely as possible to the section as it might be found by a shaft at Caseville. It must be remembered, however, that for the Marshall and the formations generally the coast of the adjacent land was to the northeast, so that as we go to the southwest there will be less variety and in general less thickness to any division of our geological column.

The plate of our Geological column, Plate I, which may be compared with Plates VI and LXXIII of Vol. V, and uses the same symbolism for the lithological character of the beds, is constructed by combining the record of the Sand Beach well below the Berea, with that of the Caseville well, filled in with local observations, as far up as it goes, then using the record of the Bayport quarry's deepest boring, and finally that of the Bauer well at Sebewaing, thus covering the whole of the column in as great detail as possible, consistent with any accuracy in summation. It is obvious in construcing the column in this way that if for instance we have overestimated the thickness of the Napoleon sandstone beneath Caseville, we shall have to increase some other formation by the amount that this sandstone is in excess and similarly in other cases.

CHAPTER III.

PHYSICAL GEOGRAPHY OF HURON COUNTY.

§ 1. Introduction. Relation of physical geography and geology.

Physical geography and geology are kindred sciences, in fact inseparable. Physical geography is the geology of the present, while one branch of geology is the physical geography of the past. But as the biography of a man usually and rightly begins with some account of his ancestors, so we can only understand physical geography rightly when we have some idea of the origin of the present forms of the earth's surface. On the other hand we use the present as the key whereby we may unlock the past. One of the marked features of the last decade is the expansion of the science of physical geography under the influence of geological ideas, and a correlative development of geology, which now endeavors to read the history of the carving of the land surfaces of the earth, as well as the history of the filling up of its sea bottoms. No farther apology is needed for introducing some account of the physical geography of Huron county into this report. I trust it may aid the teachers of the county to make their instruction more real by the introduction of familiar illustrations.

We have already described the general location of Huron county as lying at the end of a peninsula, bounded on the one side by Saginaw Bay and on the other by Lake Huron (Pl. VIII). The effect of the neighborhood of so much water in mollifying the climate is plainly to be noticed. This advantage it shares with Michigan generally and the subject has been quite fully developed by A. Winchell.* His climatological maps show that in January the temperature is about 24° to 25° F., and in July 68° to 69° F., i. e., some 3° warmer in winter and 3° colder in summer than in the middle of the state, and some 6° warmer in winter and 6° colder in summer than at a corresponding latitude in Minnesota. These figures are

*1871. Harper's Monthly, XLIII, p. 279, 281; also Walling's Atlas.

sufficient to show the effect of the lakes in producing a semi-insular climate, while the effect in checking extreme temperatures for few hours, e. g. frosts, is yet more marked. For example, the first autumnal frost at (Sand Beach) Harbor Beach in 1894 (the latest date conveniently accessible) was on October 12, while in Adrian, Lansing and Howell it was September 25, and most of Indiana was visited by frost before October 12. The mean annual temperature would be according to Winchell's maps a trifle under 45°; from 1899 to 1900 it averaged 46.0° at Hayes, 44.4° at Harbor Beach, and the weather service data furnished to U. S. G. S. paper No. 30 make it the same. This is practically the same temperature which obtains at points at a corresponding latitude on the great plains. We see thus that the effect of the lakes is to check oscillations and extreme variations of climate, rather than to change the average temperature for the year.

The following reports furnished us by C. F. Schneider, director of the State Weather Service, show the temperatures and precipitation for the past ten or twelve years in two stations within the county, and agree probably as well as observations of short period and of thirty years ago could be expected to, with Winchell's results.

PRECIPITATION AT HARBOR BEACH (SAND BEACH), HURON COUNTY, MICHIGAN. OBSERVER: W. NIMS TO FEBRUARY, 1896, SINCE THEN N. P. ARNOLD.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1887	......	......	......	......	......	3.66	1.66	1.49	1.16	3.22	1.13	1.89	......
1888	0.48	0.50	......	.....	......	......	1.30	3.44	0.76	......	......	0.40	......
1889	1.98	1.39	0.30	0.85	3 23	5.59	1.81	1.92	0.89	0.97	......	3.25	......
1890	1.41	2.34	0.72	1.86	3.30	3.34	4.27	3.40	0 82	7.37	2.54	2 60	34.93
1891	2.40	1.80	2.02	1.45	0.52	0.66	2.96	4.85	1.92	2 08	6.03	2.01	28.20
1892	6.27	1.85	1 20	1.08	2.61	3.55	1.72	2.86	4.77	3.46	2.95	2.02	34.34
1893	1.20	3 90	1.51	4.14	4.25	2.13	2.02	2.17	2.05	5.94	2.57	2.90	34.77
1894	.... .	......	1.95	1 82	4.11	4.48	1.10	0.77	3.12	3.37	1.32	0.90	25.40
1895	......	......	......	2.10	2.14	0.96	1.02	3.60	3.43	0.77	2.31	2.87	19.20
1896	......	0.38	0.35	1.49	2.73	3.72	0.93	3.99	5.56	0 62	1.50	......	21 27
1897	......	......	2.30	35.4	37.4	0.79	3.02	2.56	0.83	3 07	1.50	2.55	23.90
1898	1.30	1.40	1.85	2.27	1.82	4 [illegible]9	0.20	3.89	1.05	3.98	3.08	0.67	25.70
1899	1.41	0 95	2.47	0.88	3.22	3.14	2.05	0.19	2.84	3.09	1.63	2.16	24.03
1900	0.60	2.37	2.25	1 65	2.11	......	.....	......	......	......	......	......	......
Mean	2.06	1.61	1.47	1.95	2.88	3.02	1 83	2.91	2.20	3.17	2.49	2.01	27.98

TEMPERATURE: SAME STATION AND OBSERVER.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Average.
1887	......	......	......	......	......	64.2	74.2	66.2	59.4	45.1	36.0	28.9	......
1888	16.3	21.4	......	......	......	......	68.0	67.0	59.1	......	......	31.8	......
1889	27.6	16.5	32.3	41.6	51.8	57.2	69.0	66.4	62.0	43.8	......	34.6	......
1890	27.9	27.3	24.8	39.8	47.5	64.8	66.8	63.7	56.6	46.4	37.6	24.1	44.0
1891	26.8	26.5	26.0	41.8	48.8	60.5	62.7	64.7	61.6	45.6	32.4	29.3	43.9
1892	15.6	21.8	23.7	......	48.4	63.5	65.7	64.3	61.2	49.6	35.8	24.8	43.1
1893	14.5	17.6	29.3	39.6	49.5	64.0	68.7	67.0	59.6	52.6	35.4	24.7	43.6
1894	26.0	21.7	39.1	43.0	50.7	66.2	70.6	67.4	64.0	50.2	33.2	31.8	47.3
1895	19.4	15.9	24.0	40.0	56.5	65.2	64.5	65.8	63.6	44.5	36.1	28.7	43.7
1896	23.2	23.2	26.2	......	60.2	61.9	68.6	68.6	58.0	50.1	......	28.2	46.8
1897	23.0	27.2	29.0	40.2	50.4	56.0	67.0	63.2	62.2	51.6	36.6	25.4	44.3
1898	24.0	20.8	33.3	39.0	52.0	63.4	69.4	67.4	63.4	50.9	36.2	26.1	45.5
1899	21.0	16.4	24.3	42.8	53.2	63.0	65.6	67.9	57.4	52.8	41.7	27.4	44.5
1900	25.6	18.5	23.0	43.0	54.0	......	......	......	......	......	......	......	......
Mean	22.1	21.4	28.4	40.9	51.7	62.5	67.9	66.0	60.9	48.3	35.5	28.2	44.4

PRECIPITATION AT HAYES, HURON COUNTY, MICHIGAN. OBSERVER: C. F. LEIPPRANDT.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Average.*	Total.
1889	......	1.40	......	......	......	......	......	.....	......	......	2.59	3.36	......	......
1890	1.41	1.00	0.98	1.61	3.47	......	2.17	2.86	0.28	4.98	2.02	1.46	2.04	24.47
1891	......	3.50	1.70	......	0.84	......	1.49	9.47	2.91	2.17	......	0.60	2.32	27.82
1892	2.50	......	0.30	.....	2.45	4.84	.....	2.32	......	1.18	1.57	1.61	2.08	24.96
1893	2.90	2.50	1.40	4.35	3.36	1.25	2.65	1.13	2.11	2.76	......	2.95	2.44	29.25
1894	1.14	1.22	1.70	1.60	3.77	1.27	2.06	0.14	3.11	2.17	......	0.50	1.67	20.07
1895	4.23	0.60	0.80	1.15	3.08	1.18	2.15	1.93	2.60	0.80	1.86	2.36	1.89	22.74
1896	0.94	0.78	......	1.25	2.14	0.78	0.67	2.44	6.05	0.85	2.28	0.46	1.71	20.48
1897	3.93	1.09	3.80	3.08	4.09	2.23	3.74	1.53	1.13	2.72	1.83	1.51	2.52	33.24
1898	1.84	1.82	2.36	1.44	2.00	3.27	1.01	3.57	1.26	5.20	1.09	0.32	2.09	25.18
1899	0.90	0.70	3.54	0	2.66	3.00	3.73	Tr.	2.91	3.19	0.75	1.11	2.304	......
1900	0.68	4.68	3.00	1.11	3.10	......	......	......	......	......	......	......	3.22	......
Average	2.21	1.46	1.84	1.81	2.79	2.23	1.99	2.82	2.43	2.54	1.89	1.51	2.16	25.88

*Average per month or total per year in feet and decimals of a foot.

TEMPERATURE: SAME STATION AND OBSERVER.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Average.
1889	....	......	......	......	......	......	......	......	......	......	39.2	35.6	.....
1890	30.3	30.5	28.3	45.6	54.0	68.4	68.4	63.2	57.6	48.1	39.5	26.7	46.7
1891	26.5	......	29.5	49.4	53.3	64.4	66.0	66.4	63.6	46.8	.....	35.5	46.7
1892	19.2	......	29.2	......	52.0	66.5	......	66.7	......	49.0	35.3	25.9	45.0
1893	13.8	17.1	27.9	41.0	52.5	68.4	68.2	65.8	59.0	52.1	37.7	26.2	44.1
1894	27.1	21.3	40.0	44.5	54.1	67.4	68.5	63.4	62.2	54.2	.....	32.2	47.7
1895	17.8	15.2	24.6	43.2	56.4	70.8	69.4	66.0	67.4	44.4	36.3	27.8	44.9
1896	24.6	23.7	27.2	49.2	61.7	65.6	70.8	69.2	57.0	46.7	39.4	27.8	46.9
1897	24.2	26.1	30.4	42.0	52.8	64.2	70.8	66.6	64.2	52.8	36.6	27.0	46.6
1898	25.0	21.6	36.3	41.7	54.4	63.9	67.5	65.6	63.4	49.6	36.3	26.2	45.8
1899	22.0	15.0	22.8	44.0	57.6	66.0	67.8	67.2	58.4	49.8	40.4	27.9	44.9
1900	24.3	17.2	22.0	44.4	56.2	......	......	... ..	......	......	......	......	......
Mean	23.0	21.3	29.6	44 5	54.9	66.6	68.7	65.9	61.8	49.3	37.5	29.1	46.0

When only two or three months are missing from a year, the yearly average has been found by using the means for the missing months. The general average is the average of the monthly average, and is liable to vary slightly from the average of the yearly averages. Hayes is, I think from its position, a truer representative of the county in general.

The prevailing winds are westerly, though they are modified by the usual system of land and lake breezes, by which in the summer time, on the afternoons of hot days there is a tendency for the heated air over the land to rise and draw in a cool breeze from the lake. A rider on a bicycle quickly notices a head wind and it was quite noticeable that in riding back to Port Austin in from the south after a hot day, one was very liable to encounter a head wind.

In accord with the prevailing west wind the prevailing surface drift of the Great Lakes is eastward, as is indicated on the chart of the Great Lakes issued by the weather bureau. This general character of the lake currents and winds seems to have a marked effect on the character of the shore lines, making those facing west seats of deposit, and accelerating erosive action on those facing east by removing the debris of erosion. This is well illustrated on Lake Michigan, where the shore from Evanston to Manitowoc is

eroded away at an average rate of about 5.28 feet a year,* while around New Buffalo, and thence north the sand is piling high. The The same antithesis may be observed between the two sides of Huron County, as will be later seen.

§ 2. Level of Lake Huron.

The level of Lake Huron varies in a very complex way. Eliminating the waves of various causes which are of reasonably short periods, we find fluctuations, dependent either on the direction of the wind which may cause a very noticeable rise of level lasting over a day or two, or on the height of the barometer or on the tidal attraction of the moon, and also on the general relations of rainfall, freezing and evaporation.

Other causes, change in earth level, downcutting of outlet, etc., may have their part in affecting this level. Before we can consider these latter causes which will take us back into the realm of geology almost before we know it, we should consider what fluctuations we really have, and how far they may be accounted for by climatic considerations. Plate IV shows the effect of the fall of lake level from 1886 to 1896 in the line of undermined but deserted cliffs. This inquiry is of great practical consequence, as affecting the depth of harbor improvements, etc., and also as affecting the use of the lake as a datum plane in leveling.

Plate V below, compiled mainly by Mr. M. L. Fuller, under my direction, shows the variation of the lake level during the past century fairly completely. We are indebted to Mr. Charles Crosman for permission to extract a large part of it, viz., from 1858 to 1887, from his chart. We have brought this down to date by appending the records of the Sand Beach (Harbor Beach) gage in the Annual Reports of the U. S. Engineers, and added the earlier part from data in Foster and Whitney's Report on the Geology of the Lake Superior Land District, 1851, Chapter XIX, on the observed fluctuations of the surface of the lakes by Chas. Whittlesey. This quotes from Douglass Houghton's observations in his early reports of the Michigan Geological Survey in 1839 and 1840, so that we are but continuing researches begun by the first Geological Survey. We have also used some data from the Lake Survey.

A comparison of the recorded fluctuations of the monthly mean water level as shown in appendix SS of the Annual Report, upon the Surveys of the Northern and Northwestern Lakes,† shows that

*E. Andrews, Trans. Chicago Acad. of Sciences, 1870, Vol. II, quoted by Crosman.
†Annual Report of the Chief of Engineers, 1882.

the fluctuations are within a small fraction of a foot the same at Milwaukee and Sand Beach, and at Point aux Barques, and Port Austin. The records are from 1859 to 1882. See also § 5.

In the 18th Annual Report of the U. S. Geological Survey, Part II, p. 624, the altitude of the Port Austin gage was studied by G. K. Gilbert of the Survey to determine if there was any relative change of level, i. e., any elevation of the land. He chose a period in July and August, 1876, when the weather and wind were not likely to produce local disturbances of level, to compare it with the gage at Milwaukee. He found that the Port Austin gage zero, which was about 7.4 feet above the water level was on the average 5.21 ± probably .013 feet, above the Milwaukee gage, which was about 2.2 feet above the water level. This Port Austin gage zero was originally placed on a level with the main or Wisner benchmark (590.53 A. T.), but Gilbert says that Mss. records of the Engineers office state that in July, 1875, it was 0.003 foot too low and on Oct. 18, 1876, it was 0.040 too low, having settled in the meantime. As the readings studied by Gilbert were during the time of settling he was obliged to apply a correction, which he took to be 0.034 foot, but applied in the wrong sense and found the gage zero to be 7.460 above a check point at Port Austin, to wit, "the top of an iron bolt driven into a vertical face of bed rock on the west side of a promontory opposite the residence of J. W. Kimball," i. e. 590.570 A. T. instead of which it should be 7.39 above the check point (590.50 A. T.). Mr. Gilbert had a new series of observations made at Milwaukee and Port Austin in the summer of 1896, with the help of Mr. John P. Smith of the Port Austin News, using a new gage which he established with its zero 5.125 feet below the check point (577.985 A. T.), and about 1.2 feet below the water level of that time. Assuming the lake level to be the same at Milwaukee and Port Austin he found as the result of a series of readings that the gage zero was now 6.875 feet ± 0.019 foot below the Milwaukee gage zero. Correcting and tabulating his results we have:

	1876.	1896.
Mil. check point above Mil. gage zero	0.843	1.205
Mil. gage zero above or below Port Austin gage zero	—5.210	6.875
Gage zero above or below check point, Port Austin	7.390	—5.125
Check point at Milwaukee is above that at Port Austin	3.023	2.955
Difference	0.068 ft.	....

which is what Port Austin has risen relative to Milwaukee in the last 20 years, a quantity within the range of possible though not of probable error. The slip of the gage in 1876, which seems to be the most uncertain element, could not make the result more than .006 foot less and if all the change took place after August, 1876, the elevation would be greater.

Prof. Gilbert concludes that the land is rising to the N. W. at a rate that would produce an apparent fall of the lake in Huron county of 0.2 foot per century.

It may be worth while some time to test some of the other bench marks left by the Lake Survey, to wit:

Bench mark near Station D at the mouth of Willow River was 5.65 feet above mean water level in June, 1857.

On overhanging rock near Station No. 30, Point aux Barques, 16.8 feet above water surface in 1857.

Bench near triangulation station M, Partridge river was 5.3 feet above water surface in 1857.

Bench mark 300 feet east of triangulation station L is marked with a cross on the top which is 9.6 feet above mean level of water surface for season of 1857.

In the curves of lake level fluctuations published in the report of the Chief of Engineers, U. S. A., e. g. Appendix SS in 1882, the plane of reference for water levels on Lake Huron is taken by assuming that during the months of June, July and August, 1874, the waters on Lakes Huron and Michigan were level and that the high water of 1838 was at either Port Austin or Milwaukee at the same distance above that level.

The Point aux Barques curve was adjusted to the others by assuming that during June, July and August, 1860, Lakes Michigan and Huron were at the same level.

In studying the records plotted in Plate V we see plainly that there is an annual fluctuation of about a foot to a foot and a half.* The effect of the melting of the winter snows, and the spring rains is not fully felt in making the maximum of high water in Lake Huron until June or July. From this time, under the influence of the increasing evaporation and the shrunken inflow due to midsummer heat, the lakes dwindle and their levels fall. The approach of au-

*Crosman says 1.34 ft. See also article by A. J. Henry, National Geographic Magazine (1899), Vol. X, p. 404, and Lieut. Col. H. M. Chittenden, Transactions Am. Soc. of Civil Engineers, Vol. XL (1898), No. 839.

tumn with its cooler weather checks evaporation, the autumn rains begin and the fall is checked somewhat, but is resumed, as Mr. Fuller suggested to me, when the ground freezes and rain changes to snow and the lowest water is in the latest winter months.* Beside this annual fluctuation there is also one of greater period, dependent upon the mean rainfall of the previous years, but lagging behind the rainfall curve. Thus the high waters of 1876 and 1886 were both coincident with periods of extra rainfall. Again, in the earlier part of the century, "from the low water of 1810 to the high water of 1814 there fell in Pennsylvania 34.54 inches of rain more than from the years from 1815 to 1819." So too, the rainfall of the 11 years prior to the flood of 1838 is very large, averaging 41 inches per annum or 11 inches per annum greater than that of the preceding low water of 1819. The signs of the fall of water level since 1886 were in 1896 everywhere evident along the coast. Around Bayport the slope of the land is so gentle that some 400 feet had been added to the shore of Wild Fowl Bay for quite an extent. North Island was joined by a neck to an islet northwest of it, and northwest of Point aux Barques Gull Island had developed from a shoal. The water is said to have been somewhat higher in 1896 than in 1895, and was distinctly higher in 1897. Trespassing a little farther into the past, Mr. Webber informs me that having occasion to have Sec. 17, T. 17 N., R. 10 E., on the shore of Wild Fowl Bay resurveyed in 1895, the surveyor found the meander stakes as called for by the notes of the old Government Survey to be just at the water line. The water was lower than normal in 1895 and in the head of a bay near the mouth of a stream like Mud Creek one would expect to find the shore built out, if anything, so that such observations would indicate no considerable rise of land on lake. We hear indeed of traditions from the Indians around Saginaw Bay, of a time when the Indians could go with their canoes where it is now dry land, but a high water like that of 1838, nearly 6 feet above the recent low water, would give abundant opportunity for such a tradition, when we consider also the out-building of the coast by the accumulating sand, and the extremely gentle slope of the land. On the other hand while the water was in 1896 abnormally low, and we may expect to see it rise again, the water during the summer of 1883 to 1886 was extra high, so that we need not expect it to return

*Low water is later in Lake Superior, March having the lowest average level, and high water is not until August or September.

to that level permanently. Moreover the last report of the Chief of Engineers, for 1899 (Appendix DDD, p. 3858) reports that the head of the St. Clair has scoured materially since 1867. The indications are that this deepening started about 1887.

The fluctuations of the water level are one of the sources of embarrassment in obtaining very exact altitudes in the county or preparing a contour map, which is the subject of the next section. Before leaving the present subject, however, we must allude to the theory of Spencer,* who, while he also believes that in the more remote past the lake has subsided, believes that at present it is rising again. If there had been any considerable rise of the lake, there would be a tendency to flood the river valleys and lower their grade, causing them to build up near their mouths. Any marked effect of this sort in Huron county is inconsistent with the rock beds of Allen Creek, Willow Creek, Pinnebog and Shebeon rivers, close to their mouths. In counties farther south such flooded river valleys are plainly visible. During the past few years many wells that once flowed, have been ceasing to flow, and in general the water level in wells has lowered. This fall may be due to the settling up of the country, clearing the forests and draining the swamps, and allowing the water that falls upon the surface to run off more rapidly, and also in part to the greater demands upon it by the more numerous wells, and may also be due to such local causes as the draining of the coal mines, but it must also be affected by the unusually dry weather of the past few years. The accompanying fall in the lake level is but an index of the general lowering in ground water level, so that it would not be surprising if the water level in the wells rose again somewhat in the next few years. There are also more temporary fluctuations of the ground water level or head peculiar to individual wells which seem to correspond to the more temporary fluctuations of lake levels. (See Chapter VI.)†

§ 3. Types of shore line.

When we study the shore lines of Huron county we find three different types, which though more or less intermingled, nevertheless predominate respectively on the western, northern, and eastern sides, and depend partly on the slope and nature of the shore, and partly on its relation to the currents and waves.

*Popular Science Monthly, June 1896.

†This section was written in 1897. There has been no chance to see how much the recent rainier seasons have raised the level of the ground water.

(a). The first type, the mud flat type, is pronounced along the shore from Sebewaing up to Sand Point (Point Charities). The slope of the land surface is so gentle that the force of the waves is thoroughly broken ere they reach the shore. There is, therefore, little beach ridge or crest, though the spring ice may shove up and strand many boulders. The contours of the land sweep out under the sea with scarce a break at the shore line. The prevailing wind and currents beat back the mud brought down by the streams against the shore and the reeds and sedges creep out over the muddy flats and catch both it and the driftwood that is brought on higher stages of the water. The winds blow back into "dunes" the sand from the shore and thus little by little the land creeps out in a series of mud flats or swamps and low sand ridges.

(b). The second type, the sand beach type, occurs all along the shore at intervals, but is dominant from Sand Point to Hardwood Point close to Port Austin. From it the town of Sand Beach, now Harbor Beach, took its name, as being, so it was said, the first appearance of this type of shore line from Port Huron north on the west side of the Lake. This type of shore line occurs (Plate IV) where the water deepens more rapidly, allowing the waves freer action so that they wash away the mud from the beach, while the sand is piled up. Where such shores face the west the prevailing west winds catch the sand and throw it back above the reach of the waves, where it forms rolling ridges of shifting sands "dune sands" for these rolling, wind-built sand hills are called "dunes" and are admirably developed from Port Austin to Port Crescent, and thence to Caseville, and in fact at intervals, all along the western shore. The prevalence of this shore type on the northwest coast is due partly to the supply of sand furnished by the underlying rocks, partly to the more open sweep of water, and partly to the prevalence of on-shore winds.

In this type of shore line the land is not gaining so rapidly on the sea, though it is probably gaining somewhat, but it is the favorite type of shore line where the lake is evening off the irregularities of the land, cutting the points and filling in the heads of the bays and coves. Plate IV is taken from the bay between Point aux Barques and Burnt Cabin Pt.

(c). The third type may be called the cliff and shingle type. It alternates with the second type, but grows more and more promi-

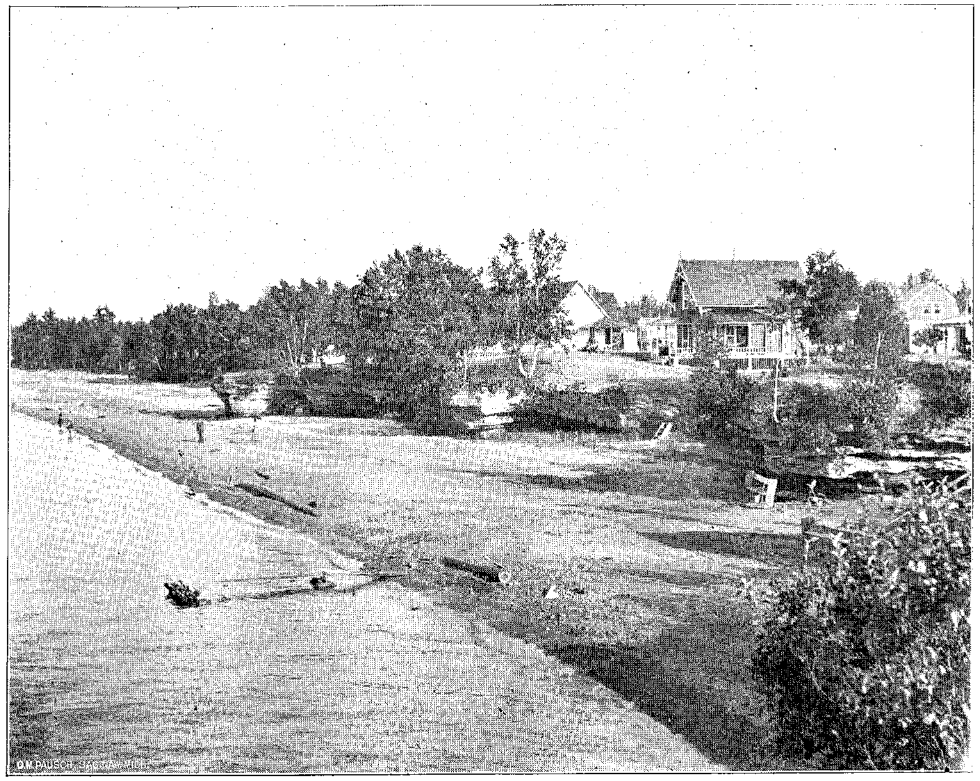


PLATE IV.

Illustrates the transition from the cliff and shingle to the sand beach type of shore line at Point Aux Barques; also the resemblance of the cliffs to boats drawn up on the beach; also the undercutting action of the waves, producing sea caves now abandoned by the water; the top of the cliff is the level of the Algonquin terrace.

(Reproduced through the courtesy of the F. & P. M. R. R.)

nent toward the southeast. In this type there are unmistakeable signs that the lake has been wearing the land back, making cliffs which rise up to 40 feet high, and face a bench made largely of their own debris, and in general more stony than the sand beach type proper, though if the rocks are sandstone, the transition to the second type is easy. For example, Plate IV might illustrate this type, except that the beaches in front of the cliffs are quite pure sand. The third type is typically represented near the Point aux Barques lighthouse (Fig. 5), and around Grindstone City. The stony beach deposit in front of outcrops of rock, composed of fragments torn off by waves, is called shingle. Often such a bench is strewn with boulders. These are perhaps in part as suggested by Spencer boulders left by the washing of the finer part of the boulder clay deposit, but are undoubtedly very largely left stranded by the melting of the spring floes of ice. We are informed that at the Oak Grove resort near Sebewaing they picked up all the stone from the beach one year, but the next year a broad winrow was piled in by the storms breaking up the ice. The ice in the bay is even now often four feet thick, and the stones left by melting are often bigger than a man can carry, even, as reported up to a ton weight. Such observations throw considerable light upon the rapidity with which the beach accumulations may be formed, and upon the depth below the water level at which such boulder benches may be formed. It may be noted that since the lakes are lowest in winter, such large stones frozen into the ice will be subject to a powerful lifting action when the water level is raised by the beginning of the spring rise. The level of the boulder bench in front of Port Austin seems to be four to six feet below present summer water level. Houghton noted concerning White Rock that it was "about 20 feet in horizontal dimensions and 8 feet high with crust on top; it is cracked in all directions, and pieces lie all around it; water 5 feet deep; siliceous limestone and probably a boulder; distance from shore 1,900 feet." In the original Lake Survey sheets this is given as 1,460 feet from shore in 6 feet of water.

On the eastern shore the winds and currents and spring ice help to bear away part of the material which the waves have beaten from the cliff, and thus prevent them from being clogged in their activity as they are on the west and northwest, while the coarser shingle left behind serves as a weapon for new onslaughts.

The contrast thus emphasized between the shore facing west, which is in general growing, and the shore facing east which has been in general retreating, is like that already mentioned in § 2 as also occurring around the lower end of Lake Michigan. While an elevation of land to the northwest and a relative down sinking to the east might accelerate this contrast between the east and west sides by making deeper water and hence more forcible waves on the east side, and vice versa, it seems probable that the lake currents and prevailing winds have been the determining influence.

§ 4. Explanation of contour map.

We find the features of the present shore lines repeated at higher levels, repeated in such a way as to assure us that although the lake has not fallen appreciably during the period of accurate records, yet it has fallen in recent times. Basing our division partly upon the modification of the surface and soil thus produced, but also upon other facts, we may divide the county into four districts, topographically distinct, but before we begin to describe them, we must first explain the contour or topographic map (Pl. VIII), which we shall use in the description.

As we have just said, in 1896, Lake Huron had been retreating. Imagine the process suddenly reversed, and the lake suddenly raised ten feet and the new shore line marked upon the map. Suppose the lake raised ten feet more, and the resulting shore line marked upon the map of the county. Such lines would be called contour lines, and all points of a given contour line are obviously at the same level above the lake. We could find such lines if we could by surveying and leveling find all the points in the county which are exactly 10 feet above the level of the lake and join them by a line. All the country lying between the 10 and 20 foot contour lines would be between 10 and 20 feet above present lake level. The lines drawn upon our contour map are the best approximations to such lines that we can draw. But as the lake level fluctuates so much they are not referred to lake level, but to an assumed level on the Atlantic Ocean, the average level of Lake Huron being between 581 and 582 feet above the sea. The United States Geological Survey has published a dictionary of altitudes of points all over the United States, referred to this level, from which we have taken the altitudes of all points that were in Huron county.*

*Bulletin No. 76, and third edition, No. 160, by H. Gannett.

With these as starting points, the profiles of various surveyed lines, furnished by Mr. Webber, gave a great many others. The county drains furnished the relative elevations of many more points, and finally barometric readings were taken as we went over the roads, checked up on points more accurately determined as often as possible, and the weather fluctuation as far as possible eliminated. Thus the altitudes of a great many other points were determined from those already given. At the same time the depths of stream valleys, and general character and slope of the country were noted. Finally the contour lines were drawn so as to harmonize with this accumulation of data. They have been constructed to determine primarily the relative positions of outcrops and of the strata intersected by the wells, and must be judged accordingly, but it is believed that they are not more than ten feet out, one way or the other, except in the hilly part of Verona, Bloomfield, Sheridan and Paris townships. Moreover, it must be understood that on our map we have adapted the river valleys *between section lines* to the stream as they are found on the county atlas which we have used as a base in all cases except where it is known to be wrong, so that if any stream as laid down on the map, proves to be out of position, the stream valley contours are correspondingly incorrect. With the time and means at our disposal, it was impossible to meander the streams. The expense required to produce a thoroughly accurate contour map, would be prohibitory with present Survey appropriations.

The present map cannot be depended upon for final location of railroads or drains, though it may be useful in their preliminary location. For example, it suggests that a very practicable line from Badaxe to Harbor Beach may be found by going north or northeast and then following the center line of the north tier of sections in Verona, Sigel and Sand Beach townships. But it is in the first place for geological use. It suggests, as will be hereafter shown, the gathering places for artesian water supply, and removes the mystery as to the origin of the head of water at the Badaxe flowing well. It helps us to make due allowance for the differing altitude of outcrops in estimating strike and dips, etc., and also aids us in tracing the ancient history of the lakes, and their abandoned shores. Without its help, too, the map showing the general conformation of the rock surface beneath (Pl. VII.) the drift mantle could not be constructed.

§ 5. Tables of altitudes.

(a). Lake survey bench marks. The most accurate leveling done in the county is presumably that of the Lake Survey.

The present plane of reference of the U. S. Lake Survey for their gages on Lakes Michigan and Huron is known as high water of 1838. This is 8.33 ft. below a bench mark on Dr. I. A. Lapham's house in Milwaukee, according to Plate III of Appendix SS of the Annual Report of the Chief of Engineers for 1882. This bench mark according to Professional Paper of the Corps of Engineers, U. S. A., No. 24, p. 609, is 592.67 feet above mean tide at New York (577.94 ± .36 feet above coast survey bench mark at Greenbush, N. Y.). The plane of reference of the U. S. Lake Survey which is also that of our Plate V is therefore 584.34 feet above tide (A. T.). According to the same reference the mean surface of Lakes Huron and Michigan from Jan. 1, 1860, to Dec. 31, 1875, was 11.39 feet ± 0.10 below the Lapham bench mark, i. e., 581.28 above tide. According to Crosman the mean water surface from 1860 to 1888 was 2.82 feet below the plane of reference i. e. 581.52 feet A. T. This is 0.24 foot higher than the mean level for 1860 to 1875, and most of the time from 1875 to 1888 the lake level was unusually high. A check point at Port Austin is the top of an iron bolt driven into a vertical face of bed rock on the west side of a promontory opposite the residence of Dr. J. W. Kimball, which was* 1.23 feet below the plane of reference, i. e., 583.11 A. T., and in July, 1875, and October, 1876, 7.424 feet below the Wisner bench mark, which is 6.19 feet above the plane of reference, i. e., 590.53 feet A. T., or 7.424 feet† above the check point.

(b). Altitudes from Gannett's dictionary of altitudes in the U. S. Bulletin No. 76 and 130 of the U. S. Geol. Survey. The last column is the distance as there given above tide, the second column is obtained by subtracting 582, the elevation of Lake Huron according to Gannett, while the first column gives the distance from the starting point of the railroad survey. Some stations are interpolated by profile combined with repeated barometric readings.

*Annual report of the Chief of Engineers for 1876, HH., p. 84.
†18th Annual Report U. S. Geological Survey, Part II, p. 628.

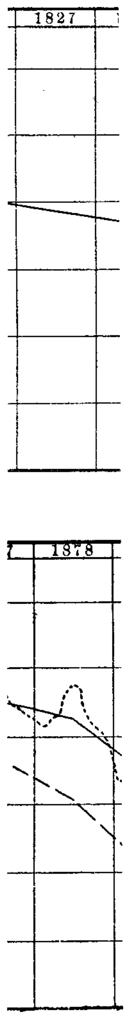


Plate V.—Illustrating the fluctuations in the level of the lakes from 1888-1899 (Sand Beach Gauge), from reports of the U. S. Engineers. From 1888-1858 from Crosman's chart, for Lake Michigan and Lake Huron, Milwaukee gauge. Previously, no special gauge. 1856-1857, Lake Survey. Previous to 1851 the data are from Whittlesey's paper. The line connecting monthly means is in dots. The line connecting annual means is full. Line connecting mean annual rainfall, for comparison, is in dashes.

PERE MARQUETTE. (PORT HURON AND NORTHWESTERN) R. R.

(*b1*) Port Austin Division.	Miles from Port Huron.	Above Lake Huron.	Above tide.
Tyre	59.9	199	781
Ubley (Ubly)	62.9	203	785
Highest Point	64.7	232	814
Wadsworth	66.4	199	781
Badaxe	70.2	169	*751
Rapson's Siding, Secs. 31/6	73	‡162	744
Clarks, Secs. 19/30	75	‡146	728
Filion, Secs. 18/19	76	139	†721
Creevy Siding, Secs. 7/16	77	‡134	716
Kinde (Dwight), Secs. 31/6	79.6	120	701
Johnson, Secs. 18/19	‡82	‡ 73	645
Port Austin	87	15	597

(*b2*) Harbor Beach Division.§	Miles from Port Huron.	Above lake.	Above tide.
Harbor Beach station	70.4	18	600
Lowest point of track on section 12	....	8	590
Shore Road crossing	....	16	598
Bridge over Allen Creek	....	44	626±6
Crossing east road between Sec. 24 and 25, T. 16 N., R. 15 E.	....	76	658±2
Crossing north road between Sec. 25 and 26	....	94	676±3
Crossing east road between Sec. 26 and 35	....	121	703
Crossing north road between Sec. 34 and 35	....	124	706
Crossing east road between Sec. 34 and 3 *Helena*	64.7	134	716±2
Crossing east road between Sec. 4 and 9, T. 15 N., R. 15 E.	....	149	731
Crossing north between Sec. 8 and 9	....	105	747
Crossing east between Sec. 8 and 17	....	169	751
Five feet below top of ridge just west, *i. e.*,	....	174	756
Crossing east road between 20 and 29 *Ruth*	60.0	172	754
Minden City, near S. O. P., T. 14 N., R. 14 E.	56.4	235	817

*This is exactly the same union station as the Badaxe of the Saginaw, Tuscola and Huron Railroad for which Gannett gives the altitude 758 feet, agreeing with the levels obtained in the office of the Railway Company. The weather service altitude is also 758. The preliminary and final line agree and for this and for various reasons I consider the Saginaw, Tuscola and Huron levels the more trustworthy, and have made them the base of my work, but I have not changed the other levels of the Port Austin Division other than at Badaxe, because the level given for Port Austin station seems too high now. According to profile obtained from the office of the Flint and Pere Marquette Railroad, Port Austin is 33 feet, Kinde 131 feet and Wadsworth 208 feet above Lake Michigan, i. e., Lake Huron, but according to letter of Chief Engineer W. B. Sears, Oct. 10, 1896, these profiles compiled from old data are certainly wrong, Port Austin being about 14 feet above lake. The fluctuations of the lake level make this reference somewhat uncertain. I should take it to be about right for 1896 lake level, but about a foot or two too high if referred to the mean height of the lake from 1860 to 1875, which is the altitude taken by Gannett. The altitude of Badaxe is by the same profile and letter 193 feet. If we subtract 18 feet from the Port Austin elevation of the profile and from the Badaxe elevation also, it will bring the latter nearly the same as the Saginaw, Tuscola and Huron elevation, and the former also nearly correct, and the same as given by Gannett. But an equal subtraction would make Kinde 113 feet above lake or 7 feet lower and Wadsworth 10 feet lower than given by Gannett. Going south into Sanilac county a similar subtraction would leave Palms 238 feet above the lake, still higher than it is given by Gannett (812 A. T. or 213 above lake). Such discrepancies cannot be satisfactorily adjusted. We have used Gannett's figures, except for obvious misprints, e. g., Port Austin = 696, with some regard to repeated barometric measurements.

The last edition of Gannett's dictionary has lowered altitudes on the S. T. & H. and P. O. & N. seven feet. This is apparently to make the reading on Saginaw Bay of the latter line agree with the level of Lake Huron, but it seems to produce many discrepancies elsewhere and our work is based on the second edition.

†740, as given in Bulletin 130, is a misprint for 720.

‡Interpolated by repeated barometric readings, assuming Badaxe = 758.

§The town of Sand Beach has received the name of Harbor Beach quite recently. The maps were printed with the old form, but I have tried to replace the old form by the new in the text. Badaxe is also written thus by the post office authorities, but by others is often written Bad Axe.

Altitudes between Harbor Beach and Minden City have been interpolated by triple barometer readings. Bulletin No. 130 gives the altitude of Harbor Beach Station as 599, and of the cisterns of the weather service barometer as 600.

(*b3*) PONTIAC, OXFORD & NORTHERN (PONTIAC, OXFORD & PORT AUSTIN) R. R

	Miles from Port Huron.	Above lake.	Above tide.
Saginaw Bay	....	....	*588
Caseville	100	12	594
Pigeon River	....	....	588
Pigeon River (Sec. 23, Caseville)	....	....	605
Berne (misprinted Barnes)	93	....	627
Berne Junction, S. & T. H. R. R.	....	....	630
Pigeon River (Sec. 14, Winsor)	....	....	617
Center of Section 23	90	†62.5	....
Winsor (misprinted Winson)	87	66	648
Owendale	69	69	651
Creel	73	....	655
Gagetown	80	....	754

Gannett's figures (in No. 76) agree exactly with those obtained by adding 582 feet to the altitudes of the profile, with the one exception of Bayport, for which he gives the altitude of 604 feet. We use therefore, the profile of that line, as obtained from the railroad office, more in detail. In No. 130 he has subtracted 7 feet straight through, which is a mistake.

*The reference to Saginaw Bay is uncertain as we do not know at just what level the Bay may have been at that time. But it is not likely that the water was six feet above the 582 feet datum though if the time was the summer of '82-83 it well may have been a foot above, i. e., 583 A. T., and consequently the altitudes given below should be reduced, but when we come to the junction with the Saginaw, Tuscola and Huron railroad at Berne Junction, now called Pigeon, we find the altitude given by the Pontiac, Oxford and Northern railroad three feet below that given by the S. T. and H. (633), so that we should not be justified in subtracting from the altitude given by the P. O. and N. right along. I think, however, that the altitude of the Caseville Station is some 3 feet too high. If we should take off three feet from all the P. O. and N. altitudes and then 6 feet from all those of the S. T. & H. to make a match, the difference between the altitudes of the Badaxe station as determined from the S. T. and H. and Port Huron and Northwestern according to Gannett No. 76 would also disappear. The third edition No. 130, subtracts 6 or 7 feet from all the P. O. & N. altitudes which is probably too much. The reading on Saginaw Bay was probably when the water was at about 583 ft. Also at the junction point of Pigeon and Clifford the P. O. & N. altitudes are low when thus corrected.

†Altitude determined by preliminary survey for S. T. and H. given below.

(*c*) SAGINAW, TUSCOLA AND HURON RAILROAD RECENTLY LEASED BY PERE MARQUETTE.

(c. 1). Preliminary line from Sebewaing to the center of Sec. 20, T. 16 N., R. 10 E., thence by quarter line to Badaxe.

Remarks.	Station of survey.	Alt. above lake.	A. T.
Union Street, Sebewaing	1950	8	590
N. line of Sec. 8, T. 15 N., R. 9 E.	1966.58	9	591
Ridge Road	2000	14	596
West side of ditch	2022	24	606
Ridge Road	2037	29	611
	2066	28	610
Town line (168 feet E. to corner between Secs. 3 and 4, T. 15 N., R. 9 E.)	2074.35	25	607
Creek (bottom at alt. 25 ft., country 27 ft.)	2097.50	25	607
Road between Secs. 34 and 35 (270 feet to the quarterpost)	2137.39	32	614
Road between Secs. 25 and 26, T. 16 N., R. 9 E., then almost dead level	2196.81	45	617
Ditch with banks at alt. 43 feet	2250.50	40	612
Shebeon Creek (alt. of banks 42 feet.)	2269.50	40	622
Near center of Sec. 20, T. 16 N., R. 10 W.	2348	45	627
(Course thence N. 88½° E.)			
Line between Sections 20 and 21	2370.90	52	634
Creek, valley about 70 feet wide, (bottom of creek at an altitude of 46 feet; flood plain at 50 feet; general country level at 55 feet	2425	54	636
Offset of 239 feet N. 1° 30′ W. to quarterpost between Sections 22 and 23	2476.62	59	641
Creek	2490	60	642
Intersect P. O. and P. A. R. R. (at Sta. 526.39)	2503.78	62.5	644.5
Country level	....	60.5	642.5
Section line road (Secs. 23 and 24)	2529.85	62	644
Pigeon river and road, top of west bank	2537	61	643
Flood plain	2537.40	55	637
River bottom	2537.50	50	632
Top of east bank	....	63	645
25 feet S. to quarterpost between Sections 24 and 19, T. 16 N., R. 11 E., 2½ miles S. to Kilkenny	2582.13	68	650
	2620	70	652
Section line between 19 and 20	2631.20	72	654
21 feet N. to quarterpost between Sections 20 and 21, T. 16 N., R. 11 E.	2683.81	....	....
Angle thence N. 88° E.			
Creek in flooded woods	2696.70	70	652
Offset S. 0° 30′ E. 940 feet on Section line.			
	2719	80	662
Road, Sections 21 and 22	2736.59	....	....
	2767	90	672
	2810.50	100	682
River road, west bank of Pinnebog	2817	104	686
Flood plain	....	90	672
Bottom of river	....	84	666
East bank, front of terrace	....	100	682
Section line between 23 and 24	2838.33	108	690
Creek	2844	106	688
	2845	110	692
	2870	120	702
113 feet north to quarterpost between Sections 24 and 19, T. 16 N., R. 12 E.	2891.27	125	707
	2905	130	722
	2930	140	....
Section line between 19 and 20	2945	147	729
Road N. E. and S. W	2975	157	739
	2985	160	742
	2990	164	746
After 2992 very flat for quite a way.			
103 feet N. to quarterpost between Secs. 21 and 22	3050.08	162.5	744.5
From here course N. 63° 27′ E.	3076.55		
Section line road, 1349 feet S. to quarterpost between Sections 22 and 23	3105.58	165	747
Change course to N. 88° 35′ E.		167	749
	3142.50	182	764
Crescent avenue, Badaxe, section line	3143.50	177	759
Road between Sec. 24 and Sec. 18, T. 16 N., R. 13 E.	3213.70	181	763

Comparing this profile with that of the Pontiac, Oxford and Northern or with that of the Saginaw, Tuscola and Huron hereafter given, it agrees very well. It does not agree with the profile of the Goodman Logging Road, if this be located as given on the town map of Oliver in the county atlas. This was a logging spur, however, and is now torn up, and is given otherwise on the map of the county.

(c. 2). The following gives the main topographic data of Goodman Logging Road:

Main track of S. T. and H. taken as beginning of Survey and at 100 feet altitude.

	Station No.	Elevation.
(Compare altitude of Goodman (=Grassmere) as given by Gannett, i. e., 686 A. T., or 104 above lake.)		
	5	97.6
	8	101.1
	40	108.1
	49	104.6
Crosses previous profile (*c. 1*) near its station 2870, i. e., about 120 feet above lake.	51	108.6
	76	117.4
	78	113.7
	91	123.4
	100	120.5
Bridge abutment over Pinnebog	102.70	112.9
Bottom of river	...	92.4
River valley, flood plain	about	93
Inner valley bench	...	113
Outer bench	...	120

It seems likely that the assumed 100 feet is about 590 feet above tide, and more than 100 feet above Lake Huron.

(*c 3*) MAIN LINE OF SAGINAW, TUSCOLA AND HURON RAILROAD.

	Station number of railroad survey.	Elevation of railroad track.	Elev. of surrounding country.	Above tide.
Base about 11 feet above Lake Huron	100 ft apart	...	...	...
Sebewaing	1958	...	...	593
	2320	15.00	13	597
Sand ridge road	2345	23.00	...	605
Bayport Junction	2354	25.50	24	607
Bayport Station	2372	20.00	...	602, (604)*
Bayport dock, north end	2388	13.00	...	695
	2413	30.00	...	612
	2448	40.00	...	622
Quarry Junction	2482	46.00	46.5	628
Rock	2486	...	at 46.6	...
	2487	...	up to 50	...
Leave rock	2493	...	51-45	...
Level of ground, 54 ft	2515.5	...	at 47.7 ext. up to	...
Mud Creek	2506	45.00	42	627

* Gannett.

(*c 3*) MAIN LINE OF SAGINAW, TUSCOLA AND HURON RAILROAD.—*Concluded.*

	Station number of railroad survey.	Elevation of railroad track.	Elev. of surrounding country.	Above tide.
Cut (the rest is fill) from 2.506 to 2,560	2538	...	...	...
Road, east line Sec. 4, T. 16 N., R. 10 E	2560	44.00	42	626
Pigeon River bridge, above bottom of valley,	2585	47.00	...	629
12 feet deep, i. e, altitude 35 ft., with river 3	2583 to	...	...	...
feet deeper, i.e., altitude 32 feet	2588	...	...	...
P. O. & N. R. R. *Pigeon.* Compare altitude on	2640	51.50	...	633
P. O. & N. R. R	2819	71	74	653
Culvert; wet marsh	2856	68	63	650
Elkton	2874	68.50	66	651
Pinnebog R., 3½ ft. above bottom	2906	70.00	66.5	652
	2940	30	...	612
	2970	90	...	672
East line Sec. 14, T. 16 N., R. 11 E	2981	95.00	94	677
	3009	...	100	682
Goodman	...	...	...	686
	3030	111	110	693
(*Grassmere*) East line Sec. 13, T. 16 N., R. 11 E	3033	112.00	...	694
Nettle Run	3068	124.50	...	697
	3080	...	120	702
East line Sec. 18, T. 16 N., R. 12 E	3086	133.50	...	715
	3114	...	143	725
	3123	...	150	732
Bottom of Silver Creek	3163	156.5	151.5	739
East line Sec. 16, T. 16 N., R. 12	3193	161.25	160	743
	3230	...	163	745
	3244	165.00	...	747
About 2 ft. below railroad	3283·	...	170	752
East line Sec. 14, T. 16 N., R. 12 E (highest)	3297	177.60	180	759
	3311.5	...	179	...
East line Sec. 13, T. 16 N., R. 12 E	3352.5	164.50	164.50	746
Lowest point between Sec. 14 and Bad Axe sta.	3354	164.00	162.5	746
Northwest end of curve	3370	167.00	163.5	749
South end of curve	3380.5	171.00	171	753
Badaxe yard	3390	172.00	170	754
Badaxe depot, junction with P. M. R. R	3400	176.00	178	758

(c 4.) A compass line northerly from Sebewaing to the quarry of Sec. 5, T. 16 N., R. 10 E., gives some additional data important as to the lower lake ridges.

	Station of railroad survey.		
Main line near Sebewaing	1,966	8+	582=590
Ridge road	2,000	14	596
Ditch, bank 20 ft. on one side and 24 ft. on the other	...	...	...
Mound sloping down to 23 ft. on the other side; bottom	2,022	18	600
Ridge road; west side of ridge 20 ft., east side 24 to 25 ft; top	2,037	29	611
Country level is 27 feet above base at summit	...	...	609
Town line road	2,070.35	25	607
Creek	...	25	607
Line between Secs. 34 and 35, T. 16 N., R. 9 E	2,137.39	32	614
Line between Secs. 25 and 26	2,197	42	624
Surrounding country of Shebeon river	...	43	625
Shebeon river	2,270	40	622
Angle to due north on Sec. 20, T. 16 N., R. 10 E	...	...	...
South line of Sec. 5	2,490	44	626
Highest point on compass line	...	49	631
Town line road (north line of Sec. 5)	2,541	42	624
	2,574	37	619

(c 5). A survey from Sebewaing to Kilmanagh and thence to Caseville gives probably (the datum is uncertain).

	Station No.	Elevation above lake.	Elevation above tide.
	2000	11	593
	2010	21	603
Line between Secs. 3 and 4, T. 15 N., R. 9 E......	2030.50	20	602
	2046	17	599
Creek (banks at 23 feet)........................	....	21	603
Line between Sec. 2 and 3........................	2085	30	612
Line between Secs. 2 and 35, T. 16 N., R. 9 E......	2116	35	617
	2107.25	38	620
Line between Secs. 35 and 36, T. 16 N. R. 9 E.....	....	40	622
Line between Sec. 36 and Sec. 31, T. 16 N., R. 10 E	2196.50	40	622
Line between Secs. 29 and 30......................	2304	50	632
Line between Secs. 28 and 29......................	2305	....	....
Line between Secs. 21 and 28......................	2360	45	627
Line between Secs. 16 and 21......................	2414	45	627
Line between Secs. 16 and 9......................	2468	44	626
Line between Secs. 9 and 4......................	2522	42	624
Line between Secs. 4 and 3......................	2523	41	623
Thence all the way a beaver swamp to line	....	34	616
between Sec. 3 and Sec. 34, T. 17 N., R. 10 E..................	2776	33	615
Line between Secs. 27 and 34, and between Secs. 27 and 22, T. 17 N., R. 10 E..................	....	34	616
From 2705.50 to 2735 altitude the same...........	2735	....	....
Line between Secs. 15 and 22......................	....	32	614
Line between Secs. 11 and 14......................	2790	25	607
Watery all the way from........................	2798	23	605
to..	2848	22	604
Course changes at................................	2912.47	23	605
Creek (banks at 17 and 19 ft.)......................	2923.70	14	596
Line between Secs. 2 and 35, T. 18 N., R. 10 E....	2900	20	602
Road (center line of Sec. 35) running east........	2927.50	18	600
Caseville..	2940	20	602

The altitudes above agree very well with those of the Saginaw, Tuscola and Huron R. R., where this line crosses the latter on Sec. 4, T. 16 N., R. 10 E., but are a little lower than that of profile (c 1) where this line crosses that on Sec. 21, and seem rather low near Caseville, but nearly right.

(d). Miscellaneous data from Mr. W. L. Webber.

The east part of Sec. 5, T. 16 N., R. 10 E. has been contoured and at the center of the northeast quarter the altitude is 56.4 feet (638.4 feet A. T.) the altitude of Mud Creek on the north line of Sec. 4 is 37.4 feet (= 618.9 feet A. T.), on S. line, 41.8 feet (= 623.3 feet A. T.). Farther altitudes will be found in connection with coal explorations in Secs. 17 and 18, T. 15 N., R. 9 E., and in Sec. 5, T. 16 N., R. 10 E., Secs 35 and 36, T. 17 N., R. 9 E.

(e). Abstract of cross-section leveled with wye level at Port Austin, on August 6, 1886, by A. C. Lane and C. A. Davis, south on center line of sections 30 and 31, Port Austin Township, T. 19 N., R. 13 E.

From water's edge.	Chains.	Alt. above lake.	Above tide.
Water level that day........................	0.00	0.00	578
Top of old beach crest........................	....	4.03	582?
Level of Spring street, and usual datum for our barometric work, assumed as 592 feet above tide, *i. e.*, 10 feet above lake datum, but very probably nearer 12 feet..............	3	13.91	592
	4	14.75	....
	5	13.64	....
	6	14.00	....
	7	20.97	598
First dune line or ridge (height of instrument when on this bench, 30.80)..................	8	25.25	603
Hollow back of first ridge..................	9	23.21	601
Level of dunes to east and west..............	....	35.42	612
	10	27.07	....
	11	31.10	609
Bench back of dunes, water line at level of Lake Algonquin..............................	12	25.98	604
Front of back bench..........................	13	24.18	602
End of sand..................................	14	20.43	598
Washington street............................	15	....	....
Bottom of flat swampy plain..................	19	14.16	....
The instrument is about on level of the Broken Rocks bench at a height of..................	....	36.72	615
	....	30	....
	24	23.26	....
	....	27.37	....
At 39.49 a fence..............................	39	42.02	....
Bench mark on beech tree at 47.28............	....	....	....
No higher land east or west..................	45	54.25	....
Crest of little beach-ridge, shingle..........	46	57.27	635
Hollow back of same..........................	47	56.63	635
Slabs of rock at 54.50 chains................	50	60.03	....
Instrument on a beach line at an altitude of...	....	69.15	647
All along here woodchucks throw up slightly fossiliferous flagstones......................	56	68.17	....
	57	....	....
	60	73.36	....
	68	80.32	....
	70	80.83	....
Sandstone outcrops on hill west..............	....	91.97	670
Height of instrument on top of hill is 99.71, *i. e.*, top of hill is about..................	....	94	....

Another line of levels referred to below was run by Locke level near Bayport up to 40 feet, and gave practically the same altitudes for terraces, etc.

(f). Altitudes obtained by barometer.

The altitudes of the points given below were obtained by barometer in the course of our bicycling trips, but are picked stations which have been occupied at least twice, with harmonious results after allowing for the weather variation. The altitude is not supposed to be more than five feet out, one way or the other, supposing that the nearest railroad levels are correct.

	Above lake.	Above tide.
T. 19 N., R. 13 E., Port Austin, N. E. cor. Sec. 27	60	642
T. 18 N., R. 14 E., Huron, bridge over Willow creek, S. line of Sec. 8	33	615
N. W. cor. Sec. 31	116	698
N. quarter-post Sec. 33	99	681
T. 18 N., R. 13 E., Dwight, N. W. cor. Sec. 36	119	701
N. W. cor. Sec. 21	71	653
N. W. cor. Sec. 31	108	690
T. 18 N., R. 12 E., Hume, E. quarter-post Sec. 12	57	639
S. E. cor. Sec. 13	75	657
N. E. cor. Sec. 31	37	619
S. E. cor. Sec. 34	85	667
T. 18 N., R. 11 E., Lake, N. W. cor. Sec. 36	46	628
T. 17 N., R. 15 E., Rubicon, S. E. cor. Sec. 33	96	678
T. 17 N., R. 14 E., Bloomfield, N. quarter-post of Sec. 9, (Redman)	131	713
State road on N. line Sec. 20	130	712
S. W. cor. Sec. 31, Rapson	160	742
T. 17 N., R. 13 E., Lincoln, N. W. cor. Sec. 7	126	708
N. W. cor. Sec. 18	133	715
N. W. cor. Sec. 30	143	725
N. W. cor. Sec. 31	163	745
S. E. cor. Sec. 31	166	748
T. 17 N., R. 12 E., Meade, S. E. cor. Sec. 6	68	650
S. W. cor. Sec. 36	146	728
T. 16 N., R. 14 E., Sigel, N. W. cor. Sec. 18	192	774
Verona Mills, W. quarter-post Sec. 19	238	820
T. 16 N., R. 13 E., Verona, E. quarter-post Sec. 10	168	750
N. W. cor. Sec. 7	166	748
N. W. cor. Sec. 18	188	770
Summit of hill on N. E. ¼ Sec. 23	273	855
Bridge over Willow creek, Sec. 23	182	764
W. quarter-post Sec. 22	200	782
W. quarter-post Sec. 21	185	767
S. W. cor. Sec. 35	234	816
S. W. cor. Sec. 31	177	759
T. 16 N., R. 12 E., Colfax, S. E. cor. Sec. 6	111	693
T. 16 N., R. 11 E., Oliver, S. W. cor. Sec. 1	82	664
S. W. cor. Sec. 35	141	723
T. 15 N., R. 16 E., White Rock, S. W. cor. Sec. 7	72	654
T. 15 N., R. 15 E., Sherman, crest of ridge east side of Sec. 7	174	756
S. E. cor. Sec. 35	98	680
T. 15 N., R. 14, E., Paris, S. W. cor. Sec. 3	195	777
S. W. cor Sec. 18	222	874
S. W. cor. Sec. 19	216	808
S. W. cor. Sec. 18	196	778
T. 15 N., R. 13 E., Bingham, S. W. cor. Sec. 19	225	807
S. W. cor. Sec. 31	254	836
T. 15 N., R. 11 E., Grant, S. W. cor. Sec. 7	80	662
S. W. cor. Sec. 15	125	707
T. 15 N., R. 10 E., Sebewaing, Voltz creek bottom, on E. side of Sec. 14	48	630
N. side of Sec. 14	41	623

§ 6. The hill district.

Glancing upon the contour map previously described it will be apparent that Huron county may be divided into two districts, the hill district and the plain district. The latter may be subdivided into still smaller districts, but the former makes a well defined core or back bone to the county. It occupies, as is apparent from the map, a roughly triangular area extending from the north part of Verona township south-southeast to Parisville and west-southwest to Gagetown. In it head all the important streams of the county. It is higher to the east than to the west and while the valleys range from 165 to 213 feet above lake or 745 to 795 feet above tide, the hills rise frequently to some 850 feet above tide

(occasionally some thirty feet more), or up to 100 feet above the valleys. It is characteristic that it is not flat like the surrounding plain, whose smooth slope indicated by continuous contours is only broken by stream valleys, but that it has hills of gravelly clay or till, whose contours may have been cut into by running water, but are not principally determined by it. The streams which flow between them often flow in valleys which are ridiculously large for the present size of the streams. This is particularly true of Cass river and Willow Creek. Sometimes* undrained hollows will be found on the top of the hills with pools of water standing in them in the wetter part of the year.

Frequently these hills are terraced on their sides with sand and gravel, and especially as we go toward the margin of the district the clay ridges become lower and lower and are gradually buried under a mantle of gravel and sand which marks the boundary of this region. These till ridges, as may be seen at a glance at the map (Plate VIII), are the chief watersheds in this region. In several places the main ridges border upon swamps which are long and narrow like river valleys. In other cases the ridges may actually enclose quite considerable marshes without any outlet. Such a case is seen on Sec. 18, Sheridan, T. 15 N., R. 12 E., and these sand plain gravels or ridges are also well developed on Sec. 30 and elsewhere in the same township, where gravel also occurs in the form of eskers. Beside the hills of gravelly clay and these gravel deposits, this region contains also considerable swamp land. The streams have not had time to cut proper drainage channels, but it is all easily drained, and such old swamps, with a soil composed of muck underlain by shell marl are most fertile land. The shell marl points to a time when these swamps were lakes, and one such lake is left in this district—Mud Lake—on Sec. 32, Grant, T. 15 N., R. 11 E. Apparently it would not be difficult to drain this off into the Shebeon or into the Pigeon. Probably the shortest way of draining the whole lake would be into the former. This district is particularly ill adapted for the system of rectangular roads which obtains, as it involves a great deal of unnecessary up and down hill. It is easy to see valleys on the map which would make easy grades between the important points. The kames and askers furnish excellent road material, in their gravels, and are very porous so that they dry easily.

*e. g. on top of a hill on Sec. 34, Verona, T. 16 N., R. 13 E.

§ 7. The plain district.

Around the rolling nucleus of low hills just described sweeps a great plain, which includes most of the county. While to the eye it often appears perfectly level, except for the stream valleys carved in it, in reality it falls gently but steadily with no prominent exceptions, in all directions away toward the lake, until it is about 20 feet above it on the west side and about 40 on the east side. The stream valleys are usually not over 20 to 30 feet deep, growing deeper toward the margin of the plain, and not over 500 feet wide, and have steep sides showing their youth. It is a typical coastal plain.

The soil is usually a calcareous gravelly clay, diversified with low ridges of sand and gravel, or bouldery streaks which run in a general way parallel to the contour lines. To one standing on a prominent hill near Verona, and looking east the contrast of the two districts is as plain as in the diagram in Frye's Physical Geography, p. 12.

In this plain the streams have not developed marked ox bows and the only thing that can be called lake is a small body of water on the south side of Sec. 11, Chandler, T. 17 N., R. 11 E., which will doubtless soon be drained into the Pinnebog or otherwise. As the streams cut through these surface sands, which usually also line the borders of their valleys as a continuous fringe of delta deposit, down to the underlying clay, springs are likely to appear along the point of contact of overlying sands and clay. Excellent examples of this action may be seen on the road along the west line of White Rock township, T. 15 N., R. 16 E.

Along the upper part of this district some stimulus to the stream drainage is required, and so we find from Brookfield around through Lincoln to Paris, a strip of country which is artificially drained. As we get toward the margin of this district the trenches cut by the streams deepen. The Pinnebog and Pigeon have both cut down about as far as possible and are now vigorously at work lowering their grade by lengthening their course by enlarging their curves, swinging from bank to bank of the flood plain and cutting away at the bluffs which border it. Corpare Sec. 26, Chandler Tp. and Sec. 25 Winsor. On the east side of this district, the streams flow, "in their narrow U-shaped trenches, quite regularly down the slope direct toward the lake." There are an extraordinary number of nearly parallel streams. This is also true on the west side for the upper part of the slope, but then the streams are all deflected to the north. This deflection is probably in part due to the tendency already noticed for the sand to work back against the shore and along to the northeast on this side of the county (§ 3) so that there was a tendency to deflect the streams with the sand that they themselves bear down and turn their mouths northward. When, for example, the mouth of the Pinnebog was near Elkton the sand brought down by it and by its neighbor the Pigeon and by other streams immediately south, was deposited abundantly where we now find it on Secs. 16 and 17, Oliver, and may have assisted in turning its course northward. There are, however, faint irregularities of the old plain, undulations in the ground moraine, as it is called, which have also assisted in this action.

Some of the exceptions to the general slope of the plain deserve notice. There are a number due to the outcrop of the Marshall sandstone. Section 31, Port Austin, and Secs. 3 and 13, Dwight, Secs. 6 and 15 Meade, and perhaps also the southeast part of Lake show low rises due to this cause. Certainly in the southeast part of Huron and Bloomfield townships the eastern border of the Willow valley is marked by the buried sandstone escarpment. The limestones of the Bayport quarries are also marked by a ridge. In the northwest part of Rubicon township a number of streams seem to have been grouped together behind the heavy gravel ridges between 128 and 108 feet above the lake. Finally through the central part of Chandler and the northwest part of Oliver is a low ridge of the ground moraine.

§ 8. The eastern shore.

Sometimes, as just north of White Rock, we find the plain descending until it drops off to the lake in a single bluff, but more often we find a narrow zone with a stairlike structure, a sea cliff and a bench, then another cliff and another bench. The top of the first cliff is from 30 odd to nearly 100 feet above the lake (Sec. 3, Huron township)—but its bottom is pretty uniformly about 25 feet above. The bench slopes from this level pretty gradually, though with lesser breaks down to about 17 feet above the lake. Often there is a sheer cliff from this level down, but at times there is another bench 10 feet above lake (592 feet A. T.). The risers of this flight of stairs are often too steep for cultivation, and often stony. The benches also are often stony, especially toward Point aux Barques, but were originally marshy. "The upper terrace follows the shore line closely nearly all the way. About three-fourths of a mile north of White Rock the lake has cut away the intervening space and is now undermining and cutting back the bluff, which is here about 40 feet high, composed entirely of clay. The section shows about 35 feet of typical till,—blue clay, filled with pebbles and cobble stones; above this three to five feet of yellowish clay stratified, includes some sands; above this about one foot of soil." This upper terrace is cut by numerous short streams "which set back but a little into the uplands, and cut steep narrow channels in the edge of the plateau. The principal shore road runs generally just above or at the foot of the upper bench."*

§ 9. The western shore.

This district is much more important than the eastern, but has about the same limits of altitude. Beginning at the north extremity of the county around Point aux Barques, there is a practically continuous ridge of knobs of shifting dune sand, which continues, swinging from point to point, like draped festoons, clear to the southwest edge of the county. Exceptionally high knobs rise more than 40 feet above lake (620 feet A. T.), but in general the top of the ridge is a little above 30 feet above lake level. The ridge road crossed by the railroad lines, § 5, (b, 1) and (b, 3), at 29 feet is on the lower part of this ridge. On the landward side this ridge is backed by extensive swamps, now rapidly being artificially drained, at an altitude of 20 to 24 feet above lake (606 feet A. T.). On the lake side we find a series of sand and gravel beach ridges, interspersed with swamps. Their altitudes are quite various, depending somewhat upon how far the ridges pass into dune sand aggregates. There are in places at least four or five distinct strand lines. Occasionally, as around Sebewaing, on very gentle slopes the sand ridges are spread so far apart that the normal soil of gravelly clay appears between them, but in general the soil of this district is too sandy to be good, except in the swamps, and the roads are very heavy in dry weather, and best mended by clayey material such as the burnt waste from the coal mines. A characteristic feature of this district is the number of ponds. These are of the lagoon type, i. e., originally portions of the lake shut off by barrier beaches. Such was Bear Lake, near Port Austin (now drained, by cutting through the barrier beach) on the south line of Sec. 25. Back of Hat Point was one, and a filled up cranberry bog indicates another. Rush Lake is the largest of this type. Around Oak Point are about three more. Around Sand Point some seven more, while beds of calcareous marl under some of the swamps point to the former existence of others. Probably before this report is printed some of those enumerated will also be converted into marshes by nature, or into fertile meadows by man. On Charity Island was one of these ponds which had temporarily disappeared, when I visited it, leaving a bare expanse of cracked and treacherous mud. Were Lake Huron to remain at its present low level a few seasons more a growth of vegetation would cover the pond permanently. In all we may reckon some sixteen of these "lagoon" ponds at least, in altitudes ranging from 22 feet above the lake (604 feet A. T.) down—quite a contrast to the practically pondless condition of the other districts described.

*Quotations are from notes of C. H. Gordon.

The origin of these ponds were very beautifully shown in revisiting Oak Point in 1897, and the effect of the oscillations of lake level on a growing shore. The fall of water level culminating in 1895 had added a broad smooth slope some 400 feet wide to the shore of the southwest side of Oak Point. The recent rise had not gained on this smoothly, but had rolled up a ridge ahead of it, two feet high or so, behind which shallow ponds were formed, and the indications were that the lake would never regain what it had lost, but that a new ridge at about equal height would be added to the shore and would be separated from the old shore ridge by a swamp and by shallow ponds quickly converted to swamp. The whole space back of Oak Point to the road is filled with alternations of ridge and swamp to be explained this way, though mainly referrible to the higher 20-25 foot level. These ponds are a great resort for wild fowl. The soundings of the Lake Survey show that if Lake Huron were to drop 12 to 18 feet, several more similar ponds would be formed.

In this district the principal streams, the Pinnebog, the Pigeon and Sebewaing wind round in oxbows characteristic of streams which have had much time for lateral erosion and the stronger streams of the eastern side had time while the lake stood at the 25 foot level to cut their main valley down to this level and are also winding in oxbows, for instance the Allen on Sec. 24, Sand Beach Tp.

South of Sebewaing and for a short distance on the road from Port Austin to Port Crescent, the dune line is interrupted and the shore type is rather that of a cut terrace like that on the eastern shore.

CHAPTER IV.

FORMATION OF THE SOILS AND SUBSOILS (PLEISTOCENE).

§ 1. The preglacial surface.

The materials of which the earth's crust is composed are in Huron county so sharply divided into consolidated and unconsolidated shale, sandstone or limestone rock, on the one side, and soils and subsoils, i. e., gravels, sands, hardpan and the like on the other, and the physical geography just described is so dependent upon the latter that it seems wise to invert the historical order and describe the latter first. During the interval btween the formation of the latest rocks represented, and the earliest of the unconsolidated deposits of the Pleistocene, a long time elapsed. Geological periods passed away, and the surface of the rocks, after having been buried beneath we know not what other sediments, was for a long time a land surface. By subtracting the depths to rock in different wells from their altitudes as obtained on Plate VIII, we are able to get a number of altitudes of the rock surface, and thus draw a contour map of that surface, which is naturally much more hypothetical than the map of the present surface. This is illustrated by Plate VII. Though the present hill district is supported upon an elevated sandstone platform of underlying rock, we notice some other features of the rock surface which are not at all indicated by the present topography. One such completely disguised feature is the old river valley which runs through the township of Winsor and the southwest part of Sebewaing. While the exact location of the river valley is somewhat uncertain, its general course is not and is quite in accord with numerous other river valleys of similar nature known elsewhere in Michigan, and indicated by sudden irregularities in the drift.*

*In Hillsdale county, H. P. Parmelee, has noted such a river valley and described it in a paper read before the American Association and from the records sent us by well-drillers another passes close to Jonesville in the same county. Farther indications of such valleys are found near Alma, Midland, Saginaw, Unionville and elsewhere.

§ 2. The ice age. (Glacial epoch.)

We can see from these valleys that at one time the base level of erosion, i. e., the water level down toward which the streams were cutting, was much lower than the present lake surface. Such buried river channels taken together with others outside the county, raise in the mind the strong presumption that the land at one time stood higher than at present. This higher elevation may have had some influence, as well as a number of other causes which have been suggested, in bringing on the accumulation of ice that followed. Even in the tropics high mountains are now covered with perpetual snow, and as we pass north to the temperate regions this perpetual snow line lowers. If now a large portion of a country is raised up to this level of perpetual snow and the precipitation is greater than that gradual wasting which takes place even in the coolest, dry winter days, we have the conditions necessary for producing a vast ice sheet, for, once such a state of things is established, the white surface of the snow tends to reflect the arrows of the sun's heat like a polished buckler, and thus perpetuate its own existence. In other words, perpetual snow once established will tend to accumulate, and slowly compacting into ice will creep like a vast flood of stiff treacle far beyond the original area, just as it now does in Alaska, Switzerland and Greenland, until it meets a climate mild enough to melt it away as fast as it advances. Now, we find that over the surface of Huron county there advanced such a sheet of ice from the north, filling up and evening off the valleys with a mass of miscellaneous material derived from farther north, and dragged along or carried with the ice. The rocks and sand in the base of this moving sheet of ice scratched, or polished and grooved the underlying rocks (Pl. IX). Evidence concerning the motion of the ice is derived from two sources: (1) the direction of the striæ,—N. 10° W. at the Bayport quarries (observations around Port Austin are not so trustworthy as they may be due to shore ice). (2) Character of transported material. The boulders on the surface, e. g., the chiastolite schist on North Island, and the material of beach sands and gravel are not to be implicitly trusted, since they may have been transported by floe ice (Chapter III, § 3), when the lake was at a higher stage. For example, in the collection of Mr. Webber, there is a small piece of native copper, which is said to have been obtained from the stripping of the Bayport limestone quarry, and most likely was thus transported. But the boulders of the till and the high level gravels, the overwash of the moraines and kames, and the very first lake beaches formed at the immediate margin of the ice are more valuable.

Important observations are:

Sec. 23, Verona. Altitude 857, A. T. hornblendic rocks, quartzites, granites pink and white, also white chert apparently from the Corniferous or Upper Helderberg, black calcareous shales, with trilobites apparently *Phacops bufo* of the Traverse, reddish-green sandstone, like the grindstone, etc.

Sec. 35, Caseville, *Atrypa reticularis* in blue shale;

Sec. 4, Winsor, and Sec. 26, Caseville, gypsum in drift. According to Davis on northernmost ridge are granite, volcanic and trap rocks, pyritiferous quartz, also found near Badaxe and now in Post and Seeley's bank; jasper conglomerate quite frequent.

This sheet of ice extended, as we know from the reports of adjacent States, down to the Ohio River, carrying with it fragments from the Laurentian highlands of Canada, whence it is called the Laurentide glacier.* Fragments of Canadian rock are frequent in Huron county, and the Corniferous cherts and Hamilton rocks which outcrop north of the county, beneath Lake Huron as well as in Canada. Such a glacial ice sheet would naturally be very much affected by the weather, the front being wasted away, or retiring during a series of dry seasons, or hot seasons, just as present glaciers are found to be advancing and receding. In this respect it would be like the lakes whose fluctuations extending over a series of years we have already described. Such fluctuations have been noted extending over many miles by geologists who have followed along the margin of the glacier. One evidence of such recession and re-advance is found in forest beds, i. e. indications of soil and wood, between two beds of gravelly clay or till, laid down beneath an ice sheet. Huron county is, however, far back from the ice front and we have no clear indications that such a retreat of the ice occurred until after the last period of farthest advance, which has been called the Wisconsin advance or stage.†

*Maps of the extent of this glacier are very numerous. One of the more recent is by Leverett and Taylor in the Inland Educator, August, 1896, p. 29, American Geologist, Vol. XXIV, Plate II.

†Leverett Inland Educator, loc. cit.

In a few well records as in Secs. 11, 17, 18, 30, Sebewaing, beds of sand or gravel are reported under hardpan, i. e., till or gravelly clay, but in many cases these are just above the rock and may have antedated the first advance of the ice sheet. In Sec 3, Brookfield, chips were brought up at 130 feet and in boring some other wells chips have been found. This is again near the bottom, and may have antedated the glacial period, as it is in a well in an old valley, where the soil and trees before the ice would be especially likely to be overriden. A piece of wood was taken from the pump of the Badaxe waterworks, but all the experts to whom I have shown it unanimously agreed that it must have found its way there accidentally.

§ 3. The ice retreat. (Early Champlain or terrace epoch.)

The ice period is then, as regards Huron county so far as we know practically a unit, and we cannot here learn how long the ice rested upon the county nor what was happening in the meantime. History is a record of current events, and there can be no history when nothing happened, while the county slept beneath the white sheet of ice. History begins again when the ice retired from the county. But to make the story clear we must begin before the retiring ice front had reached Huron county. For our knowledge of the course of events at this time we are much indebted to Mr. F. B. Taylor,* from whom we thankfully borrow a plate of the thumb region to illustrate the course of events of this epoch,—the Champlain or Terrace epoch,—Plate VI.

As the sheet advanced, it followed the low grounds like a river and as it melted back it lingered in the valleys longest. One lobe of the ice went down Saginaw Bay and another down Lake Huron, and they met in a thinner sheet over the sandstone ridge which projects into Huron county. Lakes formed in front of the melting ice and drained off to the Mississippi. In front of the Saginaw lobe

*A very clear and popular resumé is "A short History of the Great Lakes," No. X of the Studies in Indiana Geography, issued by the Inland Publishing Company, Terre Haute, Indiana, May, 1897, well illustrated, and especially to be recommended to teachers. See also article in American Geologist, Vol. XXIV, July, 1899. This report we in general follow. A technical paper, with references to the earlier literature, is in Vol. 8, of the Bull. of the Geol. Soc. of America, Jan. 1896, pp. 31-58. This paper contains the plate of the thumb region, which we reproduce in Plate VI. Numerous earlier papers of Taylor, Leverett, Upham, Tarr, Gilbert, Spencer and others will be found scattered through the American Geologist, Bulletin of the Geological Society, and Am. Jour. of Science. Particular attention may be called to Spencer's popular paper in Appleton's Popular Science Monthly, June, 1896, "How the Great Lakes were Built." It will be noticed that his views do not agree with Taylor's, but the views of the latter were based particularly upon studies in Huron county and neighborhood, and I consider them decidedly more nearly correct in reference to this region. For a fuller description of the earlier stages of the ice retreat see also Sherzer's report on Monroe county, Part I of this volume.

a lake formed, called by Taylor, Lake Saginaw, which passed over the watershed between Ashley and Bannister, and flowed down the Grand River to a larger lake, which lay in front of another lobe, covered somewhat more than the southern part of Lake Michigan, and near Chicago drained off to the Mississippi.*

Some old shore lines of this old lake are indicated on Plate VI. Gradually the ice retreated, and Lake Saginaw grew toward the northeast, and the streams began to work their way down to it from east, south and west.

But before this, another lake had formed in front of the Erie Huron lobe of the ice front, called by Taylor, Lake Maumee, which drained off past the town of Fort Wayne, down the Wabash. As the ice front retreated it was only a question of time when these two lakes would mingle, and it is easy to foresee that their meeting point would be in Huron county or just south of it. But the level of these two lakes was not the same. As we find their water marks at the southwest and southeast ends of the hill district respectively (Plate VIII), Lake Saginaw was some 75 feet below the highest watermark on the other side.†

As Lake Whittlesey and Lake Saginaw were independent the beaches of the one cannot be closely parallel with those of the other,—at least it is not to be presumed without proof that the permanent water stages of the one were correspondent to those of the other. In a general way, however, the two lakes were coeval. Taylor gives for altitude of the Forest Beach at Gagetown 765 feet, but I think that the gravels he probably had in mind were deposited before free water communication was established around the point. The beaches around the outlet of Lake Saginaw Taylor gives as 750 or 746 above tide or 100 feet above the channel floor at Pewamo. The highest point of the channel floor of the outlet must be, by levels of the Ann Arbor line which is about 65 feet above Lake Michigan

*Leverett, Bull. No. II, Geol. and Nat. Hist. Survey, Chicago Academy of Sciences.

†Note the change of topography at the 820 foot, respectively 740 feet contour lines, more particular observations are: Cass City, Tuscola County, on broad terrace (probably stream delta), 742 to 748 feet A. T.; west line, Sec. 29, T. 15 N., R. 11 E., Grant, highest gravel deposits, 744 feet A. T., same section, centerline, top of gravel bench, 740 feet A. T.; same section, 500 paces E., 1,500 paces N., 747 feet A. T., also gravel bench on south line of Sec. 21, 750 A. T.; on west line of Sec. 31, 727 feet A. T. On the other side of the hill district the beach line is by no means so well marked, but compare in Paris Township: Sec. 18, north line, front of gravel bench, 809 feet A. T.; Sec. 20, north line, top of gravel bench, 819 feet A. T.; Sec. 31, sandspur from east, 827 feet, A. T.; Sec. 34, north line, river channel, swamp, 811 feet A. T.; Sec. 34, in Bingham township (see below), sand spit, 809 feet, A. T. Average for Lake Saginaw about the time it reached Huron County, 744 feet A. T. According to Taylor, by the evidence of the Duplain beach it was at one time 20 feet or more higher.

Probable altitude for Lake Whittlesey (large successor of Lake Maumee), 809 ft.