GEOLOGICAL REPORT

ON

BAY COUNTY

BY

W. F. COOPER

Michigan Geological Survey

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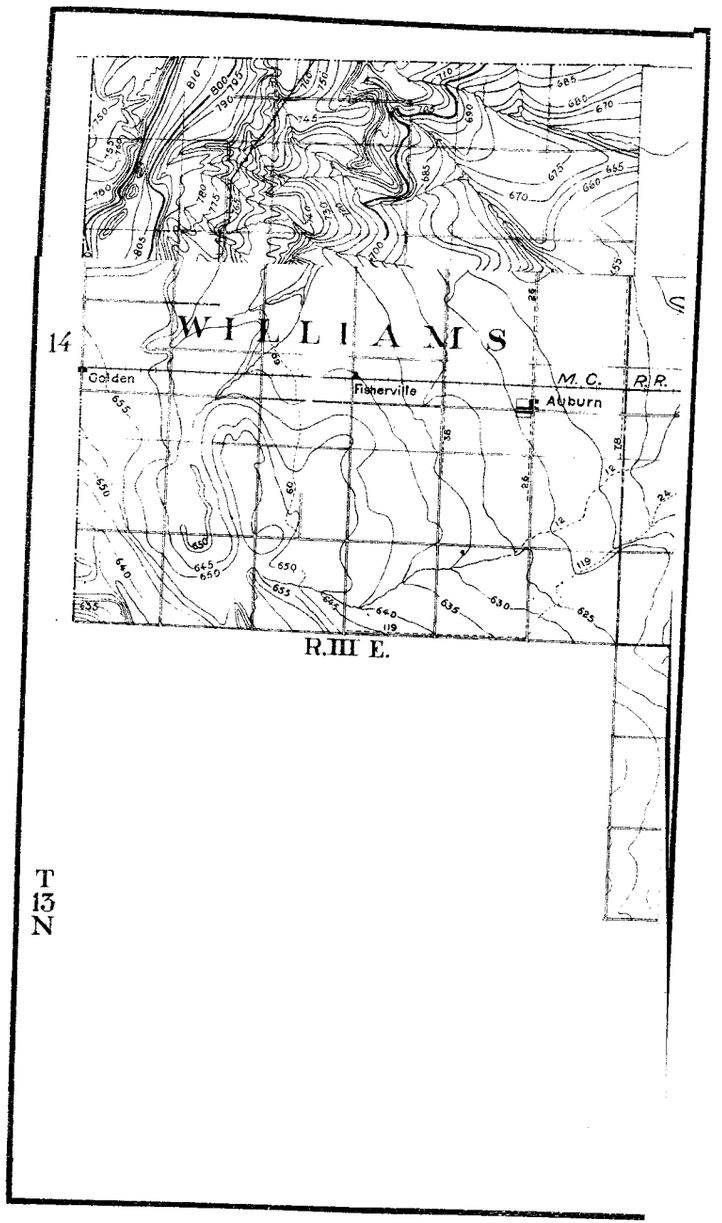

LETTER OF TRANSMITTAL.

OFFICE OF THE STATE GEOLOGIST,

LANSING, MICHIGAN, Jan. 22, 1906.

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

Hon. Fred M. Warner, President.

Hon. W. J. McKone.

Hon. Patrick H. Kelley, Secretary.

Gentlemen:—I herewith transmit for publication as part of your report for 1905, the following report on Bay county by W. F. Cooper. It represents a great deal of work on his part in compiling lines of levels and records of coal exploration, and I trust may be of service to the people of that county, especially in the development of the coal. The salt industry and bromine which might be developed in connection near the west line of the county, cannot satisfactorily be treated by counties. The full notes of the various drain lines, which he found in various hands and compiled, I have however, omitted, as they would be of interest to so few, to avoid undue expense, but they may be consulted in my office, or in that of the Bay County Drain Commissioner.

Very respectfully,

ALFRED C. LANE,

State Geologist.

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CHAPTER I.

HISTORICAL, INTRODUCTION.

1. *Position.*

Bay county, appropriately named from its situation on the western and southern shore of Saginaw Bay, is further bounded on the east by Tuscola county, situated at the base of the "Thumb" of Michigan, on the south by Saginaw county, on the west by Midland and Gladwin counties, and on the north by Arenac county. Bay City, which is situated in the southern part of the county, is in longitude 80° 50′ west, and latitude 43° 36′ north, as given on the chart of the U. S. Lake Survey.

It embraces in the U. S. Government Linear Survey, nine full and seven fractional townships, the latter being along the shore of Saginaw bay with the exception of Frankenlust township, which is in the southern part of the county. Townships 13 to 18 north and ranges 3 to 6 east fall within its limits.

2. *Area of Bay County.*

The area as determined by a planimèter, from the Government township plats in the office of the Land Commissioner at Lansing, is approximately 450.29 square miles. Of this amount 86.11 square miles is east of Saginaw river; 3.96 square miles is occupied by the river and the Middle Ground. The balance amounting to 360.22 square miles is west of Saginaw bay and the Saginaw river. The area and location as determined from the same Linear Survey sheets, of the different important civil divisions given in the Bay county atlas published in 1896, is as follows:

Bangor, T's 14, 15 N., R. 5 E.....	13.3685	square	miles.
Bay City, T's 13, 14 N., R. 5 E.....	4.885	"	"
Beaver T. 15 N., R. 3 E.....	35.325	"	"
Essexville T. 14 N., R. 5 E.....	1.40	"	"
Frankenlust T. 13 N., R's 4, 5 E.....	23.1625	"	"
Fraser T. 16 N., R's 4 5 E.....	33.2935	"	"
Garfield T. 16 N., R. 3 E.....	35.225	"	"
Gibson T. 18 N., R. 3 E.....	35.5325	"	"
Hampton T. 14 N., R's 5, 6 E.....	27.5119	"	"
Kawkawlin T. 15 N., R. 4 E.....	34.045	"	"
Merritt T. 13 N., R. 6 E.....	32.1275	"	"
Monitor T. 14 N., R's 4, 5 E.....	37.2265	"	"
Mt. Forest T. 17 N., R. 3 E.....	36.2450	"	"
Pinconning T. 17 N., R's 4, 5 E.....	37.3365	"	"
Portsmouth T. 13, 14 N., R's 5, 6 E....	20.1875	"	"
West Bay City T. 14 N., R. 5. E.....	3.945	"	"
Williams T. 14 N., R. 3 E.....	35.515	"	"

3. *Railroads.*

The Michigan Central railroad system ramifies in several different directions from Bay City. The Detroit and Bay City branch running in a southeasterly direction through Munger enters Saginaw county near the south eastern corner of Bay county. The Saginaw division, continued northward from Bay City as the Mackinaw division, unites to form the Jackson, Lansing and Saginaw branch, which runs along the west side of Saginaw river and Saginaw bay, crossing the Saginaw river at Bay City and the Kawkawlin river at Kawkawlin village. From this branch in the northern part of Bay county, the Saginaw Bay and Northwestern branch runs west-northwest from Pinconning through the village of Mt. Forest and thence on to Gladwin. At Mt. Forest the late Mr. Charles Van Lieuw and John Bloomshield of West Bay City, ran the transit line and levels for a spur north through Bently and into Arenac county, which is still quite largely used for lumbering purposes. The Midland division of the Michigan Central runs west after leaving West Bay City, through the village of Auburn, tapping with its spurs several important coal deposits. The Grand Trunk (C. S. & M.) and Pere Marquette systems connect Bay and West Bay Cities with Saginaw, following the Saginaw river. The Detroit and Mackinac railroad parallels the Michigan Central from Bay City to Pinconning. Mr. Henry C. Thompson, City Engineer of West Bay City, ran during the summer of 1902, the levels for the Huron and Western railroad, which follows the quarter line of sections 7-12, T. 14 N., R. 4 E., and thence due east, as originally laid out, to the Saginaw river.

During the lumbering period several spurs were laid out in the northern part of the county, but have been in part abandoned with the decline in the lumber industry. Such an abandoned line, which has been pressed into service for a wagon road, runs through the north half of section 5, Gibson township, entering Gladwin county at or near the west quarter post of section 6, T. 18 N., R. 3 E., a branch running south to about the center of section 7 and connecting with the main line. Another abandoned spur known as the old Nine Mile branch runs through sections 10 and 3 of Mt. Forest township, thence through the southeastern and eastern part of Gibson township, into a part of the county otherwise largely unopened. The Fisher branch, still in use, runs from Mt. Forest village through sections 9, 16, 21, 22, 27, 26, 35 in T. 17 N., R. 3 E. The Eddy branch, which unites with the spur at Fisher Junction in the northern part of section 21, is at present used for a wagon road. This branch runs in a general southerly direction through sections 21, 28 to the southeast corner of section 33, and thence for a short distance into Garfield township. The Sullivan branch, also in use, terminates in section 19 of Mt. Forest township, joining the main Fisher branch in the lower half of section 16. Forming a junction with the Saginaw Bay and Northwestern road, a short abandoned branch runs north approximately along the quarter line of sections 11 and 14, T. 17 N., R. 3 E. Another abandoned line which is partly corduroyed, runs east and west through sections 7 and 8, Mt. Forest township, and was used as a base in running beach meanders. Still another branch started at Pinconning, terminating at Glencoe in the southwestern corner of Mt. Forest township.

Taking the county as a unit; with its situation on the shore of Saginaw Bay and at the head of deep water navigation; with abundant railroad facilities; a progressive and quite complete system of stone roads in the eastern and southern part of the county; the natural resources and geographic location are destined to place the same in the very front rank.

4. *Linear Survey.*

The Linear Survey of Michigan was begun in 1815, and entered Bay county in 1820, when Joseph Wampler ran the township lines of T. 14 N., R. 4 E. Subsequent township lines by the same surveyor were as follows: T's 13 and 14 N., R. 6 E., 1821; T's 13 and 14 N., R. 5 E., east of river, 1822; T. 16 N., R's 4 and 5 E., 1822; T. 17 N., R. 5 E., 1822; T. 15 N., R. 4 E., outside of the reserve, 1822, the reserve being surveyed by John Millett in 1840. Wampler also ran the east line of T. 16 N., R. 3 E., in 1822, the north, south and west lines being run by Robert Clark in 1831. Mr. Clark also ran in the same year the south line of T. 18 N., R. 3 E., the north, east, and west lines being run by Levis Clason in 1837. Mr. John Millett was employed in running township and section lines to wit: T. 13 N., R. 4 E., 1839; T's 13 and 14 N., R. 5 E., west of river, 1839; T. 15 N., R. 5 E., 1839. Harvey Parke determined the township lines of T's 14 and 15 N., R. 3 E., which completed the township and a portion of the sectional surveys.

Orange Risdon in 1834 ran the section lines of T's 13 and 14 N., R. 6 E. In 1840 John Millett made the sectional survey of T. 14 N., R. 4 E.; in 1846 of T. 16 N., R. 3 E. John Bent ran the section lines of T. 15 N., R. 4 E., outside of the reserve, in 1843, and also those of T. 16 N., R's 4 and 5 E. John Burt ran the section lines of T. 17 N., R's 4 and 5 E., in 1843. Three years later John Millett made the sectional surveys of T's 17 and 18 N., R. 3 E., which completed the Linear Survey within the limits of Bay county.

5. *Maps and Surveys.*

With the exception of the U. S. Lake Survey, of which further mention will be made, all the maps relating to this county are based with a greater or less degree of accuracy upon the Government Linear Survey, which is only approximately accurate for each township unit. The main map of Bay county in this report is largely based on this original survey, together with the chart of the Lake Survey showing the lower reaches of the Saginaw river and considerable of the adjacent shore line of the bay. This information has been supplemented by information obtained from drain surveys relative to intermittent streams and in the field.

"The geological maps of Bay county are those incorporated in some general map like those issued by Winchell in Walling's atlas in 1873, and by Rominger and Lane in Volume III, respectively V of these series of reports." [1]

An earlier map by Winchell, colored to represent the different geological formations in the lower and upper peninsulas, appeared in 1865. In the report on "Water Resources of the Lower Peninsula of Michigan" forming Water Supply and Irrigation Paper No. 30 of the U. S. Geological Survey, is a map revised by A. C. Lane, from a map in Volume V of the state reports. In the annual report of the State Geologist for 1901, is a map based on Silas Farmer's map, and reduced to a scale of one inch to each 56 miles. This shows the section lines and is the most accurate map to date.

Farmer's sectional map published in 1856 in 6 sheets, 7½ miles to the inch, summarizes the result of the Linear Survey, and is a most excellent map. This was issued and revised in various scales and at various dates. Mr. Farmer also published in 1901 an excellent map of the entire state on a scale of 12 miles to one inch. In 1897 the Rand McNally Company published a sectional map of Michigan on a scale of 8 miles to the inch. This map has

[1] Volume VII, Part 2, page 7.

occasionally been used in field and office work by the State Geological Survey. In 1860 the U. S. Lake Survey carefully surveyed the shores of Saginaw Bay. The map which was published in 1860 gives the results on a scale of 1 : 120,000. Another chart gives the Lower Reaches of the Saginaw river and the bar in front: scale one mile to 6.25 inches. The Geological Survey has been permitted to use photographs of the field sheets which were on a scale of 1 : 16,000.

In 1860 a map was issued entitled, "Map of Saginaw and Tuscola with part of Genesee, Lapeer, Huron and Midland counties." In Bay county are the townships of T. 16 N., R. 4 E., T. 15 N., R's 3 and 4 E., T's 13 and 14 N., R's 3, 4, 5, and 6 E., scale one mile equals .65 inch. Published by D. A Pettibone, Surveyor, Bridgeport Center, Michigan. Lithographed, printed and mounted by J. H. Colton & Co., New York.

In 1869 appeared a map of Bay county by B. F. Bush; Fred H. Herbert, Lithographer, East Saginaw. Everything within the limits of T's 13-20 N., R's 2-6 E., was included on this map. East of the river were the townships of Hampton and Portsmouth. Bangor, Monitor and Williams had much the same limits as now; Beaver included T's 15-20 N., R. 3 E.; Kawkawlin T's 15, 16 N., R's 4 and 5 E.; the rest of the county is within the limits of Arenac township. The swamp areas as given on the Linear Survey maps are indicated. The railroad, canal, swamp, and German Seminary lands are indexed by letters. The roads, plank roads and railroads are also distinguished. Scale one mile to the inch.

1873. Walling's atlas of the State of Michigan, already mentioned, contains a separate map of Bay and what is now Arenac county. Within the present limits of the county there are represented 10 civil township organizations, one of which extended into what is now Arenac county. It is rather inaccurate.

1875. Wm. Mercer, for many years City Engineer of Bay City, published a map of Bay City and the villages of Wenona (West Bay City), Banks, Salzburg, Essex and vicinity. This was compiled and drawn by Mr. Mercer. Scale one mile to every 13 inches.

In 1883 H. R. Page and Co., of Chicago published a history of the Lake Huron Shore containing biographical and other matter with a map of Bay and Arenac counties.

1884. Map of the Saginaw river and the cities of the Saginaw Valley, published by the Saginaw Board of Trade, accompanying the report for 1884. Scale 4,000 feet to the inch. The location of the different firms represented in the saw mill, shingle mill, salt works, solar field and planing mill business are given.

1885. Another map of Bay City by Geo. Turner, Surveyor and City Engineer, 1885. Scale 400 feet to one inch. Drawn by F. Tittman, C. E., 1895. Mr. Turner published another map of the city on a scale of 800 feet to one inch.

1886. Mr. Henry C. Thompson published a map of Bay county on a scale of 2 inches to the mile, based on the Linear Survey. Certain portions of the map giving accurate road meanders were used on the Geological Survey map. Mr. Thompson has also an excellent map of West Bay City.

1894. In this year appeared another map of Bay county by Henry C. Thompson, West Bay City. The scale is 2 miles to the inch. School districts are designated by large figures and their boundaries by dotted lines. This is the original of the Bay county land map extensively used by F. J. Tromble of Bay City.

1896. An atlas of Bay county was published by D. A. Bullock & Co., of Bay City, with a general map of the state and county; with township and outline maps of Bay and West Bay Cities on a scale of 2.5 inches to one mile, the cities being represented in greater detail on other sheets; village plats are on a scale of 13 inches to the mile. The township maps were largely constructed from deeds in the county records. Blue prints made from these maps were used by the Geological Survey in the field.

1902. This map was published by Snyder and McCabe of the Bay City "Tribune." Scale one and one-half inches to the mile. The roads, stone roads, railroads, electric lines, rural postal routes, are each designated. The most recent property owners are given, with the location of the houses, churches, school houses, and coal mines at that time in operation. The population of the Bay Cities and townships in 1900 is also tabulated.

1905. Soil survey of the Saginaw Area, Mich., by W. E. McLendon and M. Earl Carr, U. S. Dept. of Agriculture, 1904. This embraces all the area of Bay county as far north as the south line of Garfield and Fraser townships.

In this connection I desire to acknowledge my indebtedness to Mr. John H. Blomshield of West Bay City for a meander of the mouth of the Saginaw river made in February, 1894, with the location of the original meander lines. The scale is three chains to one inch. Mr. J. F. Pratt, Engineer of the Michigan Central R. R., stationed at Bay City has also given the Survey valuable information relative to lumber and other railroad locations in Mt. Forest township, which we have incorporated on the map in this report.

6. *Historical.*

Originally occupied by the Sacs and Fox, as far as our present knowledge goes, these tribes were displaced by the Chippewa or Ojibway Indians from the north, after being almost exterminated. Mr. W. T. Shaw, who was employed by the Survey in the northern part of the county, writes that the Indians had a tradition of the time when Saginaw Bay extended to the Algonquin shore line now traversed by the East Saginaw and Au Sable State Road. If this tradition did not occur to the Indians from the analogy of the old and present beach lines, it implies an antiquity of some 2,000 years. The finding of stone implements in the till of southern Ohio would point to such a possibility. Mr. Harlan I. Smith of the American Museum of Natural History, has recently been engaged in investigations for that institution.[2] He finds that the Chippewas living in the valley today, have much the same culture, and are manufacturing many of the same implements as he excavated from the mounds near which they are living, and he concludes, are therefore the descendants of the mound builders. The mounds appear to be mostly filled with the remains of the unfortunate Sacs, who were massacred at the time of the invasion. With the advent of the early French traders, the civilization of the whites replaced in part, the culture of the red, so that we have the dignity of the "plug" instead of the coonskin, clay-pipes instead of the ornamental stone, while to make the evolution complete, there is the black bottle filled with fire water.

In the beginnings of settlement geography, and its precursor geology, go hand in hand with history, the divergence becoming wider and wider as culture advances, and the art of man enables him to assume the mastery over nature.

Originally a part of Saginaw, Midland and the whole of Arenac counties,

[2] Harper's Weekly, Jan. 3, 1903.

this territory was organized into Bay county in 1857. The townships of Hampton and Williams had been heretofore organized in 1843 and 1853, being the only townships with a full organization. At a special meeting of the Board of County Supervisors in February, 1859, the territory of Arenac was separated into a township. In March, 1859, the township of Portsmouth was organized, while later in the same year, the township of Bangor was separated. The State Legislature in 1867 separated Beaver township from Williams which lies to the south. The Board of Supervisors in January, 1868, passed an act organizing the township of Kawkawlin which had previously formed a part of Bangor. In 1869, Monitor township was established by the legislature. Two years later in 1871, the old township of Portsmouth was divided and the township of Merritt constituted. In 1873 the township of Pinconning was organized by the State Legislature. In 1875 Fraser township was formed, with Wm. Mitchie as its first Supervisor. The township of Frankenlust was detached from Saginaw county, and annexed to Bay in the winter of 1880. Mr. W. V. Renner, Township Clerk of Garfield, writes as follows: "Prior to April 4, 1897, Garfield was a part of Fraser township. At the annual October session of the Board of Supervisors in 1896, said board ordered that T. 16 N., R. 3 E., should be organized and known as Garfield township. I have been informed that the township of Gibson, which previously formed a part of Pinconning, was separated in 1889." During the biennial session of the legislature in 1902-1903, the township of Gibson was annexed to Arenac county, but this act was declared unconstitutional by the Supreme Court. Mr. Thomas Cronk, Township Clerk of Mt. Forest, writes that the township was set off in 1890, forming previously a part of Pinconning township.

In 1851 appeared a pamphlet by Frederick C. L. Koch entitled "Die Deutschen Colonien in der Nahe des Saginaw-Flusses." This is accompanied by a map showing the location of the colonies in Frankenlust and Amelith.

7. *Previous Geological Work.*

There being no outcrop of rock in Bay county, it received but little attention from the first Geological survey. However, Douglass Houghton, the first State Geologist, in his second annual report submitted in February, 1839, remarks:

"The country north of the southern boundary of Arenac county" (at that time part of Bay county) "and east of the Meridian, so far as examined, is on the whole but ill adapted to the purpose of agriculture, being chiefly composed of sandy ridges with intervening swales, and rising so gradually toward the central portions of the state as to leave the country extremely flat. There are, however, many valuable tracts of white pine, which will serve to render this portion of the state of some importance. Yellow pine well adapted for light spars also abounds."

A large portion of the immediate shores of the lake is composed of marsh."

As will be seen, the author was under considerable misapprehension concerning the agricultural resources of the region, but his description of the topography sufficed to give an idea at that time.

In his fourth annual report, published in 1841, page 132, the Pleistocene deposits are termed Tertiary clays. They are stated to have a thickness of from 1 to 100 feet.

In the first biennial report of Alexander Winchell published in 1860, coal is stated to underlie the greater part of Bay county.

Dr. Carl Rominger in Volume III, page 69, gives some details of two salt wells at Kawkawlin of which further mention will be made. There is also given in the same report, in the Appendix by Dr. S. S. Garrigues, a list of the companies engaged in the salt industry in this county.

In 1873 A. Winchell prepared for Walling's Atlas a number of articles which were reprinted under the title, "Michigan, Being Condensed, Popular Sketches of the Topography, Climate and Geology of the State." [3]

In Bulletin 99 of the Michigan Agricultural Experiment Station, 1893, is a soil analysis from the farm of Judge Marston, Bay City, but which I believe is from the Algonquin beach near Kawkawlin, northwest of West Bay City.

For the following reference I am indebted to Mr. Lane, who has translated the work mentioned. "The earliest extensive treatment of the salt manufacture in the Saginaw Valley was by Dr. H. C. Hahn, in the 'Berg und Huettenmaennische Zeitung' for 1869, in a series of articles running through the year from page 97 to page 339. Dr. Hahn was located in the New York and Saginaw works in Saginaw county, and it is intended to give a full account of his tests in the Saginaw county report. He published, however, some analyses from the Portsmouth Co., the Bangor Co., and Gilmore (well) in Bay City which were made by Dr. Goessmann and are given in a paper on salt manufacture which Garrigues published in Volume III of our reports." In Volume V part 2, of the same series of reports, there are numerous references concerning the stratigraphical geology of Bay county, to which reference will be made in their proper place in Chapter II. Also in Volume VII, part 2, Lane has compared the stratigraphic succession in the two counties of Huron and Bay.

Volume VIII of the series of State quarto reports is devoted to the economic geology of the lower peninsula of Michigan. Part 1 of this volume is by Dr. H. Ries, being a report on the clays and shales of Michigan. Part II, by A. C. Lane, is the final report on coal, the preliminary report appearing serially in the "Michigan Miner," Volume I, Nos. 3-10, February to September, 1899. Further reference will be made to this volume in the chapter devoted to economic geology and the coa measures.

Mr. F. B. Taylor has been engaged in tracing the Algonquin and Nipissing beaches from the west side of Saginaw bay to the Straits of Mackinac. [4]

In 1897 appeared an article by Taylor in a Bulletin of the "Geological Society of America," Volume 8, pp. 31-58, with a plate showing the location of the moraine on the east side of the Tittabawassee river.

In the annual reports of the State Geologist, A. C. Lane, for 1901 and 1902, are incidental references to the geology of Bay county, to which reference will be made further on. Mr. Lane has written for the series of Water Supply and Irrigation Papers of the U. S. Geological Survey, Bulletin No. 30, on the "Water Resources of the Lower Peninsula of Michigan," in which are found references to the Pleistocene geology quite applicable to the Saginaw bay basin.

Finally in the different numbers of the "Michigan Miner" edited by the late Mr. C. B. Schaefer, there have appeared articles from time to time, bearing on the geology and physical geography of this county. This monthly was later edited by Messrs. Davis and Clark, and at the present time is edited by John W. Clark.

[3] Volume VII, Part 2, page 4.
[4] American Geologist, Volume XVII, pp. 253–257, 1896.

8. *Recent Work.*

The detailed field work in Bay county was undertaken in the summer of 1900 by Prof. W. T. Shaw, who was at that time connected with the Michigan Agricultural College, and myself. The upper part of the county comprising the townships of Kawkawlin, Fraser, Garfield, Pinconning, Mt. Forest, and Gibson, were worked by Mr. Shaw, while I finished the field work in the northern part of Saginaw county and the remainder of Bay. This field work consisted for the most part, of collections of well records, and data from which a soil map could be prepared. In the fall of 1900, with headquarters in West Bay City, about three months were spent in obtaining maps, locations and levels of the various drains which had been dug in the county, along with a good many incomplete lines. Specific acknowledgement and suggestions in connection with the subject will be found in connection with the chapter on Physical Geography and Drainage.

In the summer of 1901, Mr. John H. Blomshield and I were engaged in running 33 miles of levels in order to obtain the elevation of certain inland drains and records, as well as to furnish base lines for aneroid elevations in the western and northwestern part of the county. From this work it is possible to obtain an accurate idea of the elevation of each drain line above the Bay, or as it is expressed, above tide, the elevation of the bay being 580.37 feet A. T. during August, 1902.

In the fall of 1901 I spent three weeks in getting aneroid elevations west of the Saginaw river. In the fall of 1902 this work was completed for the entire county, obtaining sufficient data for a five foot contour map of that area.

Outside of the stream valleys and beach lines showing former lake margins, the topography of Bay county is comparatively even. In the spring and fall of 1902, meanders were run over all beach lines of any importance. This greatly facilitated the work of contouring, beside adding to our knowledge of the Pleistocene lake history.

During the summer of 1902 Mr. Floyd D. Owen of the Michigan Agricultural College was engaged in studying Bay county waters. The results of his work appeared in the annual report of the State Geologist for 1902, under the title, "Some Field and Laboratory Tests of Bay County Waters." Further mention will be made of this in some notes on the water supply of the county.

Mr. Geo. M. Bradford of Bay City has prepared a very complete paper on the flora of the county showing the different plant societies, ecology, and lists of species. His father, P. A. Bradford, is also actively engaged in the same subject, and I am indebted to him for suggestions about submerged shore lines.

Finally while engaged in obtaining levels in Bay and West Bay Cities, I obtained the records of 361 test holes for coal of which further detailed mention will be made where they belong, but principally in Chapter III on Coal. Subsequently 101 additional records have been obtained.

CHAPTER II.

GEOLOGICAL COLUMN.

1. *Introduction.*

By a geological column is meant a section down into the earth's crust, showing the various materials of which it is composed in that particular district. In the section here given the greater part of our information was obtained from the record of the deep well at the North American Chemical Company at South Bay City. We have also introduced other records from the Lower Peninsula for comparison whenever possible.

2. *Pleistocene, the Drift, Soils and Sub-soils.*

Our first division includes the materials most recently laid down, or even now in the process of formation. This includes for the most part beds of muck, alluvial deposits, and small accumulations of bog iron ore. By referring to the soil map, it will be observed that in a portion of the region west of the Algonquin shore line in Kawkawlin township, there is a considerable area of muck land, which at the time of the Linear Survey was occupied by a swamp. This has now been drained forming fertile land. The soil is largely the result of the decay and accumulation of vegetable remains. Beds similar in origin are also met with in the territory adjacent to the State drain in Merritt township, in the southwestern portion of Williams township, and the southwest part of Mt. Forest, besides numerous areas of lesser extent. Such beds are also now in process of formation in the low lying tracts adjacent to Saginaw bay in the southern part of Bay county, and around Tobico Bay in Kawkawlin township. The present conditions under which these beds are accumulating afford a satisfactory explanation of the somewhat earlier deposits mentioned above. Carrying the parallel farther back into time, the coal beds which underlie Bay county are formed of spores and vegetable deposits, which very probably accumulated in estuaries and inlets of the Carboniferous sea. Muck, however, may be said to be the first stage in the formation of coal.

Beds of alluvium are formed where the transporting power of water is insufficient to hold the material in suspension. In Bay county during times of freshet, such accumulations are formed in Saginaw Bay near the mouth of the river. In periods of low water, or when northeasterly winds prevail, the river being practically an estuary of the Bay, would drop its deposit farther up stream. The bar situated between Bay City and Saginaw may represent such a deposit. More rarely flood plains are formed in lateral deposits along the bank of streams, forming a dam which prevents direct drainage into the river. Such a deposit was probably formed at the time when the Lower Fork of the Kawkawlin river emptied into lake Algonquin. This may be seen on the south bank of the stream, just east of the line between Williams and Monitor townships.

Deposits of bog iron ore with a considerable amount of siliceous mate-

rial are occasionally found in the sand ridges back from the bay. The iron has probably been leached out of the sand by organic acids, leaving an almost perfectly white sandy deposit above.

Adjacent to the bay are ridges of sand which are the result of the action of wind and water. The transporting power of the wind in carrying particles of sand may be readily observed on any stormy day. At a somewhat earlier period delta deposits of sand accumulated on the shore line of the Pleistocene lakes. A typical deposit of sand of this character may be seen about one mile south of the home of Pierre Lemieux in the eastern part of Kawkawlin township. Delta deposits which in the aggregate seriously impede the effects of drainage may be observed in numerous places, where small rivulets carry their burden of sediment into drain courses. Moreover, the main drainage lines themselves deposit considerable amounts of sediment along their flood-plains, or form delta deposits in streams tributary to Saginaw Bay.

The deposits described above have obtained their material for the most part from the beds of unconsolidated drift formed at a time when the physical geography was somewhat different from the present. These beds of clay, hardpan, sand and gravel vary in thickness from 30 feet in the northeast part of Fraser township to 220 feet at Auburn, even having a greater development farther west near the Midland county line. An average depth of these Pleistocene deposits, determined from the records of 462 test holes for coal and 126 well records scattered over Bay county, would make the thickness 97 feet. Where the surface deposits are clay, generally underlain by hardpan forming the Wisconsin drift sheet, the average of 406 test hole records for coal make the upper drift formation 82 feet. This is underlain at greater depths, by strata of sand and gravel, occasionally inter-stratified with beds of clay, being of pre-Wisconsin age, and having an average thickness of 33 feet. The coal hole records being from the lower third portion of Bay county, it is impossible to give an estimate for the two divisions of the drift for the remaining portion of this region.

Beds of interglacial material have occasionally been found in the construction of shaft holes. Near Amelith, in the shaft of the Pittsburg Coal Co. such a deposit was met with at a depth of 110 feet, being underlain by beds of sand and gravel and overlaid with clay drift of Wisconsin age. At the shaft of the old Monitor mine, similar deposits of later age, probably forming a subdivision in the Wisconsin drift sheet, were obtained at a depth of 45 feet. In the shaft hole of the Hecla mine, in the northeastern part of Frankenlust township, fragments of trees were found in beds of sand just above the bed rock, at a depth of 85 feet. This vegetal deposit is probably contemporaneous in age with the 110 foot bed near Amelith. For additional information concerning these deposits, the reader is referred to Chapter IV on soils and sub-soils.

3. *Coal-bearing Measures or Saginaw Formation.*

Within the limits of Bay county, the coal formation consists for the most part of strata of sandstone, shale and coal of variable quality and thickness. Carbonates of iron and lime occur in nodules or thin beds. Iron pyrites is also occasionally found with the coal or shale. The formation varies in thickness, owing both to glacial and preglacial erosion, and to the elevation of the basement on which the coal formation rests. Thus the coal measures in South Bay City have a thickness of 350 feet, the base of the formation

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being 90 feet above tide (A. T.). At Bradley's deep well on the Bay-Tuscola county line, the top of the Parma comes in at a depth of 367 feet, or 216 feet above sea level, showing how the lower series, on which the coal formation rests, rises in that direction. West of South Bay City, in the center of section 4, T. 13 N., R. 4 E., a hole put down by W. L. Ralston enters the Parma sandrock at a depth of 409 feet, or very nearly 200 feet A. T. The drift here is 108 feet in depth, which makes the coal formation 300 feet thick. This hole is probably near the top of an anticline running north from Saginaw. Farther west at Midland, the Pleistocene or drift is 285 feet thick, and the coal measures 525 feet. The underlying Parma also shows an increased thickness. Towards Saginaw the coal measures show a considerably decreased thickness, which is also true of the formation northward from Bay City. In Arenac county the underlying Grand Rapids formation comes to the surface in the northeastern part of the county.

Within this formation from 10 to 12 beds of coal have been deposited at different elevations. A detailed account of these strata and the associated beds is given in the following chapter.

4. *Parma Sandstone.*

This bed immediately underlies the coal measures. At the South Bay City well, it is a light colored sandstone overlain by a bed five feet thick, chiefly composed of iron pyrites. The same relationship is observed at Bradley's well where the sandrock is apparently 107 feet in thickness. As has already been observed, the Parma increases considerably in elevation in this direction. At Midland the Parma is a white sandstone 110 feet thick. I am not aware that this formation has been identified in Arenac county. In the well drilled by Ralston in section 4 of Frankenlust township, the thickness of this formation was not determined.

5. *Upper Grand Rapids.—Maxville or Bayport.*

For a detailed account relative to the age of this formation, the reader is referred to the report on Huron county by Lane.[5] The order of sequence of these beds is not unlike that given for the "Thumb." In the samples from the deep well at South Bay City, beds of brown siliceous dolomites extend down from 540 to 560 feet. These in turn are underlain by even grained, green, apparently homogeneous siliceous beds of dolomite for a depth of 50 feet. This is underlain by light colored beds of sandstone and shale for 10 feet, with dark shaly rock mixed in. The entire thickness as thus given is approximately 70 feet. In Huron county where these beds are well exposed around Bayport, Lane makes the maximum thickness 50 feet. Northwestward in Arenac county the formation is quarried northeast of Omer at Griffin's quarry. These beds are apparently not represented in the well records at Midland or Saginaw.

6. *Lower Grand Rapids.*

This is the Michigan Salt Group of A. Winchell and the Michigan Series of Lane in his report on the geology of Huron county, to which the reader is referred for information regarding the age of these deposits, which are there correlated with the Augusta, or Burlington and Keokuk limestones of the Mississippian series. The entire series represents rapid alternations of dolo-

[5] Volume VII, Part 2, p. 12.

mite, limestone, shale and gypsum, indicating constant changes in physical conditions. In the samples obtained from the South Bay City well, the sequence beginning at the top, is as follows:

From 620 to 625 feet, drab colored dolomite with fragments of shale and chert, underlain by 25 feet of gray shale down to 650 feet. In the drillers log which was used by Lane to construct the section of this well printed in the annual report for 1901, page 225, the next 10 feet is given as gypsum. The sample, however, from this depth is clearly dolomite. Likewise in the next 30 feet down to 690, the beds are classed as limestone, shale and sandstone. The drillings, however, show from 30 to 35 feet of gray shale, becoming lighter and more sandy toward the bottom. In the 30 feet of strata down to 720 feet, the driller's log gives 15 feet of gypsum, 5 feet of limestone, and 10 feet of gypsum and shale. The drillings for this portion of the column, show beds of drab colored sandy limestone, passing into light gray colored shales, at a depth of 720 feet. The next 60 feet in the log are indicated as slate and sandstone. The samples show 10 feet of greenish shales down to 730 feet, underlain by 10 feet of soft gray shales. From 740 to 750 feet siliceous shaly limestone having a salt and pepper color, which is succeeded by 20 feet of gray shale down to a depth of 770 feet. In the log and section referred to above, the section from 780 to 790 feet of limestone, from 790 to 800 limestone, gypsum and shale, underlaid with 20 feet of limestone and shale down to 820 feet. Thence down to the bottom of the formation, the log represents 20 feet of shaly limestone with iron pyrites, down to 840 feet. The drillings, however, from 770 to 820 feet show a gray shaly limestone, with gypsum from 780 to 790 feet. The thickness of the Lower Grand Rapids as thus limited, amounts to 220 feet. In Huron county Lane makes the thickness of the beds 232 feet. At Saginaw the strata have a thickness of 165 feet down to a depth of 690 feet, showing less alternation in structure, and a considerable upward flexure, which as we have seen, holds true for the overlying Upper Grand Rapids formation. At Midland these beds show a considerable thickening, the formation having a depth of from 920 to 1,205 feet, or a thickness of 285 feet, at the Midland Chemical Co. well. This would make the dip of the formation westward approximately 20 feet to the mile, including any possible additions to the base of the formation, which may not be represented in the South Bay City well.

7. *Upper Marshall or Napoleon.*

This formation is well marked at the top, in common with the equivalent beds in the "Thumb." In structure it is a light coarse grained sandstone, containing salt brine, which comes in at 850 feet, being the second salt horizon. From the sample at 870 feet the sandstone is there more shaly, becoming salty again at 890 feet. Thence down to 970 feet, the formation is a coarse, gray, briny sandstone, exhibiting but very little variation in structure, in the drillings from the South Bay City well. The total thickness is very nearly 150 feet, or half the depth of this formation in Huron county. The line between this and the underlying formation is arbitrarily drawn. I am inclined to believe that the beds of red sandstone aggregating 100 feet in thickness, should be included with this, rather than the lower Marshall.

8. *The Lower Marshall.*

In its entirety, this portion of the column is composed of blue and reddish beds of sandstone and shale extending in depth from 970 to 1290 feet, in the South Bay City well. The order of sequence beginning at the top is as follows:

feet, becoming a dark reddish sandy shale at a depth of 1,950 feet. At 1,960 there are blue shales again for 100 feet, forming the base of the series. The drillings do not tally with the account kept in the drillers log.[6]

The thickness of the formation as given above is 770 feet. In the Huron county section described by Mr. Lane, the thickness of the formation, including the transition beds merging into the overlying Marshall, is 896 feet.

[6] Annual report of the Michigan Geological Survey for 1901, page 224.

mite, limestone, shale and gypsum, indicating constant changes in physical conditions. In the samples obtained from the South Bay City well, the sequence beginning at the top, is as follows:

From 620 to 625 feet, drab colored dolomite with fragments of shale and chert, underlain by 25 feet of gray shale down to 650 feet. In the drillers log which was used by Lane to construct the section of this well printed in the ann
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8. *The Lower Marshall.*

In its entirety, this portion of the column is composed of blue and reddish beds of sandstone and shale extending in depth from 970 to 1290 feet, in the South Bay City well. The order of sequence beginning at the top is as follows:

From 970 to 1,070 feet red sandstone.
From 1,070 to 1,100 feet blue shale.
From 1,100 to 1,120 feet red shale.
From 1,120 to 1,140 feet red sandstone.
From 1,140 to 1, 185 feet blue shale.
From 1,185 to 1,190 feet red shale.
From 1,190 to 1,290 feet red sandstone.

The entire thickness of the formation as thus determined is 320 feet. In Huron county Mr. Lane makes the thickness of the more or less equivalent beds 265 feet. Both here and in Huron county this formation is a transition from the heavy beds of shale composing the underlying Coldwater series, to the solid Napoleon sandstone formation just described.

9. *Brines of the Marshall Sandstone.*

In the salt wells put down in Bay City, and in the adjacent region to the north and south, the depth to brine is seen to vary considerably, the bottom of the syncline or trough being not far from Hargraves Mill on the Middle Ground, where the depth is 1,040 feet. Northward from here at Pitts and Craniges, near the Michigan Central R. R. bridge, the depth to the top of the brine is about 1,000 feet; at the Detroit and Mackinaw bridge 920 feet; at Boyce's in Essexville 800 feet; near Kawkawlin from 700 to 800 feet. Going south from Hargraves Mill the depth to brine is also seen to increase in elevation. Thus at the plant of the North American Chemical Co. at South Bay City, brines are struck at 850 and 890 feet in depth, the salt water sandstone extending down to 970 feet; at Melbourne one-half way between Bay City and Saginaw at 890 feet deep; at Zilwaukee 810 to 840 feet. Southward from here the salt brines are found at a minimum depth of 710 feet at Wylie Bros.' well in Saginaw, increasing in depth towards Garfield and St. Charles.

10. *Coldwater Shale.*

In the South Bay City well there is included within this part of the geological column, a series of reddish, light, and dark blue shale beds having a depth of from 1,290 to 2,060 feet. The series as represented in the drillings is essentially a shale deposit, characteristically blue in color. The beds are quite uniform lithologically, as far as the drillings show. From the top of the formation down to 1,750 feet are light blue shales becoming darker at 1,800 feet, and again light blue for 100 feet more or less, down to a depth of 1,900 feet. At 1,920 feet red shales, with a light blue shale at 1,940 feet, becoming a dark reddish sandy shale at a depth of 1,950 feet. At 1,960 there are blue shales again for 100 feet, forming the base of the series. The drillings do not tally with the account kept in the drillers log.[6]

The thickness of the formation as given above is 770 feet. In the Huron county section described by Mr. Lane, the thickness of the formation, including the transition beds merging into the overlying Marshall, is 896 feet.

[6] Annual report of the Michigan Geological Survey for 1901, page 224.

In the deep well at Alma, the beds composing this formation are 675 feet in thickness. At Grayling the Coldwater has apparently a thickness of 965 feet.[7] It will thus be seen that while this formation tends to decrease in thickness west from Huron county, the depth of the deposits increase considerably towards the northwest.

There are numerous outcrops of this formation in Branch and Huron counties, containing in places beautifully preserved fossils in nodular structures.

11. *Berea Shale, Sunbury Shale.*

This formation which has until recently been known as the Berea shale formation, has been recently designated the Sunbury shale in an article on the "Nomenclature of the Ohio Formations."[8] The name Sunbury has the right of priority.

This bed, which is a subdivision of the Coldwater shale, in common with its counterpart in Ohio, nowhere attains a very great thickness, but is notable for its persistency, the outcrop extending north and south from the Ohio river, at least as far north as Saginaw Bay.

In the South Bay City well, this is a black shale showing marked signs of oil and gas. The thickness of the formation here amounts to 40 feet, carrying the section down to a depth of 2,100 feet below the surface. In the section of the deep well printed in Volume V, Plate VI, of the Michigan Geological Survey report, located at the Atlantic Mill in the northern portion of Bay City, this same formation has a thickness of 35 feet. The bottom of the formation there has a depth of 1,833 feet, showing a considerable upward dip of the beds from South Bay City. Whether this upward trend of the formation is part of a local anticline, or merely the general dip forming the great Saginaw Valley syncline, is not determined. The occurrence of very considerable bodies of gas encountered during the drilling of this well, rather leads to the former view. It was observed in the record of the well put down by W. L. Ralston in section 4, T. 13 N., R. 4 E., near Bay No. 2 mine, that there was a strong upward fold or anticline of the coal measures passing underneath that place. Such folds occasionally serve for the accumulation of oil and gas when sufficiently porous, and capped with an impervious covering, which in this case is served by the overlying Coldwater shales. Whether or not the Berea shale conforms to this upward trend of the overlying coal measures is largely a matter of speculation. It would seem, however, from the oil well put down by Mr. Gage near the southwest corner of section 26, Monitor township, T. 14 N., R. 4 E., that this anticline extends down into the Coldwater shale. It would be better to prospect a mile west; say near the old Monitor mine, or one mile south of there.

The Berea shale has not been reached in drilling at Saginaw. At Alma this formation has a thickness of 25 feet, the bottom of the beds being at a depth of 2,300 feet, or 210 feet below the same formation at South Bay City.

12. *Berea Grit.*

This is a famous producer of oil, gas and brine in Ohio. The same remarks that were made concerning the overlying formation in the territory adjacent to Bay No. 2 shaft in Frankenlust township, hold with this formation also.

[7] Annual report of the Michigan Geological Survey for 1901, page 231.
[8] Journal of Geology, Volume XI, No. 6, 1903.

In the deep well put down for rock salt at South Bay City, this formation is a characteristic gray or white sandstone having a thickness of 130 feet. The bottom of the formation is reached at a depth of 2,290 feet. In the drillings the beds at 2,115 feet are light gray colored sand rock, "very hard," and fine grained with fairly strong brine. Thence down to 2,140 feet, the beds become darker with black shaly partings. At a depth of 2,150 feet the water in the drill hole was within 100 feet of the top, which flowed over the surface at 2,170 feet. The flow amounted to 1.25 gallons in 3.5 minutes. From 2,180 to 2,260 feet, fine hard white sandstone of uniform texture. At 2,230 feet, the well overflowed 19.19 gallons per hour. At a depth of 2,265 feet beds of sandstone and blue shale, which grade off into the underlying formation at 2,270 feet. In the salt well put down at the Atlantic Mill in the northern part of Bay City, this formation is represented as having a thickness of 165 feet.[9] The increased thickness of 35 feet, when compared with the record at South Bay City, is probably due to additions to the base of the formation, as the bottom of the grit here is at a depth of 2,306 feet as against 2,270 feet in the former well. The elevation of the two well heads is very nearly the same.

In Huron county the Berea Grit is 70 feet thick. At Alma the Berea is not represented.

13. *Antrim Shales.*

In the geological column this is nearly the same as what is known as the Ohio black shale in that state, where the latter formation includes, beginning at the top, the Cleveland, Erie and Huron shales. The Antrim also includes the Bedford shales. The name Erie being preoccupied, this formation has been recently designated the Chagrin formation by Prof. C. S. Prosser of the Ohio Geological Survey. The Chagrin shale is characteristically blue, and is nearly, if not quite, the equivalent of the Chemung formation in northern Ohio. The black shale formation has a widespread geographical distribution, extending as far south as Blount Springs, Alabama, and northward into Cheboygan county of this state. It was formerly designated the St. Clair shales by Mr. Lane, but the name was found to be preoccupied.

In the drillings from the well of the North American Chemical Co. at South Bay City, the top of this series is a blue shale extending from 2,270 to 2,290 feet in depth. This was provisionally included with the Bedford shales, but I am now inclined to believe that it is the representative of the Chagrin or Erie or Chemung formation in this state. In Volume V, Plate VI, there is indicated as Erie a white shale formation in the well of the Atlantic Mill, which extends in depth from 2,306 to 2,371 feet. If this correlation is supported by further evidence, it will eliminate the Cleveland shale from the geological column in this portion of Michigan. This leaves the great bulk of this formation as the general equivalent of the Genesee black shale of New York, and the Huron shale of Ohio.

In the South Bay City well, the Antrim shales extend in depth down to 2,610 feet; at Atlantic Mill down to 2,585 feet, having a total thickness of 320 feet at the former locality, and of 279 feet at the latter place. The formation is essentially a black shale occasionally shading off into brown, with signs of oil and gas. At 2,380 and 2,490 feet the formation is somewhat calcareous. This calcareous material may represent the great concre-

[9] Vol. V, Plate VI. There were two wells, one 2,900 feet deep the other 2,250, at this location,—the Hall well, No. 93½ of the Saginaw Board of Trade map. When they struck the Berea Grit, wells near by, the Folsom wells, only down to the Marshall, flowed. There was also one well on the west side of the river down to the Berea Grit,—Maclean's well near 28th Street.

tions which are occasionally found in the Ohio outcrops. They do not form true bedding planes.

Somewhat anomalous is the reported occurrence of a bed of rock salt toward the top of the formation (from 2,304 to 2,310 feet), having a thickness of 6 feet. May not this really have been precipitated in the bottom of the hole? Apparently this formation, during the latter stages of its deposition at least, was deposited in a more or less enclosed sargassum sea.

In Huron county the Antrim or Ohio shale is represented as having an entire thickness of 463 feet, of which 270 feet is assigned by Mr. Lane to the Huron shale.[1] At Alma these shales extend in depth from 2,360 to 2,750 feet, having a total thickness of 390 feet. At Grayling, the Antrim shales have a thickness of 575 feet down to a depth of 2,165 feet. Specimens of black shale have been found embedded in the drift at Indian River in Cheboygan county, which is three miles further north than represented on the latest geological map of the state.

Altogether this formation is one of the most widespread and well marked of the lithological datum-planes.

14. *Traverse Group, Marcellus Shale.*

At the South Bay City well this formation is broadly divisible into three general divisions, consisting of an upper shaly portion with occasional thin beds of limestone, a central division with siliceous beds of limestone, and a lower division of shale beds capped by sandstone, with a single horizon of limestone. The middle limestone division may correspond to the "middle" limestone described by Mr. Lane in the St. Clair river region.[2] Mr. A W. Grabau in his report on the "Stratigraphy of the Traverse Group of Michigan"[3] also makes out an upper shaly series, a middle limestone division, and a lower portion composed of shales and limestones. This is in the vicinity of Alpena. It would thus seem that the Traverse formation is quite persistent in its stratigraphy in the eastern portion of the Lower Peninsula of Michigan. The details of the record of the South Bay City well, as made out from the drillings, are as follows: From 2,610 to 2,620 dark gray sandy limestone, effervescing freely in acid, with fragments of black shale from the overlying transition beds mixed in. Then dark calcareous sandstone for the next 10 feet, becoming light colored from 2,630 to 2,635. At this depth blue calcareous shale down to 2,690 feet, having a thickness of approximately 55 feet. This is underlain by limestone with fragments of *Aulopora*, *Favosites*, and the omnipresent *Atrypa reticularis*, with a thickness of 10 feet, down to a depth of 2,700 feet. For the next 27 feet the limestone gradually becomes more shaly, passing into a bed of blue calcareous shale, extending from 2,716 to 2,727 feet. This is the bottom of the Upper Traverse division, which is here 117 feet in depth. Grabau is of the opinion that the upper Traverse division is not represented in the Alpena section. Whether this is the equivalent of our portion of the South Bay City section, has not been determined.

Next below there is a bed of salt and pepper limestone, almost identical in appearance with that occurring from 2,690 to 2,700 feet, in which I was unable to find any fossil fragments. This bed carries the series down from 2,727 to 2,734 feet. From 2,734 to 2,740 feet is a briny calcareous sandstone of a light gray color, with indications of gas. This salt brine sandstone extends to a depth of 2,760 feet, with but little variation, the strata becoming gradually darker from 2,760 to 2,780 feet. From 2,780 to 2,810 feet is a light sandy limestone effervescing briskly with acid; at 2,810 to 2,860 feet a dark brown sandy limestone. From 2,860 to a depth of 2,905 feet, there is 45 feet of dark gray sandy limestone containing brine. This is underlain from a depth of 2,905 feet to 2,940 feet, by a fine grained, pepper colored siliceous limestone, which is said to contain gypsum in the drillers log. This series of limestone beds capped by sandstone, constitutes the second or middle division of the Traverse formation, as outlined above. The entire thickness is 213 feet.

From 2,940 to a depth of 3,120 feet, the Traverse formation is composed of characteristic blue calcareous shales, not unlike the outcrop at Hill's gulch near LeRoy, Genesee county, New York. These shales effervesce freely in acid. This is underlain by 40 feet of fine, steel gray, slightly shaly limestone, down to 3,160 feet. The bottom of this series is a blue shale 50 feet thick down to a depth of 3,210 feet. This would make the thickness of the lower shaly series with its interstratified bed of limestone, 270 feet thick.

The black bituminous Marcellus shale is closely allied faunally with the overlying beds, but on account of its persistency of outcrop and well marked lithological characteristics, it is usually given a definite designation. In the drillings from the South Bay City well, this black shale is stated to have a thickness of 60 feet, or down to a depth of 3,270 feet below the surface. This forms the bottom of the Traverse formation, and is in a sense, a portion of the lower Traverse group.

The entire thickness as outlined above is 660 feet, showing an enormously increased thickness when compared to the same formation in the southeastern part of the state. In the deep wells at Grayling and Killmaster, the bottom of this formation was not struck. In Huron county Lane makes the section 605 feet thick. Grabau estimates the thickness in the vicinity of Alpena, 403 feet in depth.

15. *Dundee or Corniferous.*

This limestone is buff, yellowish, or almost white in color, and is the lowest formation shown in the South Bay City well. The drillings indicate a uniform yellow colored limestone from 3,270 down to 3,508 feet, without disclosing any change that could be noted to Monroe dolomites.

[1] Michigan Geological Survey, Vol. VII, Pt. 2, p. 29.
[2] Volume V, part 2. p. 24.
[3] Annual report of the State Geologist for 1901. p. 169.

CHAPTER III.

THE COAL FORMATION.

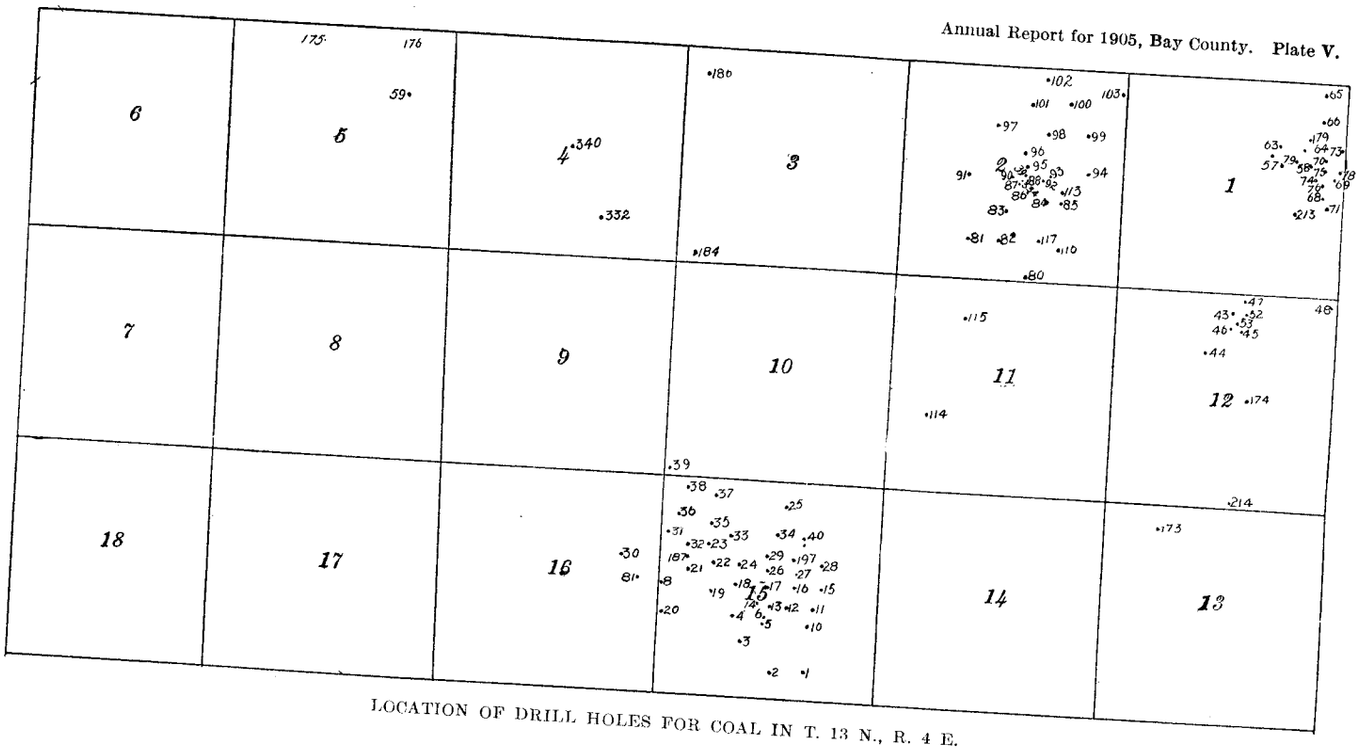
1. *Introduction, Coal Map, and Sections.*

Volume VIII of the series of Michigan State quarto Geological Survey reports is devoted to the economic geology of the Lower Peninsula. Part II of this report, by Alfred C. Lane, is confined to coal. In this chapter it is intended to deal only with certain local questions not adequately discussed in that volume, such as the subject of washouts as affecting the mining and distribution of coal; the drainage of preglacial times and the results of erosive action during the advance of the Laurentide glacier; also the results of sedimentation, while the coal beds were in process of formation. The deposition of beds of sandstone formed quite considerable areas in which the coal is either cut out, or is almost altogether absent. Furthermore, there is to be considered the succession of the different beds of coal in this portion of the basin. While the Verne coals supply almost the entire market in Bay county, it will be seen that there are other beds which are to be taken into account in prospective operations and development.

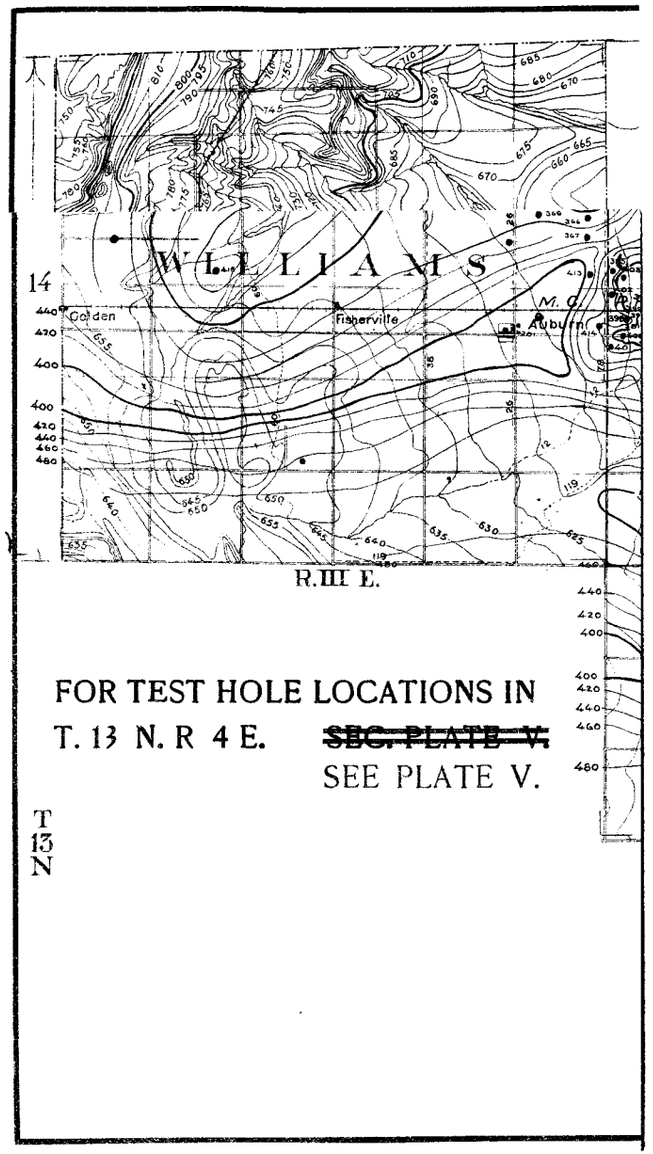
Other matters of a general nature Lane has considered in his report, such as the origin and occurrence of coal, and the analyses and the tests of the coal from which the heating power is computed. This is also dealt with here so far as it relates to Bay county. The development of coal is also taken into account, and certain principles enunciated to guide exploration. Some additional remarks relative to the subject, as applied to Bay county, will be found in this chapter. The reader is referred to that volume for such general information as would only be duplicated by putting into this report.

In the map which has been prepared to accompany this chapter, the location of the different test holes for coal is indicated by a dot, the number alongside showing the record which is printed at the end of this chapter, with the rest of the text. The rock contour lines are intended to show in a general way the elevation of the rock surface above sea level, and consequently the old drainage valleys and topography before the drift or overburden was brought down by the ice, or at a still later time deposited on the shores and bottom of the later Pleistocene lakes. By noting the elevation of the rock surface and that of the surface contours, the thickness of the drift can be approximately determined, as well as the general areas in which the Verne and the overlying Salzburg coal have been washed away.

Cross sections have also been prepared, which are intended to show the succession of the different beds to one another. In this way the section A-B extending from the Amelith shaft in Frankenlust township, T. 13 N., R. 4 E., to the Wenona mine near the mouth of the Saginaw river, gives an approximate idea of the stratigraphy in a northeasterly direction. Likewise the line C-D running from near the shaft house of Bay mine number 2 to Bradley's deep hole on the Quanicassee estuary, shows a pre-glacial drain-



LOCATION OF DRILL HOLES FOR COAL IN T. 13 N., R. 4 E.



age valley near the west end, and the succession of the strata in the coal formation underneath South Bay City and eastward. The section E-F extending through Bay City, runs southeast and is instructive as showing the comparative absence of coal where heavy beds of sandstone are laid down. The last section, G-H, extends from the Amelith shaft before mentioned, through the mine now known as Wolverine No. 2 in Monitor township.

2. *History of Coal Development.*

In an instructive pamphlet by the late Chas. B. Schaefer, editor of the "Michigan Miner," entitled "The Coal fields of Bay County," there is considerable information given relative to the development of coal mining in this district. From this it appears according to the testimony of Capt. Boutell, that the first discovery of coal in Bay City was made by Wm. Walker, a well borer, who came there in 1861 for the purpose of putting down a salt well on the property where the Michigan Pipe company's plant now stands. "The discovery created considerable interest at the time, but nothing was done about the matter, as the people were anxious to find salt, and there was an unlimited supply of cheap fuel to be had anyway." With the decline in the lumber industry, and the development of the manufacturing resources in the Saginaw valley, the future development of the coal industry was assured. When, in 1893 coal was discovered, while putting down a well for water at a saw mill owned by Zill Bros. in Monitor township, five miles west of West Bay City; the discovery was followed up by a company organized at the suggestion of Alex. Zagelmeyer. To him and to Frank Zagelmeyer, is due in great part, the credit of developing the mining industry in Bay county. Land was leased from Zill Brothers, and after the basin had been drilled by Goff Paul, a shaft was sunk in the summer of 1895, in spite of the many obstacles to be overcome, and public prejudice. This was followed during the summer of 1896, by the sinking of the shaft of Bay Mine No. 1, situated just east of the former shaft. This was shortly followed by shafts sunk by the Michigan Coal and Mining Co., Mr. J. A. Etzold former president, and by the Central Coal and Mining Co. (Sec. 25 T. 14 N., R. 4 E.), of which Mr. W. A. Knapp was Secretary and Treasurer. At about the same time Handy Brothers' mine, now abandoned, but known as Wolverine No. 1, and the shaft of the Wenona Coal and Mining Co. were put down near Oatka beach. During the winter of 1899-1900 the shaft of Bay Mine No. 2 was put down by Alex. Zagelmeyer. In the summer of 1900 the shaft of the Pittsburg Coal Co. was sunk near the Amelith P. O., under the direction of Mr. John Werner. At the same time the shaft of Wolverine No. 2 Mine was sunk by a stock company of which Leonard Zill and John S. Wuepper were the active agents. As will be seen, the exploitation of the different coal basins in Bay county is largely due to the intelligent and conscientious efforts of Mr. Zill. Later developments of the coal industry in Bay county, have resulted in the development of the mine of the Salzburg Coal Co., prospected by Leonard Zill, and opened in 1902. At about the same time, the shaft of Wolverine No. 3 Mine was opened by Handy Brothers in the northeastern part of Williams township. I believe also the shaft of the New Central Mine was started in 1902. The shaft of the Hecla Portland Cement and Coal Co. in Frankenlust township was also put down in 1902.

I am indebted to different operators and drillers for information regarding the workable coal deposits in the lower third of the county. To Mr. John

H. Werner, the Survey is under obligations for the records southeast of Amelith in Frankenlust township. Mr. Werner has also given the Survey the record of several holes south of Wolverine No. 2 shaft. I understand that the greater part of this drilling was done by Mr. Ward. Mr. John H. Metcalf of Bay City has given numerous records of drilling operations on land leased by the Valley Coal Co. Mr. Ubald R. Loranger has very generously contributed a blue print showing the location of numerous test holes in the northeast part of Frankenlust township and the southeast part of Monitor township, around the shaft of the Hecla Co. I believe that this drilling was done by McIntosh and Wampler, but the records were obtained from Mr. Etzold. He has also donated to the survey several records of the Michigan Coal and Mining Co., while from the adjoining property on the east, controlled by the Central Coal Mining Co., information was obtained from Mr. Chas. Coryell of Bay City. The Survey is greatly indebted to Mr. Leonard Zill for numerous records in Monitor township, besides several additional records in other parts of the county. Mr. Goff Paul of West Bay City has also given the results of his work around Bay City, West Bay City, Bangor and Monitor townships. As a result of this exploitation, the abandoned mine of Handy Brothers, afterward called Wolverine No. 1, and the old Monitor shaft were opened. Mr. W. L. Ralston and A. J. Wampler have also done considerable drilling for the Sage Land and Improvement Co. and other parties. Finally I wish to express my indebtedness to Theodore Archambeau, Mr. William Penniman, F. J. Tromble, and O. W. Blodgett for numerous scattered records, the latter for the most part being from Merritt township. More recently, Mr. Wampler has sent in valuable records from the western and northern part of the county, which have been of great value to us.

3. *Drift Filled Channels.*

By this is meant the former drainage channels on the top of the coal formation, before the present drift or overburden was brought down by the ice sheet and deposited, smoothing over all inequalities in the underlying bed rock. This earlier drainage system trends to the west and southwest, into a main channel probably meandering from Saginaw westward through St. Louis and Alma.

The Amelith Washout.

In the report of Mr. Lane on Huron county, and in his report on "Coal," one of these early, or pre-glacial drainage channels is described as leaving the southwest corner of Huron county; he supposed it to pass near Unionville in Tuscola, and thence west and south through Portsmouth and Frankenlust townships, into Saginaw county. As a result of rather numerous well and test hole records for coal, I have been unable to locate any such washout in that part of this county. Either the old drainage channel from Unionville passes south into Saginaw county, or else, which is more likely perhaps, it takes a westerly course across the lower portion of Saginaw bay, entering Bay county near the mouth of the Saginaw river. From here a pre-glacial drainage course is well marked, passing south of Handy's abandoned mine, where the descent is abrupt, the former topography apparently being not unlike that of the Kentucky coal fields or the arroya region of the west. At the shaft of Wolverine Mine No. 1, there is 72 feet of clay drift. Within 80 rods to the south, this buried channel is filled with over 178 feet of alternating deposits of clay, hardpan, quicksand and gravel, the rock not being struck. The elevation of the rock surface, however, is probably not far from 400 feet A. T., or 180 feet below the level of Saginaw bay. This buried channel descends more abruptly from the north side than from the south, which fact very likely is due to the shearing action of the ice. Both the Verne coals, as well as the overlying Salzburg coal, are eroded away in this buried drainage channel throughout its extent in Bay county. Eighty rods south of the north line of section 9, in the same township, the amount of drift has decreased to 90 feet on the south side of this preglacial valley. From here the course was in a southwesterly direction, entering Monitor township near the northeast corner of section 13, T. 14 N., R. 4 E. A well record in section 7, T. 14 N., R. 5 E., gives the side of the valley there an elevation of 420 feet A. T. Drill records furnished by Mr. Amos J. Wampler in section 12, T. 14 N., R. 4 E., indicate that the rock elevation increases from 480 to 533 feet A. T., going towards Kawkawlin village, and on the north side of the valley, the amount of the drift being respectively 58 and 116 feet in thickness. Southward, near the east quarter post of section 13, T. 14 N., R. 4 E., there is about 86 feet of drift. Apparently the course from here was southward through sections 13, 23, 24, 26, 34, 35, of T. 14 N., R. 4 E., and thence southwest through section 3, T. 13 N., R. 4 E., swinging westerly in sections 7, 8, 9 of the same township. At Denekes, in the northeast quarter of section 35, Monitor township, there is said to be over 175 feet of drift below the elevation there of about 600 feet A. T. In the southwest $\frac{1}{4}$ of section 3, T. 13 N., R. 4 E., there is over 190 feet of drift at an elevation of 595 feet A. T. Just northwest at the shaft house of Bay No. 2, this has decreased to 111 feet, with 108 feet of drift in the center of the same section. On the opposite, or south side of this preglacial valley, the test holes northwest of the shaft of the Pittsburg Coal Co. near Amelith P. O., show 132 feet of drift in the N. W. $\frac{1}{4}$ of the N. W. $\frac{1}{4}$ section 15, T. 13 N., R. 4 E., and 168 feet near the southwest corner of section 10, T. 13 N., R. 4 E. The elevation of both these holes is nearly 607 feet A. T. The geological cross sections C-D and G-H, both indicate this buried valley. From between the two shaft holes of the Pittsburg and Bay No. 2 mines, the course of the former drainage was probably west into Tittabawassee township, Saginaw county, but it is not impossible that the course may have continued to the southward, through sections 16 or 17 of Frankenlust. There are indications of a washout north of West Saginaw, with which this may be connected. Amelith P. O. being situated on the east side of this washout, I would suggest that this name be applied to the same.

The Auburn Washout.

This name is given to designate a depressed early topographic area, or perhaps more properly a subordinate valley region, which I believe heads in east and somewhat south of Auburn village. At first I was of the opinion that this connected with the washout probably running down near Amelith, but recent drilling by Mr. Wampler in sections 21 and 22 of Monitor, and information previously obtained in section 28 go against this conclusion. This line of lowest rock elevation probably heads in near the corner of sections 21, 22, 27, 28, thence running westward near the north line of sections 28, 29, and 30 of Monitor township, underneath Auburn village, and thence probably westward and south of the Midland stone road.

Near the western line of the county, this Auburn washout probably unites with one coming down through Beaver township. There is also a lateral drainage area trending northeast from Auburn which runs through sections 18 and 8 of Monitor between Wolverine mines No. 2 and 3.

At Auburn Mr. Wm. Everett after drilling 220 feet, struck the rock at an elevation of 397 feet A. T. The top 65 feet were clay deposits, the underlying beds being alternating strata of sand and gravel, with thin layers of clay. One mile and a half north there is only 124 feet of drift, while at North Williams, one mile west, the amount of drift is 110 feet. Southwest from here in the southeast quarter of section 17, there is only 87 feet of drift where the surface elevation is 643 feet A. T., making the rock elevation there 556 feet high. I believe that this very considerable rock elevation trends northeast. West from this last location, and on the county line, there is 197 feet of drift near the northwest corner of section 19, the distance to bed rock increasing to the northward, as we shall see in investigating the Beaver washout. Near the southeast corner of section 13 of Williams, test hole 413, bed rock is struck at 407 feet A. T., the drift rapidly decreasing in thickness to the north and east, as shown by test hole records 366 and 385. In the northeast quarter of section 18, Monitor, there is over 170 feet of drift which decreases in thickness to the north and east. An examination of our rock contour map will serve to show how the depth to bed rock increases south of Wolverine mine No. 2, and south of the new Auburn shaft in the northwest quarter of section 19, Monitor township.

The Beaver Washout.

This has been designated thus on account of its very pronounced development in the central and southwestern part of Beaver township. It probably heads in the north central part of Frazer township, and has a southwesterly course through the southeastern part of Garfield township, thence running south and west through the central and southern part of Beaver, T. 15 N., R. 3 E. This channel probably unites with the Auburn washout, east of Midland. In section 33 of Beaver there is over 225 feet of drift, and no rock struck at 400 feet A. T. In the northwest quarter of section 21, near Kimmel's store, it is 227 feet to rock which is at very nearly 400 feet A. T. At test hole 453 in the west half of section 23, rock is struck at 445 feet A. T., with 168 feet of drift. Northward from here in section 7 of Beaver, the rock was struck at 530 feet A. T.; 119 feet of drift. Thence northeast, four test holes for coal recently put down by Mr. Wampler in the south half of sections 32 and 33, Garfield township have from 144 to 180 feet of drift, the greatest amount being in the southwest quarter of section 32. East and south of here, just over the township line in Beaver, Wampler went through 185 feet of drift in section 3, and 162 feet in the northwest quarter of 2, the surface elevations being about 630 feet A. T. The bed rock divide probably runs between these two last groups of holes into section 7. Additional information in section 30 of Fraser and 24 of Garfield, near the township line, show a very considerable decrease of thickness of the drift to the northeast in this washout.

The Souwestconing Washout.

This probably starts not far from the center of Bay City, extending past the Middle Ground, and thence south and west of Souwestconing creek into Saginaw county. There are no data to indicate the precise limits of this

course on its east side. Other records of test holes for coal, and occasional well records, would place the course of this early drainage valley south and east of the Valley mine and east of the shaft of the Pittsburg Coal Co. near Amelith. This area may be prolonged into the heavy drift filled channel north of West Saginaw. In this, as in the other areas of bedrock erosion, the Verne coals and the overlying Salzburg coal have been largely removed, and we may also find the Saginaw coal occasionally absent.

East of the Saginaw river the elevation of the rock surface, as far as our records show, is almost uniformly at 500 feet A. T., excepting for a small area west of Munger, where the rock falls off to the westward.

West of Saginaw bay and the Saginaw river, the elevation of the bed rock divide east of the former drainage channel in Beaver township is 540 feet A. T., this area extending at least half way across Williams township, and within two miles of the Midland county line. Thence the general course is northeast and north, the eastern front trending in a general way with the present shore line of Saginaw bay.

The 560 foot rock contour line is of interest as containing a lesser accumulation of drift on its surface, than any other portion of Bay county. In the northern part of Fraser township, there are two well records collected by Mr. W. T. Shaw, which show from 28 to 30 feet of drift. Northward from here, there are comparatively few data available in this county. W. M. Gregory, however, has shown that the rock surface rises to the north, in several places reaching the surface in Arenac county. A well put down by W. H. Hinman at Bently entered the rock at 620 feet A. T., which corresponds in a general way with the rock elevation farther east, in the adjoining county where the surface elevation is much lower. If the bed rock at Bently were down on the shore of Saginaw bay, we would have a rock bluff 40 feet high. As can be imagined, this would form quite a striking contrast with the present topography. On the other hand, the lowest bed rock elevation in the west central part of Beaver is some 180 feet below the lower reaches of Saginaw bay, giving a difference of at least 220 feet of rock elevation. The difference of surface elevation is about 250 feet. Further changes in our ideas of the bed rock elevation will doubtless result from future investigation, especially in the western tier of townships, but I trust we have been able to indicate the main courses of washouts with some degree of accuracy.

4. *Horsebacks, Sandstone Channels and Areas.*

As defined by Lane a horseback is a rising up of the foot wall, or strata underneath the coal, forming a roll which affects the overlying coal seam. Reversely, we have sandstone channels which occasionally come in from the top, and cut out to a greater or less degree the underlying coal seam. Horseback formations are often met with in the Bay county mines. Where the drifts or entries are run at angles to these horsebacks, there is considerable dead work, both in mining, track laying, and drainage. It is therefore advisable to run parallel to the crest of the horseback. An ideal way in which this operation has been carried on is seen in the mine of the Central Coal Mining Co., section 25, T. 14 N., R. 4 E.

In Volume VIII, part 2, Lane has described several localities in which the seams of coal are cut out by beds of compact sandstone. These may be likened to the washouts described in the preceding pages, except that the material has become consolidated in a manner similar to the associated beds.

In Bay county there is only one mine which shows sandstone beds cutting out seams which are being operated. It is doubtless true, however, that the deposition of irregular areas of sandstone has affected to a greater or less extent the accumulation of workable coal areas. In the Amelith coal field, operated by the Pittsburg Coal Co., the main sandstone area trends east and west. In one such sandstone belt extending through the south half of the north half of section 15, T. 13 N., R. 4 E., there are two seams of coal represented, and from three to four strata of sandstone. In the area adjoining on the south, and approximately adjacent to the east and west quarter line of the same section, there are from two to three layers of coal and one sandstone horizon is occasionally represented. In the former area 6% of the test hole records are composed of sandstone strata in nine holes having an aggregate depth of 1,861 feet, while in the area adjacent to the quarter line, the amount of sandstone has decreased to 1⅔% in 11 holes with a total depth of 2,252 feet. The coal strata amount to 1⅔% and 2 2-9% respectively, in these two areas. It was also determined that while the amount of sandstone decreased 4⅓%, that the amount of coal strata increased 5-9 of 1% in the same area to the south. This information is compiled from the record of twenty test holes having an average depth of 205 feet. In the section A-B, the coal is represented overlying a slight sandstone fold, probably trending in the same east and west direction.

The records of the territory leased by the Hecla Portland Cement and Coal Co., are not distributed in such a manner as to permit of any general deductions being made. There are indications, however, of a sandstone area running northwest and southeast in the east half of section 2, T. 13 N., R. 4 E. This area is bounded by a coal belt very nearly 80 rods wide, in which there is an entire absence of arenaceous strata at the same depth. Again to the south and west, beds of sandstone reappear at irregular elevations, being succeeded farther on by test holes in which the entire section is composed of coal and shale. In the southwest quarter of section 11, the beds of sandstone again reappear in a single record obtained there.

East from here in the territory drilled by the Valley Mine Co., the records are rather scattered. In a group of test holes near the line of sections 6 and 7, T. 13 N., R. 5 E., there are two horizons of sandstone strata which extend northwest and southwest into sections 1 and 12, T. 13 N., R. 4 E., and may embrace the sandstone area previously described in the east half of section 2, T. 13 N., R. 4 E. In the northeast quarter of section 1 there are only two holes with thin beds of sandstone out of 12 drill records. The deposition of the coal and sandstone beds here would rather indicate an east and west direction, in which the sandstone area spread out to the west like the flutings of a fan, embracing swales, from which coal alone is obtained down to a depth represented by the sandrock beds farther east. These swales would be represented by the coal and shale areas of the Hecla property.

Another series of test holes in section 33, T. 14 N., R. 4 E., and additional records around the shaft of the Monitor Coal Co. in section 28, bring out the same general trend of the sandstone strata. In this section there are from 4 to 6 feet of sandstone at depths varying from 101 to 106 feet, but at very nearly the same elevation above tide. This is very likely along the strike of the sandrock which extends N. 50° E., for about one mile, as far as our records indicate. If this area be extended N. 66° E., into the north half of section 25, T. 14 N., R. 4 E., similar associated beds of sandstone and coal are found replacing the main workable coal beds. This area in

section 25, is separated from a like deposit in the S. E. ¼ of the S. E. ¼ of the same section, by coal and shale bearing beds of workable thickness, in which the sandstone beds are absent at the same depth. In the area in the north quarter of section 33, and the south quarter of section 28, T. 14 N., R. 4 E., the bed of sandrock deposited farther south is not represented in the test holes for coal, which is of a workable thickness. Carrying the parallel northward, the records again show associated beds of sandstone and coal in the S. E. quarter of sections 29 and 22, T. 14 N., R. 4 E., which may represent another belt of sandstone sediments.

In the territory contiguous to Wolverine shaft No. 3, we have the records of 14 test holes for coal which were drilled in the eastern part of sections 12 and 13, T. 14 N., R. 3 E., and in sections 7 and 18 of T. 14 N., R. 4 E. Taken as a whole the entire area, beginning at the south, shows an alternation of shale and sandstone beds, and the latter extend in two parallel belts running east-northeast, being replaced by beds of shale in the intervening areas. The coal seams are quite persistent throughout three-fourths of the entire area. The different beds of sandstone tend to recur within the same belts, being interrupted in their horizontal extension north and south as noted above. Beginning at the south, the records of four drill holes having an average depth of 214 feet, show 44 feet of sandstone and 23 feet of coal. Expressed in percentages, this would respectively amount to 5¼ and 2 7-10 of sandstone and coal. In the next area adjoining on the north there are two test holes with an average depth of 193 feet and containing 15 feet or 4% of coal beds and no sandstone. Succeeding this, we have four records with an average depth of 186 feet and showing 28 feet of sandstone and 31 feet of coal, or approximately 5% of each. In the farthest area to the north there are four holes averaging 223 feet deep, and containing 5% of coal strata and no sandrock.

The records of 21 drill holes in T. 13 N., R. 6 E.; of 37 records in T. 14 N., R. 5 E., and 19 holes in sections 13 and 24, T. 15 N., R. 4 E., and in sections 19 and 30, T. 15 N., R. 5 E., indicate for the most part heavy beds of sandstone and shale, with scarcely any workable beds of coal. How wide this belt of sandstone sediments is has not been determined. The western side seems to extend toward the northwest in an irregular manner, very likely conforming to the shoreline of the coal measure sea.

Recent investigations near Salzburg show a sandstone channel running north-northeast, entirely cutting out the coal for a distance of about 80 feet east and west, the coal reappearing on the west side of the sandstone cut out or belt. The sandstone cuts in from the top, displacing the coal stratum, which feathers out below the sandrock. On the east side of the workable coal beds the coal is again cut out by a bed of fire clay coming in from the top, quite similarly to that of the sandstone beds to the westward. The fire clay and sandrock seem to merge into each other farther south, enclosing a U or V shaped area which opens out to the north-northeast.

In sections 17-21 of Monitor township, T. 14 N., R. 4 E., there are some four or five beds of sandstone rather irregularly distributed. With the lowest bed the greatest extent is east and west, the same bed reappearing at about half the distance to the north and south. In the intermediate areas the coal is deposited in greater amounts than where the sandstone is laid down, but at the same time there may be a workable bed of coal where sandstone has been deposited. The greater the amount of sandstone strata, the less of coal, but coal may also be deposited in small amounts where

there are no arenaceous strata. The same remarks concerning the upper beds of sandstone, as far as represented, hold for this area.

Altogether these areas of sandstone have in general an easterly trend forming folds and flutings, which enclose estuaries and inlets, in which the coal was generally deposited in greater quantities than in the intervening areas. As will be seen, however, coal beds of equal thickness were sometimes laid down regardless of local irregularities.

5. *Boiler Tests. Coal Analyses.*

There are some 12 strata of coal represented in this formation in Bay county. Analyses have only been obtained from four layers. It would undoubtedly be of great benefit if coal drillers kept samples from each seam of every test hole put down, care being taken to have a clean sample of all the drillings from the entire layer. While coal seams are too thin to work in places, they show local thickenings in adjacent localities, and analyses taken from different places would give a truer idea of their value than an isolated determination. Moreover, comparative analyses of the lower seams would very probably be an aid in correlating the different layers, as in the case of the two Verne coals.

In testing coal to determine its value for heating and boiler purposes, the result is stated in British Thermal Units (B. T. U.). By this is meant the number of pounds of water which one pound of fuel will raise one degree F. This equals 778 ft. pounds. "The heating power may be very closely computed from what is known as an ultimate analysis (where the percentage of each element or atom, instead of the molecule is given), and Dulong's formula gives as good results as any," to wit: (146 x % carbon) + [620 x (% hydrogen — $\frac{1}{8}$ oxygen)] + (40 x % sulphur). In this equation the three factors are to be considered separately and then added; that is the amount of carbon is to be multiplied by 146 giving result one. The amount of hydrogen must be subtracted by $\frac{1}{8}$ of the percentage of oxygen, and the result multiplied by 620 giving us result two. Finally the percentage or amount of sulphur multiplied by 40 gives us result three; which added to the two preceding results gives the equivalent in B. T. U.

Mr. Lane has determined the following formula from what is known as a proximate analysis, where the results are stated as so much moisture, fixed carbon, volatile combustible matter, etc.: B. T. U. = (146.6 x % combustible) + (40 x % sulphur). By the per cent of combustible in the first equation, is of course understood the amount of fixed carbon, and volatile combustible matter. These two are to be added and the result multiplied by 146.6 giving result one. The amount of sulphur multiplied by 40 gives result two. The total of these two results gives the equivalent in B. T. U. We will now proceed to give the results of some analyses of Bay county coals and their equivalent in B. T. U., as near as the accuracy of the sample and analysis permit. The analyses are classified by the layers of coal, from which the sample was obtained. Most of them are from the Upper Verne.

Mr. A. S. Ruttle of the Wenona Coal and Mining Co., has given the result of an analysis of the Saginaw seam in the southwestern part of Merritt township. I believe that the sample was obtained from a drill hole. The amount of volatile combustible is not stated separately. If this runs sufficiently high, the coal would very likely be well adapted for burning cement clinker, taking into account the very small amount of sulphur contained in the coal.

Saginaw Seam. What Cheer Mining Co.

Moisture	2.864
Ash	5.853
Combustible	91.283
	100.000
Total sulphur	0.1278
B. T. U., computed	13,382.6

Lower Verne. Michigan Coal & Mining Co.

Moisture	5.01
Vol. matter	39.62
Fixed carbon	41.67
Ash	13.70
	100.00
Specific gravity	1.33
Total sulphur	6.66
Vol. sulphur	6.37
Sulphur in Ash	0.29
B. T. U., computed	12,183.514

Lower Verne. Michigan Coal & Mining Co.

	Ultimate Analysis.	
	Moist Coal.	Dry Coal.
Water	5.01	.....
Carbon	62.29	65.57
Hydrogen	4.62	4.87
Nitrogen	1.20	1.26
Oxygen	6.81	7.17
Ash	13.70	14.42
Vol. sulphur	6.37	6.71
	100.00	100.00

B. T. U., Moist Coal, 11,686.54, computed. This is approximately 696 B. T. U. less than shown by the proximate analysis.

We next give proximate analysis from the Central Coal and Mining Co., located within half a mile of the above mine. The sample, however, is from the Upper Verne seam.

Upper Verne. Central Coal & Mining Co.

Sp. Gr	1.36
Moisture	4.52
Vol. combustible	40.57
Fixed carbon	42.16
Ash	12.75
	99.36

B. T. U. 12,128.218, computed. This mine is located about two miles east-northeast of the Valley Mine, which analysis follows:—

Upper Verne. Valley Mine.

Moisture	1.7%
Ash	9.5
Vol. matter	35.5
Fixed carbon	53.3
	100.00

B. T. U., 12,918.0, computed. Analysis by C. A. Davis.

We next have two analyses by Lathbury and Spackman, furnished us by U. R. Loranger of Bay City. They are from the drillings of the Upper Verne (?) seam, on the Goetz property in section 36 of Monitor township, and about one mile north of the Valley Mine.

Upper Verne (?). Goetz Coal No. 1.

Moisture	3.76
Vol. combustible	37.05
Fixed carbon	50.10
Ash	9.09
	100.00
Sulphur	3.72
B. T. U., computed	12,924.990

Upper Verne (?). Goetz Coal No. 2.

Moisture	6.50
Vol. combustible	33.98
Fixed carbon	40.60
Ash	18.92
	100.00
Sulphur	1.79
B. T. U., computed	11,005.028

Within three miles to the west of the Goetz coal, we have the Upper Verne represented at the Old Monitor Mine in the S. E. ¼ of section 28, Monitor township.

Upper Verne. Old Monitor Mine.

Moisture	10.03
Vol. combustible	35.36
Fixed carbon	49.94
Ash	4.67
	100.00
Sulphur	1.12

Analysis by Lathbury and Spackman, from U. R. Loranger. B. T. U., 12,594.58, computed.

The two following analyses are from the Upper Verne at Wolverine Mine No. 2. This is located at less than two and one-half miles north-northwest of the Old Monitor shaft hole. The first analysis was made by Dickman and Mackenzie for Wicks Bros. The sample is from car load lots; dried at 212° F. The second analysis is from R. M. Randall of the Saginaw Coal Co.

Upper Verne. Wolverine No. 2.

	No. 1.	No. 2.
Moisture	6.76	6.18
Volatile combustible	42.67	46.10
Fixed carbon	42.01	40.88
Ash	8.65	6.84
	100.10	100.00
Sulphur	3.50	2.27
Iron Met		2.54

B. T. U., Wickes Bros., 12,295, R. M. Randall, 13,335.
B. T. U., Geol. Surv., 12,556, Geol. Survey, 12,842, computed.

We also have another analysis from Wolverine No. 2; analyst, L. Kirschbraum, University of Michigan.

Upper Verne. Wolverine No. 2.

Moisture	8.92
Vol. combustible	36.49
Fixed Carbon	51.92
Ash	2.67
	100.00
Sulphur	1.49
B. T. U., computed	12,987.506

Two and one-half miles northwest from this last locality is Wolverine No. 3 Mine, from which Mr. R. M. Randall has sent us the following. I believe that both the Upper and Lower Verne are represented in this mine, separated by a thin bed of shale. This analysis is probably from the upper bed.

Upper Verne (?). Wolverine No. 3.

Moisture	4.14
Vol. hydrocarbons	45.70
Fixed carbon	42.14
Ash	8.02
	100.00
Sulphur	3.53
Iron Met	3.30

B. T. U., per pound, 12,519.8, R. M. Randall.
B. T. U., per pound, 12,912.464, computed.

We next have analyses of the Upper Verne from the Wenona Mine, north of West Bay City.

Upper Verne. Wenona Mine.

Moisture	2.06
Vol. combustible	41.40
Fixed carbon	51.89
Ash	4.65
	100.00

B. T. U., 13,676.314, computed.

The following analysis by Prof. Geo. A. Koenig of the Mich. School of Mines, was made in August, 1899:

Carbon	72.74
Hydrogen	5.27
Oxygen	12.26
Nitrogen	1.51
Iron sulphide	3.66
Clay	3.47
Moisture	1.09
	100 00

Sulphur, 1.95%. Iron, 1.71.
B. T. U., 13,016.84, computed.

Mr. Henry J. Williams of Boston made the following analyses from the upper seam of the same mine.

	Wet coal.	Dry coal.
Moisture	3.98	....
Carbon	73.09	76.12
Hydrogen	5.03	5.24
Nitrogen	1.31	1.36
Oxygen	8.86	9.23
Ash	5.70	5.94
Volatile sulphur	2.03	2.11
	100.00	100.00

Total sulphur, 2.50.
Sulphur in ash, 0.47.

This coal yields by calorimeter test 13.489 B. T. U. per lb. of the wet coal and 14.048 per lb. of the dry coal.

A coke analysis of the same coal by D. P. Shuler runs as follows:

Moisture	1.68
Volatile matter	3.12
Fixed carbon	79.46
Ash	15.74
	100.00

Sulphur, 1.41. Phos., 0.01.

Mr. L. Kirschbraum of the University of Michigan, has made the following analysis from the split of the Upper Verne seam at the Salzburg mine. It is noteworthy on account of the small amount of sulphur.

Upper Verne Split or Rider. West Bay City.

Moisture	6.50
Vol. combustible	43.61
Fixed combustible	47.82
Ash	2.07
	100.00
Sulphur	0.89

B. T. U., 13,439.238, computed.

Finally we have an analysis by C. A. Davis of what I believe to be a drift coal from the northeast quarter of section 22, T. 13 N., R. 6 E.

Drift Coal. Merritt Township.

Volatile matter	59.20
Ash (gray)	8.58
Fixed carbon	32.22
	100.00

B. T. U., 13,402.172, computed.

Chas. H. Hilton of the Michigan Agricultural College has made the following determination for sulphur and iron from the property of the Michigan Coal & Mining Co., Monitor township. This is from the Lower Verne seam. We also have original analysis from H. S. Williams, for comparison, as follows:

Michigan Coal Mining Co.

	Williams.	Hilton.
Total sulphur	5.72	5.80
Sulphur in ash	0.04	0.05
Volatile sulphur	5.68	5.75
Iron	....	5.71
Sulphur computed from iron	....	6.52
Ash	8.26	8.33
Moisture and Vol. matter	45.68	41.39

We also have Hilton's determination from certain drillings taken from a test hole for coal in the S. E. $\frac{1}{4}$ of section 10 of Mt. Forest township, T. 17 N., R. 3 E., as follows:

Total sulphur	1.04
Sulphur in ash	0.03
Volatile sulphur	1.01
Iron	0.94
Sulphur computed from iron	1.074
Ash	12.23
Moisture and Vol. matter	38.59

Mr. Hilton's notes on his work follow:[3]

[3] Mich. Geol. Survey, Vol. VIII, part 2, p. 99.

"It will be noticed that the moisture and volatile are uniformly lower in my determinations than in the original analysis by Williams. Inasmuch as the amounts of these two factors had little bearing upon the present investigation, I made the determination of them together. To get at as to where the loss came in I made moisture determinations on three samples and found the loss of moisture accounted for the loss in the total moisture and volatile matter. Without going further, I took it for granted that the loss was thus accounted for in every case. The loss in moisture necessitates a higher proportion in the constituents, and I find accordingly larger percentages of total sulphur and of ash. The amount of sulphur in the ash is very small and is considered as sulphate in the coal. The amounts of volatile sulphur agree quite closely in the two sets of analyses."

"So far as the investigation has been carried the determination of iron has been the significant feature. I would call attention to the peculiar relation the content of iron bears to the content of sulphur. One varies as does the iron, and they stand in almost exactly the same relation to each other in every instance, viz., in combining proportion 5,664.12 to form iron pyrite (Fe S2)."

Conclusion.

"As we stated in the introduction, the work has not been carried to its farthest analysis, and whatever conclusions are drawn must be stated as strongly indicated and not as absolute or positively demonstrated. But there is a strong probability, amounting almost to a certainty, that the sulphur is all accounted for correctly."

"First: A small amount of sulphur is non-volatile, being formed as sulphate with calcium. Gypsum is found in perceptible amounts in coal deposits and the non-volatile sulphur is thus easily accounted for."

"Second: That the volatile sulphur is all combined with iron in the form of iron pyrite (Fe S2)."

"This second conclusion is given weight by the fact that in all the samples analyzed, all the sulphur and nearly all the iron are accounted for by combining them as Fe S2. It can easily be seen how, in one or two instances, these proportions would occur by accident and thus lead to erroneous conclusions. But it is extremely improbable that this accidental relation would occur in every case of samples of coal taken from eleven different mines in widely separated parts of the state. It seems just, therefore, to conclude that the volatile sulphur is rightly accounted for as Fe S2. This is not saying that the iron and sulphur were originally deposited in these proportions. But that does not concern this investigation. The present condition in the coal is what I am after."

Boiler Tests.

The following notes are taken from Mr. Lane's Coal Report:[4] We are indebted to Mr. Edgerton, superintendent of the electric light and waterworks plant, Lansing, for the tests given below: "In these tests a 12 hour run of coal was made to each coal, and an attempt was made to leave the grates in the same condition as they were found." "The amount of feed water was measured and the feed water kept at a constant temperature of 110° F." "The boiler pressure is nearly constant, about 95 pounds to the square inch, and the coal and ashes were weighed." "Of course there are many chances for inaccuracy." The boiler pressure was not absolutely

[4] Michigan Geol. Survey, Vol. VIII, part 2, pp. 69–72.

constant, the variations of atmospheric pressure and the temperature of escaping gases and the dryness of the steam was not noted, nor the coal which preceded on the grate, and this might make quite a difference.

Bay City, Upper Verne..... 7.56 units of evaporation
Bay City, Lower Verne..... 6.73 units of evaporation

During the third series of tests made during 1900 and 1901, the coal was taken from the Upper Verne seam at the Michigan Coal and Mining Co. (No. 1) and from the Stiver Mather Co., Valley mine (No. 2) of which an analysis has been given.

	1.	2.
Coal burned during test.....	14,626	15,916
Ash.....	1,255	3,180
Per cent ash.....	8.6	19.9
Lbs. of water at 62 lbs. per 1 cu. ft.....	95,604	93,310
Water evaporated with 1 pound of coal.....	6.536	5.846
Water evaporated for $1.00....	5,335	5,314

For further information on this section the reader is referred to Chapter IV of the report on Coal.[5]

6. *Coal Seams. Thickness of the Coal Formation.*

In his chapter on the "Occurrence of Coal," Mr. Lane made a provisional arrangement of the different coal horizons, to which the following names were given, beginning at the bottom: Lower coal, Lower Rider, Saginaw coal, Middle Rider, Lower Verne, Upper Verne, Upper Rider. I have found this arrangement to fit in very well with the test hole records obtained in this county, with the following additions: Bangor coal, Bangor Rider, Lower Verne Rider; the Salzburg coal and Rider over the Upper Rider of the Verne seams. We therefore have: Bangor coal, Bangor Rider, Lower coal, Lower Rider,[1] Saginaw coal, Middle Rider, Lower Verne and Rider, Upper Verne, Upper Rider, Salzburg coal, Salzburg Rider. It is not impossible that coal seams will be found overlying the Salzburg Rider. There is an indication of such a layer in the northern part of Bay county. The following test hole records will give an idea of the relationship of the different coal beds, beginning with the uppermost strata.

Clay.....	58		58	
Hardpan.....	20	6″	78	6″
Salzburg Rider.....		6″	79	
Fire clay.....	1		80	
Sand rock.....		8″	80	8″
Slate.....	8		88	8″
Salzburg coal.....	1	6″	90	2″
Fire clay.....	7		97	2″
Coal.....		8″	97	10″
Slate.....	6		103	10″
Fire clay.....	2	2″	106	

[5] Volume VIII, part 2, pp. 51–120.
[1] It is probable that what I call Lower coal is what Cooper calls Bangor coal in larger part.

Slate		6″	106	6″
Upper Rider		8″	107	2″
Light slate	14		121	2″
Black slate	7	1″	128	3″
Upper Verne	2	7.5	130	10.5″
Fire clay	4		134	10.5″

The above record is near the Wolverine shaft No. 2. We next give a record from the south central part of Monitor township, carrying the coal formation down to the Saginaw seam.

Clay	78		78	
Sand	26		104	
Sandrock	2		106	
Upper Rider		8″	106	8″
Fire clay	10		116	8
Gray rock	9		125	8
Slate	5		130	8
Upper Verne		8	131	4
Slate	20		151	4
Fire clay	4		155	4
Slate	21		176	4
Lower Verne		3	176	7
Black slate	5	1	181	8
Middle Rider		6	182	2
Slate	7		189	2
Saginaw coal	1	7	190	9
Fire clay	2	4	193	1

In the S. W. $\frac{1}{4}$ of the S. E. $\frac{1}{4}$ of section 2, T. 13 N., R. 4 E., there is this log carrying the series on down through the Lower coal.

Sand and gravel	12		12	
Clay	42		54	
Hardpan	10		64	
Black slate	10		74	
Gray shale	32		106	
Sandy shale	18		124	
Upper Verne	2		126	
Fire clay	4		130	
Gray shale	22		152	
Lower Verne	1	8″	153	8″
Fire clay	3	4	157	
Dark gray shales	15		172	
Gray rock	5		177	
Saginaw coal	1	8	178	8
Fire clay	2	4	181	
Black slate	29		210	
Lower Rider		6	210	6
Slate and coal	2	3	212	9
Lower coal	2	3	215	
Fire clay	2		217	

We next have a test hole from Goff Paul, put down in Bangor township, which gives the two lowest coal beds yet found, and with the upper and middle beds but meagerly represented.

Sand	11		11	
Clay	71		82	
Hardpan	3		85	
Quicksand and gravel	5		90	
Quicksand and fine gravel with hard-pan streaks	70		160	
Slate	9		169	
Hard rock	6	3	175	3
Black slate	11	7	186	10
Saginaw coal ?	2	1	188	11
Fire clay	27		215	11
Slate, streaks of hard rock	60	4	276	3
Black slate	11		287	3
Hard rock	3		290	3
Black slate	4		294	3
Lower coal	1	2	295	5
Fire clay	30		325	5
Hard rock	2		327	5
Slate	20		347	5
Black slate	7		354	5
Bangor Rider		7	355	
Fire clay	18	7	373	7
Hard rock	4	8	378	3
Slate	22		400	3
Black slate	13		413	3
Bangor coal	1	9	415	
Fire clay	27		442	
Hard rock	23		465	

These records not only serve to show the succession of the different coal beds, but indicates in a very general way the absence of certain seams in other localities. If all the holes were of equal depth we would have better grounds for comparison.

The last test hole, however, does not give a complete idea of the thickness of the entire coal formation in Bay county. In the record of the deep well put down on the grounds of the North American Chemical Co. at South Bay City, by Thomas Percy, we have the following log, including the overlying drift.

Sand	15	15
Clay	35	50
Sand	10	60
Hardpan	10	70
Sand	30	100
Hardpan	38	138
Sand	2	140
Sandstone	138	278
Blue shale	17	295
Sandy shale	10	305
Blue shale	15	320

Sandy shale	5	325
Blue shale	35	360
Shale	60	420
Fire clay	10	430
Blue shale	30	460
Fire clay	10	470
Shale	10	480
Red shale	10	490
Parma sandstone	50	540

This would make the thickness of the Coal Measures 350 feet, the base of the coal formation being 90 feet A. T. The top strata have suffered considerably by erosion, which makes the thickness of the formation about 50 feet less than normal. At Bradley's deep well (record 359), the top of the Parma comes in at 367 feet or 216 feet A. T., showing how the basement, on which the coal formation rests, rises in that direction. To the west, a hole put down by W. L. Ralston in the center of section 4, T. 13 N., R. 4 E., enters at a depth of 409 feet, a conglomerate probably at the base of this formation, which extends to a depth of 450 feet. The drift here is 108 feet thick. Farther west at Midland, the drift is 285 and the Coal Measures 525 feet thick. The Parma also shows a thickness of 110 feet at a depth of 920 feet. Mr. Lane is of the opinion "that the rest of the strata shown in the Midland section are additions to the base of the Coal Measures, the elevation of the Verne coals being very nearly the same above tide at Smith's Crossing, four miles below Midland, and at Amelith in Bay county." A brief survey of the different coal horizons will now be in order. It is to be remembered that the correlations which follow are more of less doubtful, especially with the lower coal seams.

7. *Bangor Coal and Rider.*

The existence of this coal horizon is based on certain comparative data obtained from Goff Paul in sections 3 and 10 of Bangor township. The Saginaw coal is found there at a depth of 196 feet or 387 A. T. This is about 13 feet lower than its average elevation A. T. in Bay county. In test hole 273 this is underlain by the Lower Rider and Lower coal at the respective elevations of 332 and 267 feet A. T. In test hole 238 the Lower coal is found at 273 feet A. T., with what I have taken to be the rider of the Bangor coal at 266 A. T. In test hole 239 of section 3 Bangor, the Bangor coal rider is apparently struck at 248 feet A. T., depth 335 feet, the underlying Bangor seam being 192 feet A. T. at a depth of 391 feet. In the N. E. $\frac{1}{4}$ of the S. E. $\frac{1}{4}$ of section 13, T. 15 N., R. 4 E., I have identified the Bangor coal rider at a depth of 332 feet; elevation 252 feet A. T. In the diamond drill hole put down for Bradley in the southeast corner of Hampton township we have the Lower coal and rider at approximately the same elevation as already given for Bangor township. The Bangor coal rider is formed at a depth of 327 feet; elevation 256 feet A. T.; the Bangor coal at a depth of 360 feet and 222 A. T. This is only seven feet above the top of the Parma there. The accuracy of the Bradley record, and the relative elevation above tide of the Lower coal and its rider there, compared with the seams in Bangor township, together with the occurrence of these Bangor coals below, rather substantiates the existence of these seams.

The rider of the Bangor coal is found at from 56 to 60 feet higher in section 3 of Bangor township, T. 14 N., R. 5 E. At Bradley's well there is apparently only 33 feet separating the two horizons. It is probable that the relatively low elevation above tide here, is due to the decreased amount of sedimentation between and underlying these two coal beds. In section 13 of Kawkawlin, the Bangor Rider is in much the same position as Bradley's hole, in reference to the center of the coal basin.

These two coal horizons have in general a foot composed of fire clay, and a roof of black slate, or more properly shale. Should this coal prove suitable for industrial purposes, the time may come when it could be profitably mined with the underlying fire clay.

8. *Lower Coal and Rider.*

Reference has already been made to these two horizons in the sections printed at the beginning of this chapter. In the drill records which I obtained in Bay county, the lower seam was encountered in 21 drill holes. This lower layer in townships 13-15 N., R. 5 E., is found in general at an elevation of from 266 to 295 feet above tide, and at depths varying from 268 to 317 feet. In Monitor township, T. 14 N., R. 4 E., the elevation above sea level varies from 356-376 in the northwestern part of the township, being found at an average depth of 240 feet below the surface. This coal seam apparently shows a continual increase in elevation from the west quarter post of section 16, T. 14 N., R. 4 E., to the southwest quarter of section 6, of the same township. At Bradley's hole in the southeast corner of Hampton township, the elevation of this horizon is apparently 290 feet above sea level. This would rather indicate that the filling up process, by which the coal formation accumulated, extended this far east. We would thus expect this layer to be found at approximately the same elevation above tide between the Bay-Tuscola county line and Bay City.

The rider of this horizon is from 57 to 79 feet above the mother seam, in T. 14 N., R. 5 E. At Bradley's well the rider is but 36 feet higher, which probably indicates that the filling in of the coal basin had lapsed during the period when the intermediate strata were laid down. As we have seen, this is what took place during the deposition of the Bangor coal, the Bangor rider, and the strata below, the aggregate result being a very considerably thicker formation in the vicinity of Midland. In sections 6 and 7, T. 14 N., R. 4 E., the rider of the Lower coal is from 9 to 15 feet above the seam below. The considerable lapse in deposition here was apparently continuous through Verne times, throwing the entire formation there to a much greater, than normal depth. Such local depressions are not generally so persistent.

The thickness of the Lower coal varies from one to three feet. The average for 11 holes in the north half of T. 14 N., R. 5 E., is very nearly two feet. Eighty rods north of the south quarter post of section 10, T. 14 N., R. 5 E., there is three feet and one inch of coal at a depth of 310 feet, belonging to this horizon.

In the records of 17 drill holes, the Lower coal is underlain by fire clay in 15 holes, the foot of the other two being composed of sandstone and slate. The roof is of shale or slate. The thickness of the roof and foot varies very considerably in the different records. The rider is overlain by slate, and underlain by fire clay, with the exception of three holes, where the foot is of sandstone. There are 12 test holes in which this rider is apparently represented.

Since the above was written Mr. Amos Wampler has sent in the record of a test hole in the southwest quarter of section 20, T. 14 N., R. 4 E., in which the Lower coal is two inches thick at a depth of 231 feet and 327 feet A. T. He has also sent in the record of a test hole near Loehne P. O. and additional records near the Beaver-Garfield township line; from section 24 of Garfield and 30 of Fraser, which show heavy beds of sandstone and shale coming in at about the depth at which I believe the Lower coal should be found.

9. *Saginaw Coal and Middle Rider.*

These two coal horizons have been identified in the records of 70 drill holes obtained in Bay county. The average elevation of the Saginaw coal is 400 feet above sea level, the extremes of variation oscillating between 350 and 438 feet. In T. 13 N., R. 4 E., T. 13 N., R. 6 E., and T. 14 N., R. 3 E., the average elevation runs close to 400 feet A. T., in T. 14 N., R. 4 E., the height is 413 feet above sea level, with an elevation of 389 feet in T. 14 N., R. 5 E. By determining the elevation of the surface above sea level from the contour map in this report, and subtracting the elevation of this seam as given above for the different government townships, the depth at which this coal layer would be reached can be approximately determined. In T. 13 N., R. 4 E., there is a rapid increase in elevation going north and west from the southwest corner of section 10 to the center of section 4, the difference of elevation apparently amounting to 52 feet. In Monitor township, T. 14 N., R. 4 E., the lowest elevation of this seam is represented by a trough which probably trends from the southwestern part of section 21, to the southwest quarter of section 6. The elevation through here is approximately 395 feet A. T. On the west side of the syncline the elevation is some 20 feet higher. The elevation also increases to about 425 feet A. T. in section 11, T. 14 N., R. 4 E., Eastward from here, in the northern portion of T. 14 N., R. 5 E., the elevation changes considerably. The average height, however, is 13 feet lower than the usual elevation, for that portion of the township.

In the shaft hole of the What Cheer mine in the southwestern quarter of section 30, Merritt township, T. 13 N., R. 6 E., the Saginaw coal is from three to four feet thick at a depth of 200 feet, the elevation of the surface being 590 feet above tide. To the eastward, in the north half of section 32, this seam is cut out by heavy beds of sandstone. The main extension of this workable coal basin is northwest or north-northwest, into Saginaw county. In the S. W. $\frac{1}{4}$ of section 20, T. 14 N., R. 4 E., a recent drill hole into the Saginaw coal gives a thickness of one and one-half feet. The seam here is separated by two feet six inches of gray shale, the lower portion of the seam being one foot thick and 199 feet in depth. The elevation of the surface here is 605 feet above tide.

Middle Rider.

This name has been applied by Mr. Lane to the rider of the Saginaw coal. The average elevation of this seam is 421 feet above tide, or 21 feet above the next lower layer of coal. The extremes of elevation apparently range from 371 to 443 feet A. T., being only slightly less than for the Saginaw seam. In T. 13 N., R. 4 E., the average elevation is 400 feet A. T. In T. 13 N., R. 6 E., 428 feet; in section 12, T. 14 N., R. 3 E., 415 feet A. T.; in T. 14 N., R. 4 E., 423 feet, and in T. 14 N., R. 5 E., 439 feet A. T. If it is desired to obtain the depth of this horizon, the same remarks apply to this coal layer, as to the Saginaw coal.

In the S. W. $\frac{1}{4}$ of section 23, T. 15 N., R. 3 E., very nearly one mile west of Loehne P. O., the Saginaw coal is replaced by beds of shale which extend down to a depth of 288 feet. If I am right in correlating the Verne coals here, the coal measures show the same downward flexure that is so pronounced in the vicinity of Wolverine No. 3 mine, northeast of Auburn. Thence northward near the line of sections 1 and 2, in the north part of Beaver township, we have heavy beds of sandstone and shale down to a depth of 296 feet, far below the Saginaw coal; neither are the Verne coals represented here, being either washed out or replaced by sandstone beds. In the southwest quarter of section 33, Garfield, the Verne coal is at about the same depth as in the lower portion of the county, showing a pronounced rise from the vicinity of Loehne P. O. The Saginaw coal is not represented in any of the test holes in section 32 and 33, Garfield, there being a heavy bed of gray shale or sandrock at the depth where we would expect this seam to occur. The same remarks hold for section 24 of Garfield and 30 of Fraser, to the northeast. Up to this latitude I have not been able to discover any elevation of the coal measure seams, or the basement formation on which the coal measures rest.

In the southeast quarter of section 10, T. 17 N., R. 5 E., there are the records of three drill holes put down on the land of J. Mansfield, which show a coal horizon at an elevation of 475 to 485 feet A. T.; depth 175-185 feet, and a rider at about 495 feet A. T. The relationship of these two seams to the overlying coal, and additional records of this upper coal, which is relatively in the position of the Verne seam, rather points to the occurrence of the Saginaw coal at this depth and elevation, in this section. It may be, however, that what I have here called the Saginaw coal is really the Upper Verne, as it is about the same elevation above tide as the Upper Verne in the lower part of the county. If this is true, the seams which have been referred to the Verne coals in the northern part of Garfield and Mt. Forest townships, represent a higher horizon than is found near Bay City. Taking into account the general relationship of the coal strata, I believe the correlations will stand as suggested. The greater elevation of the Saginaw coal in the Mansfield holes is probably due to the increase in elevation of the basement formation on which the coal formation rests. This underlying formation comes to the surface in the northeastern part of Arenac county, Omer being near the border line. This increase in elevation of the underlying Grand Rapids formation amounts to some 600 feet between South Bay City and Omer. The Verne seams in the same distance increase at least 150 feet between Bay City and the Rifle river, and probably the greater part of this increase is from a line running west-northwest through Lengsville station. I imagine that the Saginaw and underlying seams gradually feather out as they approach the edge of the basin, each overlying stratum extending farther and farther out as the underlying formation is reached, until the entire Grand Rapids basin became filled up. This original deposition has been modified by the orogenetic movements and perhaps by differential solution below in the Grand Rapids gypsum beds.

Thickness of the Saginaw Coal and Rider.

In the record of four test holes put down in the north half of T. 13 N., R. 4 E., the average thickness of the Saginaw coal is 11 inches; that of its rider 12 inches. In T. 13 N., R. 6 E., the thickness of the respective veins is 9 and 16 inches. In both these townships the rider is more frequently

shown in the bore holes than the Saginaw coal. In the northeast quarter of section 12, T. 14 N., R. 3 E., the Saginaw coal is apparently 5 feet thick in the record of one drill hole, but rapidly decreases in thickness going east. The Middle rider has an average thickness of 13 inches in two test holes in the same quarter section. In Monitor township, T. 14 N., R. 4 E., the Saginaw coal averages 20 inches through, and its rider 9 inches. In T. 14 N., R. 5 E., the relative thickness is 18 and 19 inches. It is thus apparent that the seam which has been designated the Middle rider may prove of workable thickness upon more extensive exploitation.

The character of the foot and roof of the Saginaw coal and Middle Rider is almost invariably of so called fire clay and slate. In Merritt township the roof of the rider is sometimes of sandstone.

10. *Lower Verne.*

This vein of coal has been reached at the mine of the Pittsburg Coal Co. near Amelith, in the shaft of the Michigan Coal & Mining Co. west of Salzburg, and in the entries of Wolverine No. 3 northeast of Auburn. At the Amelith shaft the elevation is very nearly 407 feet A. T. at the mine of the Michigan Coal and Mining Co., 474 feet A. T., at Wolverine No. 3 mine the elevation has again dropped to very nearly 426 feet A. T. In certain places as in the mine of the Michigan Coal and Mining Co., and at Wolverine No. 3 shaft, the Lower and Upper Verne are either directly superimposed upon each other, or are separated by a thin bed of shale or bituminous sandstone. In the shaft near Amelith, there is apparently 47 feet of strata between these two horizons.

The elevation of the Lower Verne in the lower third of Bay county is approximately 440 feet above sea level. The average elevation for several of the government townships is as follows:

T. 13 N., R. 4 E., 432 A. T.; T. 13 N., R. 6 E., 447 A. T.; the northeast part of T. 14 N., R. 3 E., Williams township, 435 A. T.; T. 14 N., R. 4 E., 444 A. T.; T. 14 N., R. 5 E., 451 A. T.; a single record in section 32, T. 15 N., R. 5 E., at 453 A. T.; in section 4, T. 16 N., R. 3 E., a single test hole makes this seam at 512 A. T.; in section 30, T. 16 N., R. 4 E., the Lower Verne is 441 feet, in test hole 462. The approximate depth at which this vein may be found can be determined by ascertaining the elevation of the surface from the contour map, and subtracting the elevations above tide as given above. In prospective developments of this coal vein it will be advisable to have all the coal saved from the drillings and analyzed for iron and sulphur, with the opinion of a competent expert as to the value of the product for commercial purposes. A careful account should also be kept in boring operations for partings of shale or iron carbonate in this coal. The roof of the seam should also receive particular attention from the driller.

In section 15, T. 13 N., R. 4 E., the coal dips toward the center of the section, increasing in elevation southeast and northwest. This increase in elevation continues toward the northwest, until at Bay mine No. 2 the elevation is 450 feet A. T. This upward flexure of the Lower Verne has considerable breadth, as in the records of the Hecla Cement & Coal Co., in section 2, T. 13 N., R. 4 E., the average elevation of this stratum is intermediate between the height of the vein at Amelith and at the shaft house of Bay No. 2 mine in section 4, T. 13 N., R. E. In the central part of Monitor township, T. 14 N., R. 4 E., the elevation of this seam drops to nearly 430

feet A. T., but again increases somewhat in height in the vicinity of Wolverine mine No. 3. The rolls of the Lower Verne and associated strata are brought out in the section G-H. In T. 13 N., R. 6 E., the Lower Verne increases in elevation north and east, the difference in elevation, as far as our records indicate, amounting to 22 feet. In section 30 this coal is found at 428 feet A. T., increasing to 448 feet A. T. in section 19, and then dropping down to 435 feet in section 6, forming a fold not unlike that between the shaft near Amelith, and Wolverine No. 3 mine. Eastward from this western tier of sections this seam has an elevation of about 450 feet A. T. throughout the central part of this township, north and south, as far as our records show.

In the northeast part of Williams this seam is very irregularly deposited if my correlations are correct. It is not impossible that this region is slightly faulted, or other agencies may have operated to produce such irregularities as are given in the test hole records there. A single drill hole in section 17 shows the Lower Verne at 424 feet A. T. or about 10 feet lower than in the eastern part of the township. The elevation here, however, being some 30 feet higher than in the eastern part of the township, this layer is found at a depth of 219 feet, or nearly 40 feet more than in the northeastern part of Williams. Such differences of elevation are to be taken into account in coal development. The Salzburg coal and rider are found at about the normal elevation in section 17.

In T. 14 N., R. 5 E., the Lower Verne shows a tendency to increase in elevation to the northward, with considerable fluctuations in elevation. North from here and along the shore of Saginaw and Tobico bays, this coal horizon is cut out by very considerable beds of sandstone extending as far north as section 13, T. 15 N., R. 4 E.

In the northwest quarter of section 30, Fraser township, T. 16 N., R. 4 E., we again get the Verne coal at 441 feet A. T., or at very nearly the average elevation of this seam in the lower third of the county. Northward from here I believe that the Lower (?) Verne increases rapidly in elevation. Near the southwest corner of section 4, Garfield, this seam may be found at about 512 feet A. T. The test hole records in the southwest part of Garfield apparently do not show this coal horizon.

In places the Lower Verne shows a tendency to split up into two or more layers, separated by thin strata of slate. In section 15, T. 13 N., R. 4 E., we have three layers belonging to this horizon. The average elevation of the different parts of the Lower Verne there is quite nearly 7 feet below the average of that vicinity. Out of 45 test holes in that township 31 have a higher elevation. In section 30, T. 13 N., R. 6 E., the Lower Verne is again separated by shale beds into two parts where this coal horizon has the lowest elevation yet noted in that township. On the other hand in section 20 of Monitor township, T. 14 N., R. 4 E., a split of the Lower Verne is slightly higher than the average for that township, and somewhat less than for the adjacent beds in the same section. In sections 4, 22, and 23 of T. 14 N., R. 5 E., this coal is separated into from two to four beds having about the same elevation as the average of the Lower Verne in this township. In section 4, a sulphur band, probably iron sulphide, is noted as overlying the lower split, and I have based my correlations partly on this information. In places these Lower Verne splits seem to follow the same law of deposition as will be noted for the rider of the Lower Verne; that is a tendency rarely to split up along lower planes of deposition. Whether these splits

are near shore line deposits subject to oscillation and occasional inundations of sediments, with resultant local settling, remains to be seen.

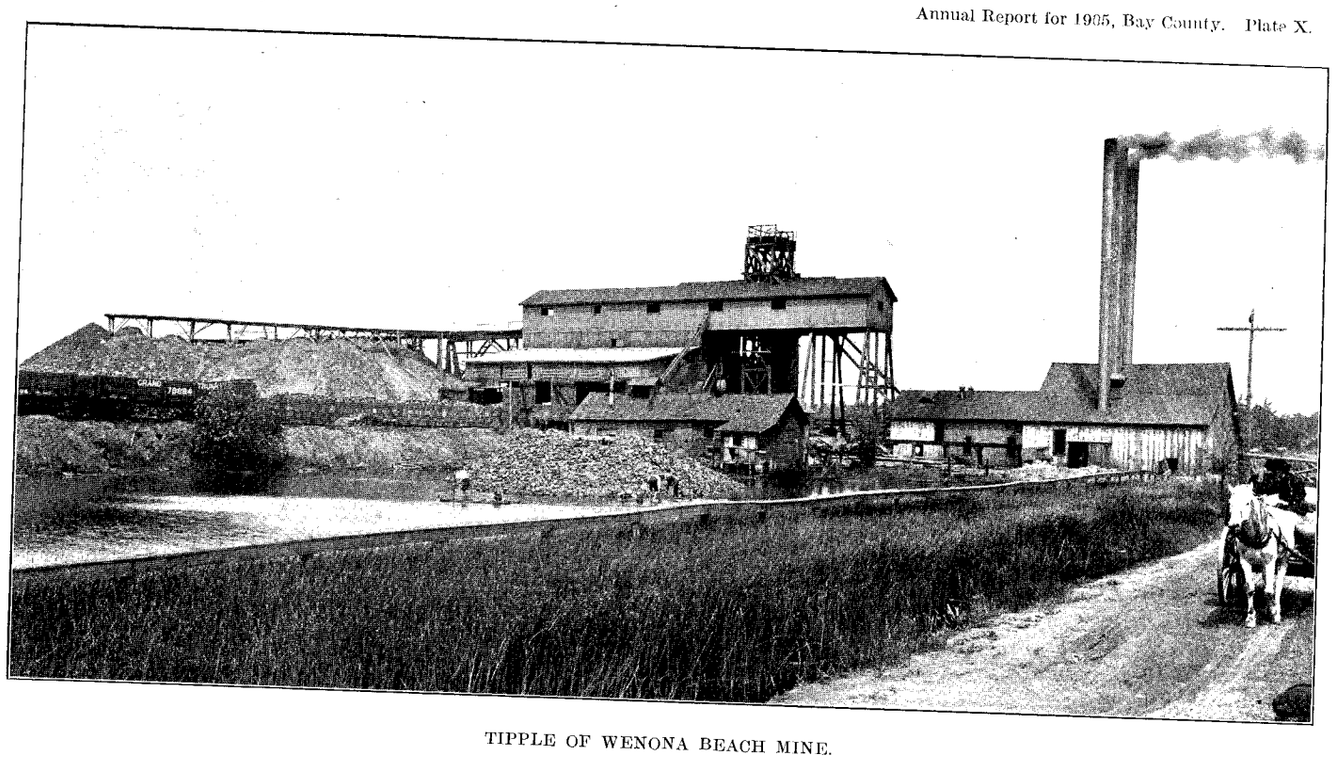
11. *Thickness of the Lower Verne.*

An average of 145 test hole records in which this seam occurs, shows a thickness of a trifle more than two feet. This average would be much reduced by areas in which the coal was never deposited. In addition to this, the coal has been removed over considerable areas by erosion which took place previous to the deposition of the drift or overburden. Inasmuch as the average elevation of this seam is some 440 feet A. T. for the lower half of Bay county, we would not expect much coal inside of the areas approximately shown by the 440 foot rock contour line, on the map which goes with this chapter.

The average of numerous records in the north half of T. 13 N., R. 4 E., is 27 inches; in T. 13 N., R. 6 E., so far as our records indicate anything, of 16 inches; in the northeast part of T. 14 N., R. 3 E., of 30 inches; in T. 14 N., R's. 4 and 5 E., of 30 inches; a single record in T. 15 N., R. 5 E., shows 14 inches of coal; in section 4, T. 16 N., R. 3 E., 26 inches of coal in one test hole; in section 30, T. 16 N., R. 4 E., we have four inches of coal in a drilling there. The Lower Verne varies constantly in thickness, and I have not been able to correlate the depth of this bed with any variation in elevation. Thus we have in section 2 of Frankenlust, three feet of coal at 442, 447, 430 and 422 feet above tide; in section 15 of the same township from three to four feet of coal at 398, 408, 411 and 420 feet A. T. In T. 14 N., R. 4 E., forming part of Monitor township the distribution of the bore holes makes it possible to arrive at a more accurate conclusion concerning the relationship of thickness and elevation. We thus have less than one foot of coal at an average height of 444 feet A. T., from one to two feet at 443 feet A. T., from two to three feet at 450 feet A. T., from three to four feet at 446 feet A. T., and from four to five feet at 443 feet above sea level. These deductions might be modified slightly by taking smaller units of areas. It will also be observed in the cross section G-H that the coal was laid down more or less regardless of local irregularities in the underlying strata, somewhat in conformity with Kuntze's idea of the formation of coal, with the exception of numerous local irregularities of the coal strata.

12. *Character of the Foot and Roof of the Lower Verne.*

In the records of 126 test holes showing the foot of this coal seam, 10 holes had a sandstone bottom, that of the remainder being of fire clay or shale. The roof is very generally of slate, or more properly shale, the drillings only showing seven test holes with a sandstone top out of 145 drill records. These facts as near as they can be determined from our records, serve to show the close relationship existing between shale beds and that of this coal layer, as far as its immediate deposition is concerned. Two of our drill records have a sulphur roof as in section 12, T. 14 N., R. 4 E., and in section 4, T. 14 N., R. 5 E. It is to be regretted that we have no specimens of this. Occasionally, as at the Amelith mine, the roof is a bituminous limestone. The roof also very commonly shows a slickensided shaly structure with an irregular fracture, quite unlike the even bedded slaty shale over the Upper Verne. There is considerable variation in the structure of the roof, which is not clearly brought out in the drill records.



TIPPLE OF WENONA BEACH MINE.

AIR COAL CUTTING MACHINE, WENONA MINE.

The fossil contents of the roof, together with its physical structure, render it a comparatively easy matter to separate the Upper and Lower Verne. In the roof of the Lower Verne, some of the most common forms which do not occur in the slate over the Upper Verne are: *Chonetes flemengi, Productus prattenanus, Productus muricatus,* and *Orthoceras rushense.* The first three species have a broad straight hinge line which forms the top, with a rather square form, the sides of the shell meeting the hinge line at right angles, which are more rounded at the bottom. This is quite unlike the species found in the shale over the Upper Verne, which is long and oval shaped at both ends, being not unlike the tongue of a bird. This is *Lingula mytiloides.* I believe that it would be well for drillers to keep samples of the roofs over the different coal seams for purposes of identification of the underlying seam. It is the duty of the Geological Survey to aid in such identifications. We have already mentioned the value of keeping samples of the different coal strata.

13. *Lower Verne Rider.*

In the territory leased by the Pittsburg Coal Co. near Amelith, and in section 33, T. 14 N., R. 4 E., this is a layer of coal which occupies a considerable depression of the Lower Verne, the Upper Verne keeping at much the same elevation as at the shaft house of Bay mine No. 2, in the S. E. $\frac{1}{4}$ of section 4, T. 13 N., R. 4 E. In section 15, T. 13 N., R. 4 E., this rider is from six to 25 feet above the Lower Verne, the greatest difference of thickness being above the lowest depth of the Lower Verne. We thus have the rider at 423 feet A. T. where the coal bed below is at 398 feet A. T.; near the southwest corner of section 10, the relative elevations are 427 and 437 feet A. T. The tendency was constantly to fill up, and consequently even out by the strata deposited the hollows in the coal basin in this particular district. In section 33, T. 14 N., R. 4 E., this rider is 11 feet above the Lower Verne.

14. *Upper Verne Coal.*

This coal has had a greater economic development than that of any other seam in Bay county and sustains to the commerce of this portion of Michigan, the same relation as does the Saginaw coal to St. Charles and the environs of Saginaw. As has already been observed, the elevation of this seam is 475 feet above sea level near the shaft of the Pittsburg Coal Co. near Amelith. In other localities where I have been able to obtain precise information from entries dug into this coal, the elevation is as follows, using the same datum, which is the mean tidal elevation of New York bay: At the shaft of the Michigan Coal and Mining Co., section 25, T. 14 N., R. 4 E., 487 A. T.; at the Old Central Mine, in section 25, T. 14 N., R. 4 E., 476 A. T.; at Bay No. 1 shaft, now abandoned, in section 33, T. 14 N., R. 4 E., 467 A. T.; Bay No. 2 mine, section 4, T. 13 N., R. 4 E., 463 A. T.; the Old Monitor Mine, also abandoned, in section 28, T. 14 N., R. 4 E., 465 feet A. T.; at Wolverine No. 1, which is worked out, in section 4, T. 14 N., R. 5 E., 470 A. T.; Wolverine No. 2, section 17, T. 14 N., R. 4 E., 461 A. T.; near Wolverine No. 3, in section 12, T. 14 N., R. 3 E., nearly 430 feet A. T.; at the shaft of the Hecla Portland Cement Co., in section 2, T. 13 N., R. 4 E., 471 feet A. T.; the Wenona mine in section 4, T. 14 N., R. 5 E., 460 feet A. T.; the Valley mine, section 1, T. 13 N., R. 4 E., 466 feet A. T. It will thus be observed that the elevation of this coal horizon is generally from 460 to 470 A. T. In the correlations of the test holes which are given at the end of this chapter I have used these shaft records as geological bench marks

from which to determine the position of this and associated coal beds in the lower portion of the county.

The average elevation above sea level of the Upper Verne is 463 feet. This is from the records of 203 test holes, the greater part being in the lower third of the county. In T. 13 N., R. 4 E., the average of 61 drill holes is 461 feet A. T.; in T. 13 N., R. 5 E., of three drill holes is 459 A. T.; in T. 13 N., R. 6 E., of 463 feet A. T.; in the northeast part of T. 14 N., R. 3 E., the average of three drillings gives 440 feet; in T. 14 N., R. 4 E., we have from 99 records an average elevation of 464 feet or only slightly more than in Frankenlust township to the south of it; in T. 14 N., R. 5 E., 29 records gives an average height of 457 feet; in T. 15 N., R. 3 E., we have only one drill hole which makes this seam at 440 feet A. T.; in T. 16 N., R. 3 E., four test holes make the Upper Verne 495 feet A. T., and T. 17 N., R. 3 E., three records give an average of 519 feet A. T. In certain drill records where the Upper Verne occurs more than once, I have had to use the number of splits, or sub-divisions of the Upper Verne, instead of the single drill records in making a correct average determination. The manner in which these records are distributed makes these averages more or less local for each township, and therefore less representative than if they were less bunched together.

Comparing the different townships in the lower third of the county we find that the Upper Verne has much the same average elevation east and west in T. 13 N., as far as represented by our records. Thence going north from T. 13 N., R. 4 E., we find a slight increase in elevation in T. 14 N., R. 4 E., with a slight general dip to the east and a very considerable falling off at the northwest. This easterly dip is also apparent in the tier of sections to the south. Going northwest and north from Monitor township to the east central part of Beaver the Upper Verne has quite a pronounced sag, being some 440 feet A. T. as far as shown by our records. In the south and east part of Garfield this coal is again back to about its normal elevation, increasing rapidly in height in section 4 of this township. In section 10 of Mt. Forest, the increase northward is less noticeable.

Within the limits of the different government townships this seam in T. 13 N., R. 4 E., varies from 432 to 491 feet A. T., as in sections 15 and 2 respectively. The dip here conforms to a somewhat more pronounced sag in the underlying Lower Verne. In T. 13 N., R. 5 E., we have the records of three drill holes in sections 6 and 7, where the Upper Verne is from 458 to 460 feet A. T. In T. 13 N., R. 6 E., half a dozen records in sections 3, 6, 23 and 30 show this layer from 460 to 470 feet above tide, as in sections 6 and 23 respectively. In Williams, T. 14 N., R. 3 E., I have only been able to satisfactorily identify this seam in section 12 and possibly in 24. The elevation is from 430 to 451 feet A. T., increasing to the westward. This quite pronounced sag in section 12 is also noticeable in the adjoining sections 6 and 7, Monitor township. The two Verne coals are only separated by thin seams of slate in section 12. In T. 14 N., R. 4 E., of Monitor township, outside of sections 6 and 7, the elevation varies from 451 A. T. as in sections 16 and 19 to 489 feet in section 25 and 487 feet in section 17. Throughout the central part of Monitor the height is quite persistent at from 460 to 470 feet A. T. In T. 14 N., R. 5 E., the variation in elevation is from 456 feet in the northeast quarter of the northwest qnarter of section 4 to 487 A. T. in section 25, and 484 feet in sections 12 and at Salzburg. Locally the coal dips quite irregularly. In order to obtain the

approximate depth of this seam, the elevations as given above may be subtracted from the ground level as given by the surface contour map.

In section 2 of Frankenlust township I believe that the Upper Verne is split into two and three seams in two drill holes in that locality. Likewise in section 19 of Monitor we apparently have the same thing taking place under apparently normal conditions of formation. In section 4, T. 14 N., R. 5 E., the Upper Verne is separated by a thin band of black shale into two beds of workable thickness which are relatively quite depressed. The same tendency to split was noted for the Lower Verne, with such explanation as I was able to give.

By taking into account the approximate elevation of the rock contours and the depth of this seam, the area in which this coal has been eroded away can be determined; that is the general average of the Upper Verne being some 460 feet A. T., we would not expect to find this seam inside of the 460 foot rock contour line, on account of the erosion of the bed rock.

15. *Thickness of the Upper Verne.*

In the records of 203 test holes showing the occurrence of this bed, the average thickness is very nearly 29 inches. This is not a true average, however, as there are 259 drill holes in about the same territory in which this seam does not occur. Taking into account the entire number of holes that have been drilled, we have a more approximate thickness of 12 inches for the lower third of the county. Our first estimate is too large on account of the way in which the records have been bunched around favorable deposits, and this will of course affect the second result. This estimate will in turn be reduced by the area in which this coal has been entirely washed away. The area embraced in this estimate of 12 inches covers 136 3-10 square miles. The entire area of Bay county is approximately 450 square miles. Assuming the average to be the same throughout, we have a total of 504,-576,000 tons of coal. This is assuming that one acre of coal one foot thick contains 1,752 tons.

For the different townships the following averages were obtained: T. 13 N., R. 4 E., 24 inches; T. 13 N., R. 6 E., 19 inches; T. 14 N., R. 4 E., 32 inches; T. 14 N., R. 5 E., 31 inches. In the remaining townships there are scarcely sufficient records to form an estimate of any value.

16. *Character of the Foot and Roof of the Upper Verne.*

In T. 13 N., R. 4 E., where this coal has been developed, the stratum underlying this coal is commonly of fire clay or shale, only four holes showing a sandstone bottom. This may be important in future development, as the fire clay or shale has been shown to be adapted to the manufacture of brick, tiling, and as a component in the production of Portland cement. The roof of this coal is commonly a black even bedded "slate" or more properly shale. There is one place in section 15 with a sandstone roof. In still another place in the same section, the overlying strata have been eroded away, leaving a covering of the unconsolidated drift. I have also been in one mine where an entry terminated in a drift-filled channel filled with gravel. In T. 13 N., R. 5 E., three test holes in sections 6 and 7 have a slate roof; one hole has a fire clay foot. In T. 13 N., R. 6 E., out of six drill holes, only one has a sandstone roof and that is the one with the highest relative elevation. A point worth investigating is whether shale beds some-

times run out, being replaced by sandstone under certain circumstances. Also in this same township the foot is of shale or slate except in a hole with a sandstone roof which has a similar bottom.

In T. 14 N., R. 4 E., the foot is commonly a fire clay or shale, there being only four bottoms of sandstone out of 90 records. The records of seven holes out of 98 show a sandstone roof, the remainder being of slate or shale. Two of these records in section 33 show this sandstone roof below the normal level and overlying a workable deposit of coal. Again in section 16, two drill holes have a sandstone cover near the lowest level of this seam; in one place the coal being two inches thick, in another 4 feet 10 inches. In section 19 we have a sandstone roof over almost four feet of coal at its highest elevation in that section, as far as determined. Obviously the formation of sandstone beds under such circumstances is very irregular, as we should naturally expect, being shore line deposits.

In T. 14 N., R. 5 E., the foot of this coal is sandstone in four records out of 26. The roof is of slate or shale in 26 records; three others are said to have a limestone roof. In T. 15 N., R. 3 E., we have the record of a single test hole in section 23 which has both a foot and roof of shale rock. In T. 16 N., R. 3 E., the records of three test holes show a foot and roof composed of shale or slate. Similar information was obtained from three drill holes in sections 10 and 33, T. 17 N., R. 3 E.

General remarks have already been made concerning the character of this roof in connection with this subject on the roof of the Lower Verne. During the summer of 1904 Mr. Geo. Bradford and I ascertained the occurrence of the Lingula black shale over a split of the Upper Verne coal at the shaft of the United City Coal Mine in West Bay City. This split was one foot thick and is underlain by three feet of gray shale, which in turn covers about four feet of coal, probably of Upper Verne age. In this gray shale David White of the U. S. Geological Survey has obligingly identified the following species:

WASHINGTON, D. C., JANUARY 24, 1905.

(1) Mariopteris muricata.
(2) Pseudopecopteris cf. avoldensis, Stur. sp.
(3) Sphenopteris (Crossotheca) n. sp.
(4) Sphenopteris (Palmatopteris?) sp., indeterminable fragment.
(5) Heterangium? stem fragment.
(6) Pecopteris dentata? (obscure).
(7) Neuropteris rarinervis (var.).
(8) Calamites ramosus.
(9) Sphenophyllum emarginatum.
(10) Bothrodendron cf. minutifolium.
(11) Lepidodendron aculeatum.
(12) Stigmaria verrucosa.
(13) Cordaites sp.
(14) Lingula carbonaria Shum.

From the composition of this flora, I conclude that it is very likely of Mercer age, and certainly not older, though possibly it may have come from an horizon as high as the Clarion group.

Thanking you for your kind interest in inducing Mr. Bradford to send me this very interesting material which I have been very glad to examine, I remain,

Very truly yours,

(Signed) DAVID WHITE.

17. *The Verne Coals in Garfield and Mt. Forest Townships.*

In the remarks made relative to the Saginaw coal, it was found necessary to make comparisons with the Verne beds in this portion of Bay county. In the four drill records furnished by Wampler in sections 32 and 33 Garfield township, the Verne coals are either washed out or are replaced by heavy beds of sandstone, with the exception of one hole in section 33, where the Upper Verne may be represented at about the same elevation above tide as in the lower third of the county, but at considerably greater depth on account of the increased elevation of the surface there. Also in two drill holes in section 24, Garfield, we have the Upper Verne and the Upper rider represented in much the same relationship as farther south. Evidently we have not yet come to the upward dip of these seams, a counterpart of which, is furnished in the increased elevation of these beds south of St. Charles. In section 30 of Fraser, T. 16 N., R. 4 E., we probably have the Lower Verne at about 441 feet above tide, or almost precisely at the same elevation as in the lower part of the county. Drilling operations through here could be carried on much the same as farther south, making due allowance for the difference of surface elevation. Northward, however, I believe that the beds begin to rise, until, in the region of the Rifle river we probably have the Verne coals some 150 or 175 feet higher than in the southern portion of Garfield township.

Near the southwest corner of section 4, Garfield, T. 16 N., R. 3 E., Mr. F. J. Tromble passed through a bed of coal at an elevation of 512 feet A. T., which I have provisionally correlated with the Lower Verne. This coal bed is also struck at an elevation of 513 feet A. T. in sections 33 and 34, T. 17 N., R. 3 E. What may be in the position of the Upper Verne was also obtained by Mr. Tromble at an elevation of 10 feet above the bed in the bore hole already referred to, in which he obtained 3½ feet of coal separated by two inches of slate toward the bottom. This bed is approximately 522 feet A. T. here. To the north, and on the land of Jas. Mansfield in the S. E. ¼ of section 10, T. 17 N., R. 3 E., I believe that this same seam occurs at an elevation of 526 feet A. T. At Estey Mr. W. E. Calkins, the driller, obtained 1½ feet of coal at a depth of 183 feet, and approximately 530 feet above sea level, which may also belong to the same Verne horizon. Apparently this bed is quite persistent in elevation within the limits under discussion, but it will also be necessary to refer to the contour map for differences in depths, which are due to inequalities in the surface elevation, in case of development. Thus we have this bed at a depth of 134 feet on the Mansfield property, and at 183 feet below the surface at Estey, but with a coal bed at very nearly the same elevation above sea level. Reference has already been made to the apparently increased elevation of Verne coals in this vicinity. If these correlations are borne out by future development, it will probably be determined that the basement on which the coal formation rests, rises in this direction.

18. *Upper Rider.*

The rider of the Upper Verne is found at an average elevation of 482 feet A. T., or approximately 100 feet lower than the level of Saginaw bay. This is from the records of 135 drill holes, a greater part being from the lower third of the county. The average elevation of the Upper rider is 19 feet above that of the Upper Verne. However, in 77 records where the Upper Verne is actually associated with this rider, as in the lower third of this county, the rider is 25 feet higher. On the average we find the Upper Verne

at a relatively lower elevation where this rider is deposited above it. Thus in T. 13 N., R. 4 E., the Upper Verne is 461 feet A. T., taking into account all the holes in which that seam occurs there, but in the 47 holes in which the Upper Verne and Upper rider occur together the Upper Verne is only 455 feet A. T., the difference in the elevation of six feet conforming with the general average given above, where the Upper Verne is directly compared with the Upper rider in all drill holes where the two strata are represented.

The same fact is brought out in 58 records in T. 14 N., R. 4 E. Where the Upper Verne is associated with the Upper rider there, the average elevation above tide of the former is 461 feet. The general average of the Upper Verne for that township is 464 feet A. T. Carrying the comparison still further, we find that where the Upper Verne is alone represented in the test holes, it is at the average height of 472 feet A. T., or only nine feet lower than the average elevation of the Upper rider. It is apparent from these three classes of records, that the Upper Verne, at least in this township, shows a constantly decreasing elevation, according to the absence or presence of the Upper rider. This factor will be of some use to coal drillers and operators in determining the distribution of the different beds of coal.

In T. 14 N., R. 5 E., we have 10 drill holes in which the Upper Verne and Upper rider were deposited together, the elevation of the former being 445 feet A. T. The average elevation of the Upper Verne is 457 feet A. T., which of course includes all records in which this seam was laid down both with and without the Upper rider.

Mr. Lane in his chapter on the "Occurrence of Coal" states[6]: "In the lower and thicker parts these troughs of coal are likely to be capped by a smaller coal seam known as a rider." This mode of occurrence was stated somewhat tentatively, but as we have just seen it is abundantly supported by data in our possession. Bain in his report on Iowa coal,[7] gives a theoretical explanation of this by supposing that the shrinkage and contraction of the lower coal beds in slowly settling and compacting, made a basin in which the upper coal was formed. At the same time I am unable to correlate the relatively lower elevations and greater thicknesses of beds which would follow as a natural corollary. It may be that during the period preceding the formation of the Upper Verne seam, that the beds of shale and sandstone formed local pools of deposits in which the Upper Verne was deposited, these relatively lower areas existing during the formation of the Upper rider, but showing in the interim a constant tendency to become filled up with beds of shale and sandstone between these two coal seams. In these local areas, perhaps forming local bays and estuaries, beds of coal are formed in a manner suggested by Kuntze, only somewhat more localized. The manner in which the Bay county coal areas show local filling and evening off of inequalities, due to the formation of shale and sandstone beds, at least suggests something of this nature. On the other hand, I believe that the beds of vegetation were laid down and compacted more or less regardless of the elevation and character of the underlying strata, forming originally water logged mattresses of vegetation. Judging from present conditions it is a common observation that marine or lacustrine vegetation is more abundant near the shore line than in deeper water. If it is possible to imagine beds of coal being formed under such circumstances during carboniferous times, we should actually have greater deposits of coal at higher elevations near the shore line. Into these relatively lower areas other beds would be laid down

[6] Volume VIII, Part 2, p. 32. 1902.
[7] 1897, p. 229–300; Journal of Geology III, p. 646.

after coal formation had for the time being ceased. After these areas have become measurably filled up such a rider would be laid down in the shallow surface waters, in a manner identical with that of the Upper Verne and the Upper rider. This fact was also brought out for the Lower Verne and the Lower rider in T. 13 N., R. 4 E. Altogether I think that sedimentation and environment were the more important governing factors in producing workable beds of coal, and that of the overlying riders. It is undoubtedly true, however, that different conditions prevailed during the formation of the coal deposits in different portions of the eastern United States.

As stated at the beginning of this section, the average elevation of the Upper rider is 482 feet A. T. In T. 13 N., R. 4 E., the height is 481; in six holes in T. 13 N., R. 5 E., of 489 feet; in three holes in T. 13 N., R. 6 E., of 484 A. T.; in five holes in the northeast part of Williams, T. 14 N., R. 3 E., 475 feet A. T.; in 58 drill holes in T. 14 N., R. 4 E., 481 feet A. T.; in 10 records in T. 14 N., R. 5 E., 483 feet A. T.; from four records in T. 15 N., R. 4 E., 488 feet A. T.; from four records in T. 15 N., R. 5 E., 488 feet A. T.; in one hole in T. 15 N., R. 5 E., 493 feet A. T.; one record in T. 16 N., R. 3 E., 480 feet A. T. While the Upper rider shows an extreme average range of elevation of about 18 feet, that of the Upper Verne amounts to some 79 feet, showing the same general tendency to fill up and equalize inequalities in elevations, as has been noted for lesser areas of the coal formation.

Occasionally, as in the records of the property leased by the Hecla Portland Cement and Coal Co. in the northeastern part of Frankenlust township, as well as in Monitor township, the Upper rider shows one or two splits, which apparently occupy but limited areas. Taken as a unit, these riders have a lower relative height than the main rider of the Upper Verne, and at least occasionally, were deposited in local swales of the Upper Verne coal. Such depressions, however, do not always contain more than one rider.

19. *Thickness of the Upper Rider.*

Throughout its extent in the southern part of Bay county, the average thickness of this seam in 135 holes where this bed has been struck, averages 16 inches. Taking into account, however, the 327 holes in which this seam is not represented, in approximately the same territory, the average is reduced to about five inches. Also, inasmuch as this seam is not represented inside the 480 foot rock contour line, as near as we have been able to locate the same, the average would still be further reduced. Providing, however, that this seam proves to be of suitable quality, the time will probably come when workable deposits will be utilized in certain localities. The following table will show the thickness of this bed in the different townships, and the number of holes.

Township.	Thickness.	No. of holes.
T. 13 N., R. 4 E.	16 inches.	47
T. 13 N., R. 5 E.	12 inches.	6
T. 13 N., R. 6 E.	8 inches.	3
T. 14 N., R. 3 E.	19 inches.	5
T. 14 N., R. 4 E.	17 inches.	58
T. 14 N., R. 5 E.	20 inches.	10
T. 15 N., R. 4 E.	3 inches.	4
T. 15 N., R. 5 E.	7 inches.	1
T. 16 N., R. 3 E.	6 inches.	1

In T. 13 N., R. 4 E., if I am correct in my correlations, we have two feet six inches of this coal in the N. E. ¼ of section 2; in section 15 the coal is sometimes of workable thickness where this property has been developed by the Pittsburg Coal Co., in section 15. In T. 13 N., R. 5 E., the few records that we have show from four inches to one foot eight inches of coal. In T. 14 N., R. 3 E., we have anywhere from three inches of coal, as in the N. E. ¼ of section 12, to 3½ feet in the N. E. ¼ of section 13. At both these places this horizon is at about the same elevation. In T. 14 N., R. 4 E., the Upper rider is over three feet thick in the west central part of the township in the southeast ¼ of sections 17, 18 and 19. In section 19 the elevation is 470 feet A. T., in sections 17 and 18, close to 485 feet, or more than four feet above the average elevation of the Upper rider in this township. In the S. W. ¼ of section 7 there is apparently over four feet of coal referable to this horizon at an elevation of 470 feet A. T. There are 11 holes in this township containing over two feet of coal at various elevations ranging from 467 to 499 feet A. T. In T. 14 N., R. 5 E., the Upper rider varies from 470 to 489 feet A. T. with the exception of one record in the southeast quarter of section 17. In section 4 we apparently have from four to six feet of coal at an elevation of 482 feet A. T. which is very nearly the average elevation of this seam in this township. In sections 30, 17, and 33 we have less than one foot of coal at elevations varying from 470 to 489 feet A. T. The meagerness of our records in the western part of the county do not permit of any results being drawn.

20. *Character of the Foot and Roof of the Upper Rider.*

In T. 13 N., R. 4 E., out of 47 drill holes showing this coal, the foot of all is composed of fire clay or shale. In two drill holes we have this seam overlain by drift sand, as in sections 2 and 5; in three records in section 15, and at another hole in section 1 this coal is under a bed of hardpan. Also in section 15 there is a sandstone roof. These records will serve to illustrate the caution which must be used in case this seam is ever developed. It is not uncommon to find a bed of sand or gravel overlying the bed rock which is quite abundantly water bearing.

In T. 13 N., R. 5 E., we have out of six records, one drill hole with a sandstone foot and one under a clay or hardpan roof. In T. 13 N., R. 6 E., there are two places in section 3 with a sandstone bottom; the roof in all three records is of slate. In T. 14 N., R. 3 E., the character of the foot and roof is of shale and slate in the five drillings we have from there.

From Monitor township where this seam occurs in 58 drill records, there is only one place, as in section 36, where the foot is composed of sandstone, the remainder being of fire clay or shale. In section 16 the roof is of sandrock in two localities as well as at one place in sections 33 and 36. In section 19 we have this coal under a bed of gravel.

In T. 14 N., R. 5 E., there are 10 records which have a foot and roof composed of shale or so-called "slate." The same remarks hold for the four records in T. 15 N., R. 4 E., In the single record which we have in T. 15 N., R. 5 E., showing this seam both the foot and roof is of sandstone.

21. *The Salzburg Coal and Rider.*

This coal and its rider have frequently been removed by erosion, while in other localities these seams have not been deposited where the bed rock is sufficiently high to contain this horizon. This coal bed as represented in 80

drill holes, has an average elevation of 494 feet A. T. or approximately 12 feet above the average elevation of the Upper rider. The average thickness of this seam is two feet, which indicates a very well developed deposit in certain places. The thickness, elevation above tide, and the number of holes in which this seam has been identified in the different townships, is shown in the following table:

Township.	Thickness.	Elevation A. T.	No. of holes.
T. 13 N., R. 4 E.....	23 inches.	496	10
T. 13 N., R. 5 E.....	18 inches.	495	3
T. 13 N., R. 6 E.....	9 inches.	489	2
T. 14 N., R. 3 E.....	16 inches.	504	5
T. 14 N., R. 4 E.....	26 inches.	501	36
T. 14 N., R. 5 E.....	30 inches.	493	15
T. 15 N., R. 4 E.....	7 inches.	497	7
T. 15 N., R. 5 E.....	10 inches.	497	1
T. 16 N., R. 4 E.....	30 inches.	502	1

In T. 13 N., R. 4 E., this bed varies from eight inches thick as in section 2, to four feet eight inches in section 7, the elevations above tide being 505 and 493 feet respectively. Apparently this coal is thick enough to work in section 12. The variations in height run from 491 feet in section 1 to 505 feet A. T. in section 2. The roof is of shale with the exception of one hole in section 1 where the overlying bed rock has been washed away leaving the coal under a bed of hardpan. In one hole in section 12 the foot is sandstone overlain by three feet four inches of coal.

In T. 14 N., R. 3 E., the Salzburg coal is from six inches thick, height 508 feet A. T., section 6, to two feet eight inches in section 17, 503 feet A. T. The roof is of shale or slate, with the exception of a hole in section 12 under a bed of sand or gravel.

In T. 14 N., R. 4 E., comprising the greater part of Monitor township, we have 36 records showing this seam in sections 6, 7, 12, 13, 16-21, 33, 36. The thickness varies very considerably. In section 36 we have a bed two inches thick with a foot and roof of sandstone, elevation 499 feet A. T. In this same section there is almost 3 feet of coal overlain by and underlaid with shale at 504 and 508 feet A. T. In section 19 we have again 3 inches of coal at 491 feet A. T., while near by we have two feet eight inches at 504 feet A. T. In section 17, this bed varies from three inches to two feet three inches at 501 to 514 feet respectively A. T. In sections 16, 21, 20, 13, 6 and 18 this coal is over three feet thick in places. At two localities in section 18 there is six and seven feet of coal represented in our records, with a slate roof, which show the greatest development of this bed. The beds are at 507 and 496 feet A. T. respectively. The roof of this coal is quite generally of slate or shale. However, in section 36, this is composed of sandstone in one record there, with an equal number in sections 20 and 21. In section 17 we have hardpan overlying this coal; in sections 17 and 21 there are two records with beds of sand and gravel on top. In section 7 we have a clay bed deposited on this coal. The foot of this coal is of so-called fire clay or shale in all our 36 records, with the exception of two in sections 16 and 36 formed of sandstone.

In T. 14 N., R. 5 E., section 29, we have from six inches to four feet nine inches of coal at very nearly 500 feet A. T. In sections 29, 30, and 31 this bed of coal is occasionally from three feet to four feet nine inches thick in

places, with a roof of slate or shale. In section 29 this coal is overlain by hardpan; otherwise the roof so far as explored is of shale. The foot in all our 15 holes is of fire clay or shale.

In T. 15 N., R. 4 and 5 E., the Salzburg coal occurs in sections 24 and 19, at an elevation of from 494 to 507 feet above sea level respectively, the average height being 500 feet A. T. The thickness varies from two to 13 inches. The foot and roof are of slate or shale, with the bed rock at about 520 feet A. T. In section 30, T. 16 N., R. 4 E., there is 30 inches of coal at about this horizon.

The Salzburg rider is found at about 515 feet A. T.; average thickness 10 inches. In the vicinity of the Valley and Hecla mines the rider is not shown, and at least in places, has not been deposited. Also in the vicinity of Wolverine No. 2 mine and in sections 16 and 17 of Monitor we get it again.

The Salzburg coal will in general only be found inside the 500 foot rock contour line, as nearly as I have been able to locate the same, and without making any allowance for ups and downs of elevation. If this coal is developed, care would have to be used that a water bearing gravel which is frequently laid down on the bed rock, is not tapped from the wrong side.

While it is not assumed that the subjects which have been discussed in this chapter will not be modified by future developments; it is believed, nevertheless, that the information given may be of use in guiding and promoting future operations. Particular attention is called to the records, cross sections and map which accompany this portion of the volume. Additional information concerning the thickness and structure of the drift or overburden, important in sinking shafts, can be obtained in chapter 4 on soils and sub-soils. Also in the chapter on economic geology will be found the records of several wells arranged by sections in alphabetical order by townships, which will help to give the distance to rock.

22. *Drill Hole Records for Coal in Bay County.*

Records of Amelith Coal Territory.

Test Holes No's 1-40.

TEST HOLE NO. 1.

In the S. W. ¼ of the S. E. ¼ of section 15, T. 13 N., R. 4 E., the elevation above tide is 600.′

Clay	90′		90′		
Hardpan	16′		106′		
Light slate	3′		109′		
Slate	39′	2″	148′	2″	
Sand rock	6′		154′	2″	
Fire clay and slate	21′		175′	2″	
Coal, Lower Verne	4′	5″	179′	7″	at 420 A. T.
Light slate	11′		190′	7″	
Black slate	5′		195′	7″	
Fire clay	1′		196′	7″	

TEST HOLE NO. 2.

In the S. W. ¼ of the S. E. ¼ of section 15, T. 13 N., R. 4 E., the elevation above tide is 601.′

Clay	90′		90′		
Sand and gravel	2′		92′		
Clay	24′		116′		
Sand	4′		120′		
Slate	5′		125′		
Bad top	....		....		

Coal, Upper Rider	2′	6″	127′	6″	at 474 A. T.
Fire clay	4′	6″	132′		
Slate	53′		185′		
Black slate	0′	3″	185′	3″	
Fire clay	5′	3′	190′	6″	
Sand rock	6′	3″	196′	9″	
Slate	33′		229′	9″	
Coal, Middle Rider	0′	4″	230′	1″	at 371 A. T.

TEST HOLE NO. 3.

In the N. E. ¼ of the S. W. ¼ of section 15, T. 13 N., R. 4 E., the elevation above tide is 603.′

Clay	80′		80′		
Sand	8′		88′		
Clay	34′		122′		
Black slate	5′		127′		
Fire clay	3′		130′		
Black slate	37′	2″	167′	2″	
Fire clay	2′	6″	169′	8″	
Black slate	7′	1″	176′	9″	
Coal		3″	177′		at 426 A. T.
Fire clay	5′		182′		
Coal, Lower Verne		5″	182′	5″	at 421 A. T.
Black slate	4′		186′	5″	
Fire clay and slate	13′		199′	5″	
Light slate	24′		223′	5″	
Black slate	2′	8″	226′	1″	
Fire clay and slate	3′	5″	229′	6″	

TEST HOLE NO. 4.

In the N. E. ¼ of the S. W. ¼ of section 15, T. 13 N., R. 4 E., the elevation above tide is 603.′

Clay	95′		95′		
Sand	13′		108′		
Gravel	3′		111′		
Clay	12′		123′		
Black slate	1′		124′		
Coal, Upper Rider	3′	9″	127′	9″	at 475 A. T.
Fire clay	3′		130′	9″	
Sand rock	8′		138′	9″	
Light slate	21′		159′	9″	
Dark slate	16′		175′	9″	
Fire clay	5′		180′	9″	
Light slate	4′		184′	9″	
Fire clay	1′		185′	9″	
Black slate	8′	4″	194′	1″	
Coal, Lower Verne	2′	3″	196′	4″	at 407 A. T.
Fire Clay	11′	5″	207′	9″	

TEST HOLE NO. 5.

Hole near shaft in the N. W. ¼ of the S. E. ¼ of section 15, T. 13 N., R. 4 E., the elevation above tide is 601.′

Clay	146′		146′		
Sandy clay	2′		148′		
Black slate	20′		168′		
Fire clay	4′		172′		
Gray shale	2′		174′		
Sand rock	3′		177′		
Fire clay and sand rock	12′		189′		
Coal, Lower Verne	2′	5″	191′	5″	at 410 A. T.
Black slate		8″	192′	1″	
Fire clay	5′	6″	197′	7″	

TEST HOLE NO. 6.

Near shaft, in the N. W. ¼ of the S. E. ¼ of section 15, T. 13 N., R. 4. E., the elevation above tide is 601.′

Clay	145′		145′	
Slate	36′	4″	181′	4″
Coal, Lower Verne	2′	8″	184′	at 417 A. T.

TEST HOLE NO. 7.

In the S. W. ¼ of the N. E. ¼ of section 15, T. 13 N., R. 4 E., elevation above tide is 605.′

Clay	104′		104′	
Slate	43′		147′	
Coal, Upper Verne	3′	7″	150′	7″ at 455 A. T.
Fire clay	13′		163′	7″
Slate	23′	7″	187′	2″
Coal, Lower Verne	1′	6″	188′	8″ at 416 A. T.

TEST HOLE NO. 8.

At the west quarter post of section 15, T. 13 N., R. 4 E, elevation above tide is 602.′

Clay to	105′		105′	
Sand	7′		112′	
Slate	22′		134′	
Sandrock	4′		138′	
Slate	15′		153′	
Sandrock	6′		159′	
Slate rock	8′		167′	
Fire clay	4′		171′	
Slate	5′	10″	176′	10″
Coal, Lower Verne?	2′	10″	179′	8″ at 422 A. T.

TEST HOLE NO. 9.

In the S. E. ¼ of the N. W. ¼ (?) of section 15, T. 13 N., R. 4 E., elevation 602′ A. T.

Clay	85′		85′	
Sand	61′		146′	
Slate	6′		152′	
Fire clay	4′		156′	
Slate	14′		170′	
Coal, Upper Verne		5″	170′	5″ at 432 A. T.
Fire clay	9′	7″	180′	
Slate	19′		199′	

TEST HOLE NO. 10.

In the N. W. ¼ of the S. E. ¼ of section 15, T. 13 N., R. 4 E., elevation above tide is 599.′

Clay	118′		118′	
Slate (drift's specimen)	1′		119′	
Sand	3′		122′	
Poor coal, Upper Rider	2′		124′	at 475 A. T.
Light slate	9′		133′	
Black slate, horizon of Upper Verne	20′	8″	153′	8″
Fire clay	5′		158′	8″
Light slate	5′		163′	8″
Fire clay	4′	4″	168′	
Gray rock	13′		181′	
Fire clay	2′		183′	
Sandrock	16′		199′	
Light slate	3′		202′	
Gray rock	15′	5″	217′	5″

TEST HOLE NO. 11.

In the N. W. ¼ of the S. E. ¼ of section 15, T. 13 N., R. 4 E., the elevation above tide is 599.′

Clay	74′		74′	
Hardpan	10′		84′	
Sand	3′		87′	
Clay	49′	5″	136′	5″
Sand	2′		138′	5″
Slate	3′	11″	142′	4″
Coal, Upper Verne		9″	143′	1″ at 459 A. T.
Fire clay	1′	5″	144′	6″
Slate	49′		193′	6″
Coal, Lower Verne	2′	6″	196′	at 403 A. T.
Fire clay and slate	3′		199′	
Sandrock	8′		207′	

TEST HOLE NO. 12.

In the N. W. ¼ of the S. E. ¼ of section 15, T. 13 N., R. 4 E., elevation above tide is 600.′

Clay	90′		90′	
Sand	10′		100′	
Clay	12′		112′	
Sand	1′		113′	
Black slate	6′		119′	
Coal, Upper Rider	4′	6″	123′	6″ at 477 A. T.
Gray shale	18′		141′	6″
Coal, Upper Verne		6″	142′	at 458 A. T.
Black slate	22′		164′	
Fire clay	6′		170′	
Black slate	4′		174′	
Gray shale	7′		181′	
Black slate	4′	9″	185′	9″
Coal, Lower Verne	3′	1″	188′	10″ at 411 A. T.
Black slate		6″	189′	4″
Fire clay	6′		195′	4″

TEST HOLE NO. 13.

In the N. W. ¼ of the S. E. ¼ of section 15, T. 13 N., R. 4 E., the elevation above tide is 601.′

Clay	38′		38′	
Sand	1′		39′	
Clay	75′		114′	
Sand	8′		122′	
Sandrock	19′		141′	
Coal, Upper Verne	6′		147′	at 454 A. T.
Gray shale and sandrock	13′		160′	
Black slate	6′		166′	
Gray shale	4′		170′	
Fire clay, sandrock	11′		181′	
Black slate	2′		183′	
Sandy fire clay	7′		190′	
Black slate		6″	190′	6″
Coal, Lower Verne	2′	9″	193′	3″ at 408 A. T.
Fire clay	4′		197′	3″

TEST HOLE NO. 14.

In the N. E. ¼ of the S. W. ¼ of section 15, T. 13 N., R. 4 E., the elevation above tide is 602.′

Hard clay	20′		20′	
Soft clay	105′		125′	
Sand	5′		130′	
Gravel and clay	5′		135′	
Sand	12′		147′	
Black slate	26′		173′	
Gray shale	8′		181′	
Fire clay	7′		188′	
Black slate	3′	6″	191′	6″
Coal, Lower Verne	3′		194′	6″ at 408 A. T.
Fire clay	7′		201′	6″

TEST HOLE NO. 15.

At the intersection of the east and west quarter line, and the east 80 rod line of section 15, T. 13 N., R. 4 E., the elevation above tide is 600.′

Clay	80′		80′	
Hardpan	12′		92′	
Clay	10′		102′	
Hardpan	32′		134′	
Coal, Upper Rider	1′		135′	at 465 A. T.
Light slate	4′		139′	
Black slate	24′		163′	
Coal, Upper Verne		3″	163′	3″ at 437 A. T.
Black slate	4′		167′	3″
Gray rock	13′		180′	3″
Black slate	3′		183′	3″
Coal		3″	183′	6″ at 417 A. T.
Slate		10″	184′	4″
Coal		6″	184′	10″ at 416 A. T.
Black slate		7″	185′	5″
Coal	2′	4″	187′	9″ at 413 A. T.
Gray shale	5′	3″	193′	

(Coal, Slate, Coal, Black slate, Coal = Lower Verne)

TEST HOLE NO. 16.

In the S. W. ¼ of the N. E. ¼ of section 15, T. 13 N., R. 4 E., the elevation above tide is 600.′

Clay	80′		80′	
Hardpan	29′		109′	
Black clay	10′		119′	
Coal, Upper Rider	1′	2″	120′	2″ at 480 A. T.
Fire clay	3′		123′	2″
Gray shale	8′		131′	2″
Black slate	22′	7″	153′	9″
Coal, Lower Verne Rider		4″	154′	1″ at 446 A. T.
Gray shale	18′	7″	172′	8″
Black slate	7′	6″	180′	2″
Coal, Lower Verne	3′	6″	183′	8″ at 416 A. T.
Black slate	1′	8″	185′	4″
Fire clay	5′		190′	4″

TEST HOLE NO. 17.

Intersection of N. and S. ¼ line and the E. and W. ¼ line of Section 15, T. 13 N., R. 4 E., the elevation above tide is 601.′

Clay	79′		79′	
Sand and gravel	25′		104′	
Clay	20′		124′	
Soft slate	10′		134′	
Gray slate	14′	2″	148′	2″
Coal, Upper Verne	1′	3″	149′	5″ at 452 A. T.
Black slate	18′	4″	167′	9″
Coal	1′	2″	168′	11″ at 433 A. T.
Fire clay	4′	5″	173′	4″
Gray slate	16′		189′	4″
Coal, Lower Verne	4′	1″	193′	5″ at 408 A. T.
Black slate		8″	194′	1″
Fire clay	9′	3″	203′	4″
Gray shale	24′	9″	228′	1″
Coal, Middle Rider		3″	228′	4″ at 373 A. T.
Sand rock	....		....	

TEST HOLE HO. 18.

In the S. E. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 603.′

Clay	75′		75′	
Hardpan	45′		120′	
Slate	19′	5″	139′	5″
Coal, Upper Verne	1′	9″	141′	2″ at 462 A. T.
Fire clay	5′	7″	146′	9″
Light slate	17′	11″	164′	8″
Black slate	5′	6″	170′	2″
Slate	8′		178′	2″
Coal, Lower Verne Rider	1′	4″	179′	6″ at 423 A. T.
Fire clay	3′	6″	183′	
Black hard slate	9′	2″	192′	2″
Good coal, Lower Verne	3′		195′	2″ at 398 A. T.
Fire clay	2′	6″	197′	8″

TEST HOLE NO. 19.

In the N. W. ¼ of the S. W. ¼ of Section 15, T. 13 N., R. 4 W., the elevation above tide is 603.′

Clay	74′		74′	
Hardpan	36′		110′	
Sand and gravel	9′		119′	
Fire clay	1′	2″	120′	2″
Slate	12′	5″	132′	7″
Coal, Upper Rider		1″	132′	8″ at 471 A. T.
Slate	30′	2″	162′	10″
Flint rock		7″	163′	5″
Carbonate of iron?	....		163′	5″
Slate	4′	5″	167′	10″
Coal and slate, Upper Verne		10″	168′	8″ at 435 A. T.
Slate	6′	10″	175′	6″
Coal Rider of Lower Verne		2″	175′	8″ at 427 A. T.
Slate	33′		208′	8″
Light slate	16′	5″	225′	1″

TEST HOLE NO. 20.

In the N. W. ¼ of the S. W. ¼ of Section 15, T. 13 N., R. 4 E., Elevation above tide is 606.′

Clay	130′		130′	
Sand	7′		137′	
Black slate	26′		163′	
Fire clay	2′		165′	
Light slate	12′		177′	
Sandrock	8′		185′	
Slate	7′	10″	192′	10″
Coal, Lower Verne		2″	193′	at 413 A. T.
Dark hard slate	7′		200′	

TEST HOLE NO. 21.

In the S. W. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., elevation above tide is 604.′

Clay	116′		116′	
Gravel	6′		122′	
Slate	2′		124′	
Coal		6″	124′	6″ at 480 A. T.
Fire clay		6″	125′	
Slate	52′	4″	177′	4″
Black slate	1′		178′	4″
Coal, Lower Verne Rider		8″	179′	at 425 A. T.
Black slate	6′		185′	
Fire clay	3′		188′	
Dark slate	5′	9″	193′	9″
Coal, Lower Verne	2′	2″	195′	11″ at 408 A. T.
Slate and coal		10″	196′	9″
Fire clay	5′	3″	202′	

TEST HOLE NO. 22.

In the S. ½ of the S. W. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., elevation above tide is 600.′

Clay	118′		118′	
Sand	2′		120′	
Fire clay	3′		123′	
Coal, Upper Rider		2″	123′	2″ at 477 A. T.
Fire clay	4′		127′	2″
Light slate	57′		184′	2″
Black slate	2′		186′	2″
Coal, Lower Verne	3′		189′	2″ at 411 A. T.
Black slate	13′		202′	2″
Coal, Middle Rider	2′	5″	204′	7″ at 395 A. T.
Fire clay	3′	2″	207′	9″

TEST HOLE NO. 23.

In the S. W. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 602.′

Clay	116′		116′	
Slate	58′		174′	
Coal, Lower Verne	1′	9″	175′	9″ at 426 A. T.
Fire clay	25′		200′	9″
Coal, Middle Rider		11″	201′	8″ at 401 A. T.

TEST HOLE NO. 24.

In the S. E. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 600.′

Clay	137′		137′	
Coal, Upper Rider	3′	7″	140′	7″ at 460 A. T.

TEST HOLE NO. 25.

In the N. W ¼ of the N. E. ¼ of Section 15, T. 13 N., R. 4 E., elevation above tide is 599.′

Clay	115′	6″	115′	6″
Slate	49′		164′	6″
Coal, Lower Verne Rider	2′		166′	6″ at 433 A. T.

TEST HOLE NO. 26.

In the S. E. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 601.′

Clay	86′		86′	
Hardpan	22′		108′	
Clay	17′		125′	
Sand	1′		126′	
Slate	22′	6″	148′	6″
Coal, Upper Verne		10″	149′	4″ at 452 A. T.
Fire clay	3′	8″	153′	
Gray shale	7′		160′	
Fire clay	3′		163′	
Gray shale	4′	5″	167′	5″
Coal, Lower Verne Rider	1′		168′	5″ at 433 A. T.
Black slate	3′		171′	5″
Slate	32′	5″	203′	10″
Coal, Middle Rider		7″	204′	5″ at 397 A. T.
Fire clay	3′		207′	5″
Gray slate	3′		210′	5″

TEST HOLE NO. 27.

In the S. W. ¼ of the N. E. ¼ of Section 15, T. 13 N., R. 4 E., elevation above tide is 600.′

Clay	67′		67′	
Hardpan	37′		104′	
Slate	13′	11″	117′	11″
Coal, Upper Rider	1′	6″	119′	5″ at 481 A. T.
Nothing came out	3′	7″	123′	
Coal, Upper Verne	3′	7″	126′	7″ at 474 A. T.
Slate	17′		143′	7″
Fire clay	3′	6″	147′	1″
Slate	16′	1″	163′	2″
Coal, Lower Verne	1′	7″	164′	9″ at 435 A. T.
Gray rock	30′		194′	9″
Dark slate	1′	6″	196′	3″
Slate	21′		217′	3″
Coal, Middle Rider		10″	218′	1″ at 383 A. T.
Fire clay	2′		220′	1″

TEST HOLE NO. 28.

In the S. W. ¼ of the N. E. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 600.′

Clay	86′		86′	
Hardpan	26′		112′	
Slate	6′		118′	
Coal, Upper Rider		10″	118′	10″ at 481 A. T.
Fire clay	7′		125′	
Slate	30′	3″	156′	1″
Coal, Lower Verne Rider		1″	156′	2″ at 444 A. T.
Fire clay	13′	5″	169′	7″
Black slate	8′	3″	177′	10″
Light slate	7′		184′	10″
Sandrock	8′		192′	10″
Slate	15′	1″	207′	11″

TEST HOLE NO. 29.

In the S. E. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 601.′

Clay	80′		80′	
Sand and gravel	9′		89′	
Clay and sand	17′		106′	
Slate	9′	6″	115′	6″
Soft coal, Upper Rider	2′		117′	6″ at 484 A. T.
Fire clay	9′	6″	127′	
Shale	23′		150′	
Sandrock	5′		155′	
Light slate	10′	3″	165′	3″
Coal, Upper Verne	1′		166′	3″ at 435 A. T.
Fire clay	13′	10″	180′	1″
Blue slate	5′	2″	185′	3″
Gray shale	8′		193′	3″
Sandrock	4′		197′	3″
Gray slate	4′		201′	3″
Fire clay	1′	2″	202′	5″
Gray shale	13′	3″	215′	8″
Sandrock	8′		223′	8″
Gray shale	6′		229′	8″
Sandrock	16′		245′	8″

TEST HOLE NO. 30.

In the S. E. ¼ of the N. E. ¼ of Section 16, T. 13 N., R. 4 E., elevation above tide is 605.′

Clay	110′		110′	
Sand and gravel	19′		129′	
Slate	21′		150′	
Fire clay	6′		156′	
Slate	14′	4″	170′	4″
Coal, Lower Verne Rider	1′	5″	171′	9″ at 433 A. T.
Slate	2′		173′	9″
Light slate	9′		182′	9″
Coal, Middle Rider	1′	5″	184′	2″ at 421 A. T.
Fire clay	4′		188′	2″
Slate	25′		213′	2″
Sandrock	5′		218′	2″
Slate	13′		231′	2″

TEST HOLE NO. 31.

In the N. ½ of the S. W. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 606.′

Clay	120′		120′	
Hardpan	8′		128′	
Sand	3′		131′	
Slate	3′	8″	134′	8″
Coal, Upper Rider		10″	135′	6″ at 471 A. T.
Fire clay	1′	8″	137′	2″
Black slate	6′	2″	143′	4″
Gray slate	6′	2″	149′	6″
Coal, Upper Verne		4″	149′	10″ at 456 A. T.
Gray shale	10′		159′	10″
Fire clay	3′		162′	10″
Slate	1′	10″	164′	8″
Coal, Lower Verne Rider	1′	5″	166′	1″ at 440 A. T.
Gray slate	18′		184′	1″
Sandrock	1′		185′	1″
Gray rock	10′		195′	1″

TEST HOLE NO. 32.

In the N. ½ of the S. W. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 605.′

Clay	68′		68′	
Stone and gravel	15′		83′	
Clay	30′		113′	
Sandrock	9′		122′	
Slate	2′		124′	
Gravel rock (conglomerate?)	6′		130′	
Slate	40′		170′	
Coal, Lower Verne Rider	2′	6″	172′	6″ at 433 A. T.
Fire clay	3′		175′	6″
Slate	7′	8″	183′	2″
Coal, Lower Verne	2′	4″	185′	6″ at 420 A. T.
Black slate		10″	186′	4″
Fire clay	2′		188′	4″
Slate	10′		198′	4″
Coal, Middle Rider		7″	198′	11″ at 406 A. T.
Gray slate	17′		215′	11″

TEST HOLE NO. 33.

In the S. E. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 600.′

Clay	75′		75′	
Hardpan and sand	44′	6″	119′	6″
Gray slate	21′	2″	140′	8″
Coal, Upper Verne	4′	7″	145′	3″ at 455 A. T.
Fire clay	6′	9″	152′	
Sandrock	2′	8″	154′	8″
Gray shale	10′		164′	8″
Black slate	20′		184′	8″
Coal, Lower Verne Rider		4″	185′	at 415 A. T.
Black slate	7′	4″	192′	4″
Fire clay	3′		195′	4″
Black slate		6″	195′	10″
Poor coal, Lower Verne	2′		197′	10″ at 402 A. T.
Fire clay	2′	6″	200′	4″
Sandrock	10′	8″	211′	

TEST HOLE NO. 34.

In the N. E. ¼ of the N. E. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 601.′

Clay	79′		79′	
Hardpan	24′		103′	
Black slate	4′		107′	
Sandrock	10′		117′	
Gray shale	17′		134′	
Fire clay	6′		140′	
Coal, Upper Verne		6″	140′ 6″	at 461 A. T.
Fire clay	4′		144′ 6″	
Gray shale	16′	4″	160′ 10″	
Black slate		4″	161′ 2″	
Gray rock	27′	4″	188′ 6″	
Sandrock	1′	6″	190′	

TEST HOLE NO. 35.

In the N. W. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 605.′

Clay	85′		85′	
Hardpan	37′		122′	
Sandrock	7′		129′	
Gray shale	15′	8″	144′ 8″	
Black slate	26′	6″	171′ 4″	
Coal, Lower Verne Rider	1′	6″	172′ 10″	at 432 A. T.
Fire clay	3′		175′ 10″	
Black slate		6″	176′ 4″	
Fire clay	10′	8″	187′	
Gray shale	23′		210′	
Fire clay	3′		213′	

TEST HOLE NO. 36.

In the N. W. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 607.′

Clay	82′		82′	
Sand and gravel	10′		92′	
Clay	8′		100′	
Sand and gravel	18′		118′	
Hardpan	17′		135′	
Coal, Upper Verne		3″	135′ 3″	at 472 A. T.
Sandrock	16′	9″	152′	
Slate	1′		153′	
Fire clay	1′		154′	
Slate	4′		158′	
Sandrock	3′		161′	
Slate	1′	6″	162′ 6″	
Coal, Lower Verne Rider	1′	3″	163′ 9″	at 443 A. T.
Fire clay	3′	2″	166′ 11″	
Slate	8′		174′ 11′	
Coal, Lower Verne	2′	11½″	177′ 10½″	at 429 A. T.
Black slate		4½″	178′ 3″	
Fire clay	7′	8″	185′ 11″	
Slate	3′		188′ 11″	
Sandrock	21′		209′ 11″	

TEST HOLE NO. 37.

In the N. W. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 605.′

Clay	73′		73′	
Hardpan	44′		117′	
Sand	14′		131′	
Clay	3′	5″	134′ 5″	
Slate	23′	5″	157′ 10′	
Coal		5″	158′ 3″	at 447 A. T.
White slate	10′	11″	169′ 2″	
Coal, Lower Verne Rider	1′	5″	170′ 7″	at 434 A. T.
Fire clay	4′	11″	175′ 6″	
Coal, Lower Verne	1′	7″	177′ 1″	at 428 A. T.
Fire clay	4′	7″	181′ 8″	
Dark slate	2′		183′ 8″	
Fire clay	7′	5″	191′ 1″	
Slate	2′	2″	193′ 3″	
Coal, Middle Rider	1′	2″	194′ 5″	at 411 A. T.
Fire clay	2′	4″	196′ 9″	
Coal		6″	197′ 3″	at 408 A. T.
Fire clay and slate	19′		216′ 3″	

TEST HOLE NO. 38.

In the N. W. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 607.′

Clay	90′		90′	
Hardpan	30′		120′	
Clay	12′		132′	
Slate	33′		165′	
Coal, Lower Verne Rider		2″	165′ 2″	at 442 A. T.
Light slate	1′	6″	166′ 8″	
Fire clay	4′	2″	170′ 10″	
Slate	5′		175′ 10″	
Soft coal, Lower Verne	2′	7½″	178′ 5½″	at 429 A. T.
Fire clay	11′	3″	189′ 8½″	
Slate		6″	190′ 2½″	
Fire clay	8′	6″	198′ 8½″	
Slate	3′		201′ 1½″	
Sandrock	2′		203′ 8½″	
Slate	16′		219′ 8½″	

TEST HOLE NO. 39.

In the S. W. ¼ of the S. W. ¼ of Section 10, T. 13 N., R. 4 E., the elevation above tide is 608.′

Clay	73′		73′	
Hardpan	74′		147′	
Sand	11′	2″	158′ 2″	
Clay	10′	2″	168′ 4″	
Coal, Lower Verne Rider	2′	4″	170′ 8″	at 437 A. T.
Fire clay	8′	7″	179′ 3″	
Slate	1′	5″	180′ 8″	
Coal, Lower Verne		6″	181′ 2″	at 427 A. T.
Black slate	19′		200′ 2″	
Light slate		6″	200′ 8″	
Black slate	19′	4″	220′	
Coal, Middle Rider		3″	220′ 3″	at 388 A. T.
Slate		2″	220′ 5″	
Coal, Saginaw Coal	1′	3″	221′ 8″	at 386 A. T.
Sandrock	2′	5″	224′ 1″	

TEST HOLE NO. 40.

In the S. W. ¼ of the N. E. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 600.′ This record is very likely inaccurate.

Sand	16′		16′	
Gravel	2′		18′	
Light slate	18′	4″	36′	4″
Coal	4′	5″	40′	9″ at 559 A. T.
Fire clay	6′	2″	46′	11″
Light slate	32′	1″	79′	
Fire clay	3′		82′	
Light slate	8′		90′	
Coal	1′	5″	91′	5″ at 509 A. T.
Fire clay	4′		95′	5″
Slate	25′		120′	5″

Valley Coal Mining Co.

Test Holes Nos. 41-79.

TEST HOLE NO. 41.

In the S. E. ¼ of the S. W. ¼ of Section 6, T. 13 N., R. 5 E., the elevation above tide is 580-583.′

Clay	83′		83′	
Coal, Upper Rider	1′	3″	84′	3″ at 499 A. T'
Fire clay	2′		86′	3″
Light shale	6′		92′	3″
Sandrock	4′	6″	96′	9″
Dark shale	7′		103′	9″
Light shale	8′		111′	9″
Black slate	3′		114′	9″
Coal, Upper Verne		11″	115′	8″ at 467 A. T.
Fire clay	4′		119′	8″
Light shale	6′		125′	8″

TEST HOLE NO. 42.

In the N. W. ¼ of the N. E. ¼ of Section 7, T. 13 N., R. 5 E., Elevation above tide is 580-583.′

Clay	82′		82′	
Shale	1′		83′	
Slate	2′		85′	
Salzburg coal	1′	7″	86′	7″ at 496 A. T.
Fire clay	3′		89′	7″
Sandrock	6′		95′	7″
Light shale	8′		103′	7″
Light slate	3′		106′	7″
Sandrock	8′		114′	7″
Shale	2′		116′	7″
Slate	5′		121′	7″
Coal, Upper Verne	2′	5″	124′	at 459 A. T.

TEST HOLE NO. 43.

In the N. W. ¼ of the N. E. ¼ of Section 12, T. 13 N., R. 4 E., elevation above tide is 584.′

Clay	77′	77′	
Hardpan	11′	88′	
Sand	27′	115′	

TEST HOLE NO. 44.

In the S. E. ¼ of the N. W. ¼ of Section 12, T. 13 N., R. 4 E., elevation above tide is 585.′

Clay drift	77′		77′	
Slate	5′	6″	82′	6″
Salzburg coal	3′	6″	86′	at 499 A. T.
Fire clay	1′	6″	87′	6″
Sand rock	2′	6″	90′	
Shale	3′		93′	
Slate	4′		97′	
Coal, Upper Verne Rider	1′	6″	98′	6″ at 487 A. T.
Fire clay	2′		100′	6″
Gray sandrock	4′		104′	6″
Shale	6′		110′	6″
Sandrock	5′		115′	6″
Shale	3′		118′	6″
Gray sandrock	4′		122′	6″

TEST HOLE NO. 45.

In the N. W. ¼ of the N. E. ¼ of Section 12, T. 13 N., R. 4 E., the elevation above tide is 584.′

Clay	77′		77′	
Hardpan	2′	4″	79′	4″
Sand	1′		80′	4″
Sandrock	1′	7″	81′	11″
Dark shale	2′	5″	84′	4″
Dark slate	1′	10″	86′	2″
Salzburg coal	3′	4″	89′	6″ at 495 A. T.
Gray sandrock	1′	4″	90′	10″
Fire clay	2′	6″	93′	4″
Shale	3′		96′	4″
Slate	3′	8″	100′	
Coal, Upper Verne Rider	1′	2″	101′	2″ at 483 A. T.
Fire clay	1′	4″	102′	6″
Shale	2′		104′	6″

TEST HOLE NO. 46.

In the N. W. ¼ of the N. E. ¼ of Section 12, T. 13 N., R. 4 E., the elevation above tide is 584.′

Clay	76′		76′	
Hardpan	2′		78′	
Sand	1′	6″	79′	6″
Sandrock	3′	4″	82′	10″
Dark shale	2′		84′	10″
Slate	3′	6″	88′	4″
Ribbon of coal, Upper Rider	....		....	at 495 A. T.
Fire clay	8′		96′	4″
Sandrock	11′		107′	4″

TEST HOLE NO. 47.

In the N. W. ¼ of the N. E. ¼ of Section 12, T. 13 N., R. 4 E., elevation above tide is 584.′

Clay	75′		75′	
Hardpan	3′		78′	
Sand	3′	6″	81′	6″
Shale	4′		85′	6″
Slate	3′	6″	89′	

Salzburg coal	2′ 8″	91′ 8″	at 492 A. T.
Fire clay	10″	92′ 6″	
Shale	3′	95′ 6″	
Sandrock	4′ 4″	99′ 10″	
Slate	3′	102′ 10″	
Coal, Upper Rider	1′ 6″	104′ 4″	at 480 A. T.
Fire clay	1′	105′ 4″	
Shale	2′	107′ 4″	

TEST HOLE NO. 48.

In the northeast corner of Section 12, T. 13 N., R. 4 E., the elevation above tide is 583.′

Clay	75′	75′	
Hardpan	1′ 10″	76′ 10″	
Sand	4′	80′ 10″	
Shale	6′	86′ 10″	
Slate	2′ 4″	89′ 2″	
Salzburg coal	1′ 2″	90′ 4″	at 493 A. T.
Fire clay and shale	5′	95′ 4″	
Shale	6′ 6″	101′ 10″	
Black slate	3′	104′ 10″	
Fire clay	3′	107′ 10″	
Shale	4′	111′ 10″	
Gray sandrock	6′	117′ 10″	
White sandrock	4′	121′ 10″	

TEST HOLE NO. 49.

In the S. E. ¼ of the S. E. ¼ of Section 6, T. 13 N., R. 5 E., the elevation above tide is 582.′

Clay	75′ 6″	75′ 6″	
Hardpan	7′ 9″	83′ 3″	
White sandrock	2′	85′ 3″	
Shale	6′	91′ 3″	
Slate	3′	94′ 3″	
Coal, Upper Rider	1′ 2″	95′ 5″	at 487 A. T
Fire clay	1′ 6″	96′ 11″	
Shale	16′	112′ 11″	
Dark shale	5′	117′ 11″	
Slate	2′	119′ 11″	
Light shale	14′	133′ 11″	
Dark shale	3′	136′ 11″	

TEST HOLE NO. 50.

In the N. E. ¼ of the N. W. ¼ of Section 7, T. 13 N., R. 5 E., elevation above tide is 583.′

Clay	70′	70′	
Hardpan	3′	73′	
Shale	5′	78′	
Slate	1′ 2″	79′ 2″	
Soapstone	3′	82′	
Shale and rock	5′	87′	
Slate	1′	88′	
Salzburg coal	2′ 2″	90′ 4″	at 493 A. T.
Fire clay	8″	91′	

TEST HOLE NO. 51.

In the N. E. ¼ of the N. W. ¼ of Section 7, T. 13 N., R. 5 E., elevation above tide is 583.′

Clay	72′	72′	
Hardpan	2′	74′	
Shale	2′ 6″	76′ 6″	
Slate	2′ 6″	79′	
Salzburg coal	1′ 7″	80′ 7″	at 502 A. T.
Fire clay	1′ 6″	82′ 1″	
Shale	7′	89′ 1″	
Sandrock	8′	97′ 1″	
Shale	7′	104′ 1″	
Sandrock	36′	140′ 1″	

TEST HOLE NO. 52.

In the N. W. ¼ of the N. E. ¼ of Section 12, T. 13 N., R. 4 E., elevation above tide is 584.′

Clay	72′	72′	
Hardpan	5′	77′	
Sand	8′	85′	

TEST HOLE NO. 53.

In the N. W. ¼ of the N. E. ¼ of Section 12, T. 13 N., R. 4 E., elevation above tide is 584.′

Clay	73′	73′	
Hardpan	5′	78′	
Sand	1′	79′	
Shale	4′	83′	
Slate	3′ 8″	86′ 8″	
Salzburg coal	4′ 8″	91′ 4″	at 493 A. T.
Fire clay	2′	93′ 4″	

TEST HOLE NO. 54.

In the N. W. ¼ of the N. E. ¼ of Section 7, T. 13 N., R. 5 E., elevation above tide is 583.′

Clay	84′	84′	
Sand	6′	90′	
Shale	8′	98′	
Sandrock	4′	102′	
Light shale	3′	105′	
Slate	5′ 6″	110′ 6″	
Coal, Rider	1′ 6″	112′	at 471 A. T.
Fire clay	3′	115′	
Sandrock	6′	121′	
Slate	3′	124′	
Coal, Upper Verne	1′	125′	at 458 A. T.
Fire clay	2′ 6″	127′ 6″	

TEST HOLE NO. 55.

In the S. W. ¼ of the S. E. ¼ of Section 6, T. 13 N., R. 5 E., elevation above tide is 583.′

Clay	82′ 6″	82′ 6″	
Shale	1′ 6″	84′	
Slate	2′	86′	
Coal, Upper Rider?	5″	86′ 5″	at 497 A. T.
Fire clay	1′ 6″	87′ 11″	
Sandrock	6′	93′ 11″	
Light shale and slate	9′	102′ 11″	

TEST HOLE NO. 56.

In the S. E. ¼ of the S. W. ¼ of Section 6, T. 13 N., R. 5 E., elevation above tide is 583.′

Clay	84′	84′	
Shale	4′	88′	
Slate	2′	90′	
Coal, Upper Rider	1′ 8″	91′ 8″	at 491 A. T.
Fire clay	2′	93′ 8″	
Sandrock	7′	100′ 8″	
Shale	8′	108′ 8″	
Sandrock	6′	114′ 8″	
Shale	5′	119′ 8″	
Slate	2′	121′ 8″	
Coal, Upper Verne	1′ 5″	123′ 1″	at 460 A. T.

TEST HOLE NO. 57.

In the S. W. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., elevation above tide is 583.′

Clay	81′	81′	
Dark slate	15′	96′	
Coal, Upper Rider	3″	96′ 3″	at 487 A. T.
Fire clay	8′	104′ 3″	
Slate	1′	105′ 3″	
Coal	1″	105′ 4″	at 478 A. T.
Fire clay	4″	105′ 8″	
Coal, Upper Verne	4″	106′	at 477 A. T.
Fire clay	4′	110′	
Light slate	8′	118′	
Dark slate	7′	125′	
Light slate	12′	137′	
Sandrock	1′ 2″	138′ 2″	

TEST HOLE NO. 58.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., elevation above tide is 583.′

Clay	79′ 7″	79′ 7″	
Hardpan	2′ 2″	81′ 9″	
Fire clay	2′	83′ 9″	
Dark slate	5′	88′ 9″	
Coal, Upper Rider	10″	89′ 7″	at 493 A. T.
Light slate	1′ 6″	91′ 1″	
Fire clay	3′	94′ 1″	
Dark slate	19′	113′ 1″	
Coal, Upper Verne	2′ 9″	115′ 10″	at 467 A. T.

TEST HOLE NO. 59.

In the center of the N. E. ¼ of Section 5, T. 15 N., R. 4 E., elevation above tide is 615.′

Clay	127′ 6″	127′ 6″	
Slate	145′ 8″	273′ 2″	
Sandrock and clay	149′ 10″	423′	
Black slate	157′ 6″	580′ 6″	
Coal	2′	582′ 6″	at 33 A. T.

TEST HOLE NO. 60.

In the S. E. ¼ of the S. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 589.′

Clay	89′	89′	
Sand	12′	101′	
Slate	7′	108′	
Coal, Upper Rider	10′?	118′	at 471 A. T.
Fire clay	7′	125′	
Slate	7′	132′	
Coal, Upper Verne	1′ 9″	133′ 9″	at 455 A. T.
Fire clay	4′	137′ 9″	
Slate	24′ 6″	162′ 3″	

TEST HOLE NO. 61.

In the S. E. ¼ of the S. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 590.′

Clay	86′	86′	
Sand	3′	89′	
Hardpan	5′	94′	
Gravel	4′	98′	
Soapstone	7′	105′	
Sand	16′	121′	
Soapstone	10′	131′	
Sandrock	26′	157′	

TEST HOLE NO. 62.

In the S. E. ¼ of the S. E. ¼ of Section 36, T. 14 N., R. 4 E., the elevation above tide is 589.′

Clay	89′	89′	
Sand and shale	4′ 5″	93′ 5″	
Slate	18′ 9″	112′ 2″	
Coal, Upper Verne	2′ 10″	115′	at 474 A. T.
Slate	8′ 7″	123′ 7″	
Sandrock	....	....	

TEST HOLE NO. 63.

In the S. W. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., elevation above tide is 583.′

Clay	83′	83′	
Slate	7′ 6″	90′ 6″	
Coal, Upper Rider	4″	94′ 6″	at 489 A. T.

TEST HOLE NO. 64.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., elevation above tide is 583.′

Clay	82′	82′	
Slate	27′	109′	
Coal, Upper Verne	2′ 5½″	111′ 5½″	at 472 A. T.

TEST HOLE NO. 65.

In the N. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., elevation above tide is 584.′

Clay	92′	92′	
Sand and clay shale	10′	102′	
Slate	8′ 10″	110′ 10″	
Coal, Upper Verne	2′ 8″	113′ 6″	at 471 A. T.

TEST HOLE NO. 66.

In the N. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., the elevation above tide is 582.′

Clay	94′	7″	94′	7″
Slate	8′	8″	103′	3″
Coal, Upper Rider	2′	7½″	105′	10½″ at 476 A. T.
Fire clay	6′		111′	10½″
Sandrock	....		....	

TEST HOLE NO. 67.

In the S. E. ¼ of the S. W. ¼ of Section 6, T. 13 N., R. 5 E., the elevation above tide is 583.′

Clay	73′	73′	
Hardpan	10′	83′	
Soft shale	3′	86′	
Slate	12′	98′	
Sandrock	30′	128′	
Slate and sandrock	5′	133′	

TEST HOLE NO. 68.

In the N. E. ¼ of the S. E. ¼ of Section 1, T. 13 N., R. 4 E., the elevation above tide is 583.′

Clay	81′	6″	81′	6″	
Slate	7′	6″	89′		
Salzburg coal	3′	3″	92′	3″	at 491 A. T.

TEST HOLE NO. 69.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., the elevation above tide is 583.′

Clay	70′		70′		
Hardpan	13′		83′		
Fire clay	2′		85′		
Slate	4′		89′		
Coal, Upper Rider	1′	5″	90′	5″	at 493 A. T.
Fire clay	2′		92′	5″	
Slate	7′	11″	100′	4″	
Sandrock	3′	10″	104′	2″	

TEST HOLE NO. 70.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., the elevation above tide is 583.′

Clay	83′	4″	83′	4″	
Light slate	15′		98′	4″	
Dark slate	4′	2″	102′	6″	
Coal, Upper Rider	2′	5″	104′	11″	at 478 A. T.
Slate	3′	1″	108′		
Good fire clay	8′		116′		
Slate	10′		126′		
Coal, Upper Verne	1′		127′		at 456 A. T.
Fire clay	1′		128′		
Slate	6′		134′		

TEST HOLE NO. 71.

In the N. E. ¼ of the S. E. ¼ of Section 1, T. 13 N., R. 4 E., elevation above tide is 583.′

Clay	80′		80′		
Slate	2′		82′		
Sandrock	3′		85′		
Dark slate	1′		86′		
Fire clay	5′	2″	91′	2″	
Light slate	9′	3″	100′	5″	
Dark slate	2′	9″	103′	2″	
Fire clay	1′		104′	2″	
Slate	6′	1″	110′	3″	
Slate and rock	10′		120′	3″	

TEST HOLE NO. 72.

In the S. E. ¼ of the S. W. ¼ of Section 6, T. 13 N., R. 5 E., the elevation above tide is 583.′

Clay	81′		81′		
Slate	11′		92′		
Coal, Upper Rider		4″	92′	4″	at 491 A. T.
Soft sandrock	1′		93′	4″	
Hard sandrock	8′		101′	4″	
Slate	5′	5″	106′	9″	
Sandrock	7′	5″	114′	2″	
Slate	8′		122′	2″	
Coal, Upper Verne	1′	10″	124′		at 459 A. T.

TEST HOLE NO. 73.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R .4 E., the elevation above tide is 582.′

Clay	74′		74′		
Hardpan	8′		82′		
Shale	2′		84′		
Slate	4′		88′		
Slate and coal		6″	88′	6″	
Coal, Upper Rider	11′	5″	89′	6″	at 493 A. T.
Fire clay	2′	6″	92′		
Slate	7′	2″	99′	2″	
Gray rock	7′	2″	106′	4″	
Gray rock	2′		108′	4″	
Slate	3′	1″	111′	5″	
Coal, Upper Verne	2′		113′	5″	at 469 A. T.
Fire clay	2′	9″	116′	2″	
Sandrock	2′		118′	2″	
Fire clay and slate	16′	10″	135′		
Slate	2′	7″	137′	7″	

TEST HOLE NO. 74.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., elevation above tide is 583.′

Clay	82′		82′		
Drift coal	2′	1″	84′	1″	
Fire clay	2′		86′	1″	
Slate	3′	6″	89′	7″	
Coal, Upper Rider	1′	5″	91′		at 492 A. T.
Fire clay	3′	1′	94′	1″	
Slate	12′	6″	106′	7″	
Black slate	3′	1″	109′	8″	
Bone coal		8″	110′	4″	
Coal, Upper Verne	3′	1″	113′	5″	at 470 A. T.
Fire clay	3′	7″	117′		

TEST HOLE NO. 75.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., the elevation above tide is 583.′

Clay	83′		83′	
Slate	2′		85′	
Fire clay	3′	6″	88′	6″
Light slate	7′		95′	6″
Dark slate	17′	6″	113′	
Coal, Upper Verne	3′		116′	at 467 A. T.
Fire clay	1′	2″	117′	2″

TEST HOLE NO. 76.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., elevation above tide is 583.′

Clay	73′		73′	
Hardpan	6′	3″	79′	3″
Salzburg coal and slate	2′	2″	81′	5″ at 502 A. T.
Fire clay	3′		84′	5″
Slate	5′		89′	5″
Fire clay	1′	4″	90′	9″
Slate	14′	8″	105′	5″
Coal, Upper Verne	3′	4″	108′	9″ at 474 A. T.

TEST HOLE NO. 77.

In the N. W. ¼ of the S. W. ¼ of Section 6, T. 13 N., R. 5 E., elevation above tide is 583.′

Clay	86′	86′	
Hardpan	12′	98′	
Light slate	9′	107′	
Sandrock	14′ 6″	121′ 6″	

TEST HOLE NO. 78.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., the elevation above tide is 583.′

Clay	82′	7″	82′	7″
Slate	10′	11″	93′	6″
Coal, Upper Rider		8″	94′	2″ at 489 A. T.
Fire clay	7′	5″	101′	7″
Slate	2′		103′	7″
Slate and sandrock	15′		118′	7″
Slate	9′	2″	127′	9″

TEST HOLE NO. 79.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4. E. the elevation above tide is 583.′

Clay	79′		79′	
Drift coal	1′	10″	80′	10″
Fire clay	2′		82′	10″
Slate	9′	3″	92′	1″
Coal, Upper Rider	1′		93′	1″ at 490 A. T.
Fire clay	3′	9″	96′	10″
Slate	9′	11″	106′	9″
Hard slate and bone	....		....	
Coal, Upper Verne	4′		110′	9″ at 473 A. T.
Coal	2′	8″	113′	5″

Drillings from the N. E. Part of Frankenlust and S. E. Part of Monitor, Bay Co. Hecla Portland Cement Co. of Bay City. The Elevations Above Sea Level Were Determined by Spirit Level.

Test Holes Nos. 80-117.

TEST HOLE NO. 80.

In the S. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 584.0.′

Clay	68′		68′	
Black slate	4′		72′	
Dark gray shale	11′		83′	
Fire clay	6′		89′	
Gray shale	12′		101′	
Black slate		6″	101′	6″
Coal, Upper Rider		6″	102′	at 482 A. T.
Fire clay	5′		107′	
Gray shale	21′		128′	
Black slate	2′		130′	
Coal, Upper Verne		9″	130′	9″ at 453 A. T.
Fire clay	3′	3″	134′	
Gray shale	2′	6″	136′	6″
Coal, Lower Verne Rider		6″	137′	at 447 A. T.
Fire clay	3′		140′	
Gray shale	10′		150′	
Hard rock		6″	150′	6″
Black slate	1′		151′	6″
Coal, Lower Verne		6″	152′	at 432 A. T.
Fire clay	4′		156′	
Gray shale	2′		158′	
Coal	1′	4″	159′	4″ at 425 A. T.
Fire clay	4′		163′	4″
Gray shale	4′	8″	168′	
Black slate	22′		190′	
Coal, Saginaw Coal Rider	3′		193′	at 391 A. T.
Fire clay	1′		194′	

TEST HOLE NO. 81.

In the S. E. ¼ of the S. W. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 590.′

Clay	50′		50′	
Sandy clay	30′		80′	
Hardpan	40′		120′	
Horizon of Upper Verne	....		....	at 470 A. T.
Fire clay	5′		125′	
Light shale	13′		138′	
Gray shale	10′		148′	
Black slate	7′		155′	
Fire clay	4′		159′	
Black slate		6″	159′	6″
Fire clay	3′	6″	163′	
Sandy shale	32′		195′	

TEST HOLE NO. 82.

In the S. E. ¼ of the S. W. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 591.′

Clay	50′		50′	
Sandy clay	25′		75′	
Sand and gravel	34′		109′	
Gray shale	9′		118′	
Coal, Upper Verne		6″	118′	6″ at 473 A. T.
Fire clay	2′	6″	121′	
Sandy shale	24′		145′	
Dark gray shale	15′		160′	
Black slate	6′		166′	
Coal, Lower Verne	2′	8″	168′	8″ at 422 A. T.
Black slate		4″	169′	
Fire clay	7′		176′	
Gray shale	20′		196′	
Black slate	10′		206′	
Coal, Middle Rider	1′	4″	207′	4″ at 384 A. T.
Fire clay	1′	8″	209′	
Light shale	21′		230′	
Dark shale	9′		239′	
White sandrock	3′		242′	

TEST HOLE NO. 83.

1900′ S. of the center of Section 2, T. 13 N., R. 4 E., elevation above tide is 592.′

Sandy clay	75′		75′	
Sand and gravel	35′		110′	
Coal, Upper Rider	1′		111′	at 481 A. T.
Sandy fire clay	11′		122′	
Dark gray shale	15′		137′	
Black slate	3′		140′	
Coal, Upper Verne	2′	6″	142′	6″
Sandy fire clay	6′		148′	6″ at 450 A. T.
Gray shale	3′		151′	6″
Coal, Lower Verne		6″	152′	at 440 A. T.
Sandy fire clay	4′		156′	
Gray shale	14′		170′	
Black slate	18′		188′	
Coal, Middle Rider	3′		191′	at 401 A. T.
Black slate		6″	191′	6″
Sandy fire clay	1′	6″	193′	

TEST HOLE NO. 84.

In the N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 591.′

Clay	78′		78′	
White soapstone	2′		80′	
Gray shale	5′		85′	
Gray sandrock	4′		89′	
Gray sandy shale	8′		97′	
Black slate		6″	97′	6″
Coal, Upper Rider		10″	98′	4″ at 483 A. T.
Gray shale	28′	8″	127′	
Black slate	10′		137′	
Coal, Upper Verne	2′	7″	139′	7″ at 451 A. T.
Fire clay	4′		143′	7″
Dark gray shale	16′	5″	160′	
Black slate	1′	6″	161′	6″
Coal, Lower Verne		6″	162′	at 429 A. T.

TEST HOLE NO. 85.

In the N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 591.′

Clay	80′		80′	
Gravel	4′		84′	
Black slate	2′		86′	
Salzburg coal		6″	86′	6″ at 505 A. T.
Fire clay	4′		90′	6″
Gray shale	24′	6″	115′	
Coal, Upper Rider		6″	115′	6″ at 476 A. T.
Sandy fire clay	7′	6″	123′	
Sandy shale	15′		138′	
Dark sandy shale	12′		150′	
Black slate	8′		158′	
Coal, Lower Verne	3′		161′	at 430 A. T.
Black slate	1′		162′	
Fire clay	4′		166′	
Sandy shale	9′		175′	
Black slate	19′		194′	
Coal, Middle Rider	2′	5″	196′	5″ at 395 A. T.
Black slate		7″	197′	
Sandy fire clay	9′		206′	

TEST HOLE NO. 86.

In the N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 593.′

Sand	3′	3′	
Sandy clay	77′	80′	
Hardpan	12′	92′	
Sand	21′	113′	
Fire clay	3′	116′	
Gravel	2′	118′	
Gray shale	12′	130′	
Black slate	5′	135′	
Coal, Upper Verne	3′	138′	at 455 A. T.
Fire clay	4′	142′	
Sandrock	3′	145′	

TEST HOLE NO. 87.

In the N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 597.′

Sand	4′	4′	
Sandy clay	64′	68′	
Hardpan	48′	116′	
Black slate	3′	119′	
Coal, Main Rider of Upper Verne	1′	120′	at 477 A. T.
Fire clay	6′	126′	
Coal, Upper Rider	1′	127′	at 470 A. T.
Fire clay	3′	130′	
Gray shale	14′	144′	
Black slate	4′	148′	
Coal, Upper Verne	3′	151′	at 446 A. T.
Fire clay	4′	155′	

TEST HOLE NO. 88.

In the N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 594.′

Sandy clay		68′		68′	
Hardpan		15′		83′	
Sandy clay		12′		95′	
Shale		13′		108′	
Hardpan		4′		112′	
Shale		5′		117′	
Coal, Main Rider of Upper Verne		1′		118′	at 476 A. T.
Fire clay		4′		122′	
Shale		4′		126′	
Coal	Upper Verne	1′	8″	127′	8″ at 466 A. T.
Fire clay		3′	4″	131′	
Coal		1′	6″	132′	6″ at 462 A. T.
Fire clay		5′	6″	138′	
Gray shale		6′		144′	
Black slate		5′		149′	
Coal, Lower Verne		3′		152′	at 442 A. T.

TEST HOLE NO. 89.

In the N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 594.′

Sand		2′		2′	
Sandy clay		48′		50′	
Clay		12′		62′	
Hardpan		12′		74′	
Clay		3′		77′	
Hardpan		4′		81′	
Clay		5′		86′	
Sandy clay		12′		98′	
Clay		5′		103′	
Dark shale		9′		112′	
Light shale		4′		116′	
Coal, Upper Rider		1′		117′	at 477 A. T.
Fire clay		6′		123′	
Black slate		3′		126′	
Fire clay		4′		130′	
Coal, Upper Verne		1′	6″	131′	6″ at 463 A. T.
Fire clay		6′	6″	138′	
Gray shale		5′		143′	
Black slate		5′		148′	
Coal, Lower Verne		3′		151′	at 443 A. T.
Fire clay		6′	3″	157′	3″
Black slate		29′		186′	3″
Coal, Middle Rider		2′	8″	188′	11″ at 405 A. T.
Black slate			8″	192′	7″
Fire clay		5′	6″	195′	1″

TEST HOLE NO. 90.

In the N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., near shaft of Hecla Coal and Portland Cement Co., cf. hole No. 334, elevation above tide is 598.′

Sandy clay		75′		75′	
Hardpan		38′		113′	
Black slate		6′		119′	
Coal	Riders of Upper Verne	1′	6″	120′	6″ at 478 A. T.
Fire clay		1′		121′	6″
Coal			8″	122′	2″ at 476 A. T.
Sandy fire clay		2′	10′	125′	

Black slate		15′		140′	
Coal, Upper Verne		2′	10″	142′	10″ at 455 A. T.
Sandy fire clay		4′	2″	147′	
Black slate		28′		175′	
Coal, Lower Verne		3′		178′	at 420 A. T.

TEST HOLE NO. 91.

In the N. E. ¼ of the S. W. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 584.′

Clay		53′		53′	
Hardpan		11′		64′	
Sand and gravel		31′		95′	
Sandy clay		24′		119′	
Black slate		10′		129′	
Coal, Upper Verne		2′	8″	131′	8″ at 452 A. T.
Black slate			4″	132′	
Sandy fire clay		8′		140′	
Sandy shale		8′		148′	
Black slate		22′		170′	
Coal, Lower Verne?		3′		173′	at 411 A. T.
Sandy fire clay		2′		175′	

TEST HOLE NO. 92.

In the N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 594.′

Sand		3′		3′	
Sandy clay		12′		15′	
Clay		47′		62′	
Hardpan		10′		72′	
Blue clay		8′		80′	
Hardpan		3′		83′	
Clay		10′		93′	
Black slate		7′		100′	
Sandrock		8′		108′	
Coal, Upper Rider		1′		109′	at 485 A. T.
Fire clay		2′		111′	
Sandrock		6′		117′	
Black slate		2′		119′	
Coal	Upper Verne	2′		121′	at 473 A. T.
Fire clay		2′		123′	
Coal			6″	123′	6″ at 471 A. T.
Fire clay		5′	6″	129′	
Coal		1′		130′	at 464 A. T.
Fire clay		3′		133′	
Gray shale		7′		140′	
Black slate		4′		144′	
Coal, Lower Verne		3′	1″	147′	1″ at 447 A. T.
Fire clay		4′		151′	1″

TEST HOLE NO. 93.

In the N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 593.′

Sandy clay		30′		30′	
Clay		48′		78′	
Sandy shale		16′		94′	
Black slate		1′		95′	
Coal, Upper Rider			6″	95′	6″ at 498 A. T.
Fire clay		7′	6″	103′	
Gray shale		19′		122′	
Black slate		6′		128′	

Coal, Upper Verne	2′	11″	130′	11″ at 462 A. T.
Fire clay	4′	1″	135′	
Sandrock	28′		163′	
Coal, Lower Verne	1′		164′	at 429 A. T.
Sandy shale	30′		194′	
Sandrock	6′		208′	

TEST HOLE NO. 94.

In the S. E. ¼ of the N. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 584′.

Sandy clay	40′		40′	
Clay	28′		68′	
Black slate	13′		81′	
Sandy shale	11′		92′	
Coal, Rider of Upper Verne	1′		93′	at 491 A. T.
Sandy shale	9′		102′	
Black slate	3′		105′	
Coal, Main Rider, Upper Verne	2′	6″	107′	6″ at 477 A. T.
Fire clay		6″	108′	
Coal	1′		109′	
Fire clay	3′		112′	
Coal		4″	112′	4″ at 472 A. T.
Dark gray shale	7′	6″	119′	10″
Black slate	2′	6″	122′	4″
Coal, Upper Verne	3′	1″	125′	5″ at 459 A. T.
Black slate		5″	125′	10″
Fire clay	4′		129′	10″
Gray shale	15′		144′	10″
Coal, Lower? Verne		9″	145′	7″ at 438 A. T.
Fire clay	4′	3″	149′	10″
Sandy shale	38′		187′	10″
Sandrock	4′		191′	10″

TEST HOLE NO. 95.

In the S. W. ¼ of the N. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 595′.

Sand	2′		2′	
Sandy clay	62′		64′	
Hardpan	16′		80′	
Shale	16′		96′	
Black slate	17′	6″	113′	6″
Coal, Upper Rider	1′		114′	6″ at 481 A. T.
Slate		6″	115′	
Light shale	3′		118′	
Coal, Upper Verne Main Rider	1′		119′	at 476 A. T.
Fire clay	4′		123′	
Black slate	15′		138′	
Coal, Upper Verne	3′		141′	at 454 A. T.
Fire clay	6′		147′	
Gray shale	7′		154′	

TEST HOLE NO. 96.

In the S. W. ¼ of the N. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 598′.

Sand	6′	6′	
Sandy clay	59′	65′	
Hardpan	30′	95′	
Shale	12′	107′	

Coal	Riders of Upper Verne	1′		108′	at 490 A. T.
Fire clay		3′		111′	
Coal		1′	6″	112′	6″ at 486 A. T.
Fire clay		6′		118′	6″
Coal			6″	119′	at 479 A. T.
Fire clay		4′		123′	
Black slate		4′	6″	127′	6″
Coal, Upper Verne		3′		130′	6″ at 468 A. T.
Fire clay		3′		133′	6″

TEST HOLE NO. 97.

In the S. E. ¼ of the N. W. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 595′.

Sand	10′		10′	
Clay	50′		60′	
Sandy clay	20′		80′	
Hard gravel	43′		123′	
Fire clay	2′		125′	
Black slate	20′		145′	
Coal, Lower Verne	3′	1″	148′	1″ at 447 A. T.
Black slate		5″	148′	6″
Fire clay	1′	6″	150′	
Dark shale	22′		172′	
Coal, Middle? Rider	2′		174′	at 421 A. T.
Sandy fire clay	8′		182′	
Sandy shale	14′		196′	

TEST HOLE NO. 98.

In the S. W. ¼ of the N. E. ¼ of Section 2, T. 13 N., R. 4 E., the elevation above tide is 594′.

Sand and gravel	18′		18′	
Clay	40′		58′	
Gravel	20′		78′	
Fire clay	4′		82′	
Sandrock	4′		86′	
Coal		4″	86′	4″ at 508 A. T.
Black slate	1′	8″	88′	
Salzburg coal		8″	88′	8″ at 505 A. T.
Sandy fire clay	7′	4″	96′	
Black slate	3′		99′	
Coal, Upper Rider	1′		100′	at 494 A. T.
Sandy fire clay	4′		104′	
Dark gray shale	16′		120′	
Coal, Upper Verne	2′	10″	122′	10″ at 471 A. T.
Black slate		2″	123′	
Fire clay	4′		127′	
Black slate	4′		131′	
Gray shale	19′		150′	
Black slate		6″	150′	6″
Coal, Lower Verne	1′		151′	6″ at 443 A. T.
Black slate	1′		152′	6″
Fire clay	3′	6″	156′	
Gray shale	10′		166′	
Sandy shale	20′		186′	
Sandrock	1′		187′	

TEST HOLE NO. 99.

In the S. E. ¼ of the N. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 593.′

Sandy clay	34′		34′	
Sand and gravel	13′		47′	
Clay	46′		93′	
Dark gray shale	16′		109′	
Coal, Upper Rider	3′	4″	112′	4″ at 481 A. T.
Black slate		8″	113′	
Sandy shale	24′		137′	
Coal, Upper Verne		6″	137′	6″ at 456 A. T.
Black slate	2′	6″	140′	
Dark gray shales	9′		149′	
Sandy shale	21′		170′	

TEST HOLE NO. 100.

In the N. E. ¼ of the N. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 594.′

Gravel	15′		15′	
Clay	45′		60′	
Gravel	19′		79′	
Fire clay	6′		85′	
Sandrock	10′		95′	
Dark shale	15′		110′	
Black slate	13′		123′	
Coal, Upper Verne	3′	4″	126′	4″ at 468 A. T.
Fire clay	1′	8″	128′	

TEST HOLE NO. 101.

In the N. W. ¼ of the N. E. ¼ of Section 2, T. 13 N., R. 4. E, elevation above tide is 595.′

Clay	80′		80′	
Gravel	24′		104′	
Dark gray shale	16′		120′	
Black slate	5′		125′	
Coal at 128¾′, Upper Verne	3′	4″	128′	4″ at 467 A. T.
Sandy fire clay	1′	8″	130′	

TEST HOLE NO. 102.

In the N. W. ¼ of the N. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 596.′

Sandy clay	60′		60′	
Clay	41′		101′	
Fire clay	10′		111′	
Dark shale	15′		126′	
Black slate	9′	6″	135′	6″
Coal, Upper Verne	3′	4″	138′	10″ at 457 A. T.
Fire clay	2′	2″	141′	

TEST HOLE NO. 103.

In the N. E. ¼ of the N. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 590.′

Clay	55′		55′	
Sandy clay	51′		106′	
Sandy fire clay	6′		112′	
Dark gray shale	24′		136′	
Coal, Upper Verne	1′	8″	137′	8″ at 452 A. T.
Sandrock	10′	4″	148′	

TEST HOLE NO. 104.

In the S. E. ¼ of the S. W. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 581.′

Clay	68′		68′	
Slate	2′	6″	70′	6″
Salzburg coal	2′	9″	73′	3″ at 508 A. T.
Slate	43′	9″	117′	

TEST HOLE NO. 105.

In the S. W. ¼ of the S. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 586.′

Sandy clay	77′		77′	
Black slate	11′		88′	
Salzburg coal	1′	3″	89′	3″ at 497 A. T.
Fire clay	3′	9″	93′	
Black slate	8′		101′	
Coal, Upper Rider	1′		102′	at 484 A. T.
Fire clay	3′		105′	
Dark slate	20′		125′	
Coal, Upper Verne	2′	2″	127′	2″ at 459 A. T.
Fire clay	3′		130′	2″

TEST HOLE NO. 106.

In the S. W. ¼ of the S. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 585.′

Sandy clay		77′		77′	
Gravel		5′		82′	
Dark shale		18′		100′	
Black slate		4′		104′	
Coal	Riders of Upper Verne	2′		106′	at 479 A. T.
Fire clay		2′		108′	
Gray shale		5′		113′	
Coal		1′		114′	at 471 A. T.
Fire clay		2′		116′	
Coal		1′	8″	117′	8″ at 467 A. T.
Fire clay		1′	4″	119′	
Black slate		6′		125′	
Coal, Upper Verne		2′	6″	127′	6″ at 458 A. T.
Slate			6″	128′	

TEST HOLE NO. 107.

In the S. W. ¼ of the S. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 589.′

Clay	78′	6″	78′	6″
Shale	26′	4″	104′	10″
Coal	2′	2″	107′	at 482 A. T.
Slate	3′		110′	
Coal, Upper Rider	1′	10.5″	111′	10.5″ at 477 A. T.
Clay	2′	5″	114′	3″
Slate	2′	10″	117′	1″
Coal, Upper Verne?		5″	117′	6″ at 472 A. T.
Clay and slate	8′	5″	125′	11″

TEST HOLE NO. 108.

In the N. E. ¼ of the S. W. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 584.37′.

Clay	74′ 8″	74′ 8″	
Slate	2′ 7″	77′ 3″	
Salzburg coal	2′ 9″	80′	at 504 A. T.
Shale	71′	151′	

TEST HOLE NO. 109.

In the S. W. ¼ of the N. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 590.′

Clay	82′	82′	
Blue shale	4′	86′	
Black sandrock	5′	91′	
Salzburg coal	2″	91′ 2″	at 499 A. T.
Black sandrock	1′ 10″	93′	
White sandrock	4′	97′	
Gray rock	3′	100′	
Black slate	2′ 10″	102′ 10″	
Coal	2″	103′	at 487 A. T.
Black slate	1′ 2″	104′ 2″	
Coal	1′ 10″	106′	at 484 A. T.
Gray rock	1′ 6″	107′ 6″	
Fire clay	1′ 6″	109′	
Gray slate	1′ 5″	110′ 5″	
Coal, Upper Rider	1′ 3″	111′ 8″	at 478 A. T.
Fire clay	1′ 8″	113′ 4″	
Coal	6″	113′ 10″	at 476 A. T.
Gray rock	4′ 6″	118′ 4″	
Coal	1′ 11″	120′ 3″	at 470 A. T.
Gray rock	7′ 8″	127′ 11″	
Coal, Upper Verne	3′ 3″	131′ 2″	at 459 A. T.
Fire clay	2′ 6″	133′ 8″	
Gray shale	26′ 4″	160′	
Gray rock	2′	162′	

TEST HOLE NO. 110.

In the N. W. ¼ of the S. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 589.′

Clay	87′	87′	
Slate and rock	16′	103′	
Coal, Upper Rider	8″	103′ 8″	at 485 A. T.
Clay and rock	51′ 4″	155′	

TEST HOLE NO. 111.

In the N. W. ¼ of the S. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 589.′

Clay		94′	94′	
Coal, Slate, Coal	Upper Riders	10″	94′ 10″	at 494 A. T.
		3′ 9″	98′ 7″	
		1′ 11″	100′ 6″	at 489 A. T.
Rock		23′	123′ 6″	
Coal, Upper Verne		2′ 7″	126′ 1″	at 463 A. T.

TEST HOLE NO. 112.

In the N. W. ¼ of the N. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 594.′

Sandy clay	26′	26′	
Clay	54′	80′	
Gravelly clay	11′	91′	
Clay	10′	101′	
Sandy clay	8′	109′	
Soapstone	2′	111′	
Gray rock	3′	114′	
Coal, Upper Rider	2′ 3″	116′ 3″	at 478 A. T.
Gray rock	4′ 6″	120′ 9″	
Coal	1′ 10″	122′ 7″	at 471 A. T.
Gray rock	2′ 5″	125′	
White sandrock	7′ 7″	132′ 7″	
Coal, Upper Verne	4″	132′ 11″	at 461 A. T.
Light gray rock	7′ 6″	140′ 5″	

TEST HOLE NO. 113.

In the S. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation 592 A. T.′

Clay	64′	64′	
Black slate	4′	68′	
Gray shale	22′	90′	
Black slate	1′	91′	
Coal	....	....	
Fire clay	6′	97′	
Dark gray shale	12′	109′	
Coal, Upper Rider	1′	110′	at 482 A. T.
Sandy fire clay	3′	113′	
Sandy shale	9′	122′	
Black slate	6″	122′ 6″	
Coal, Upper Verne	1′ 3″	123′ 9″	at 468 A. T.
Gray sandrock	8′ 3″	132′	
Black slate	16′ 6″	148′ 6″	
Coal, Lower Verne	2′ 6″	151′	at 441 A. T.
Black slate	6″	151′ 6″	

TEST HOLE NO. 114.

In the N. W. ¼ of the S. W. ¼ of Section 11, T. 13 N., R. 4 E., elevation above tide is 595.′

Clay	52′	52′	
Sand and gravel	44′	96′	
Gray shale	24′	120′	
Coal, Upper Rider	1′	121′	at 474 A. T.
Fire clay	2′	123′	
Gray shale	11′ 6″	134′ 6″	
Coal, Upper Verne	6″	135′	at 460 A. T.
Fire clay	2′	137′	
White sandrock	66′	203′	
Coal	....	....	
Fire clay	4′	207′	
White sandrock	8′	215′	